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How labour organization may affect technology adoption: an analytical framework analysing the case of integrated pest management

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ABSTRACT. Integrated Pest Management (IPM) is an important component of sustainable agriculture. Farmers who switch from a more capital-intensive pesticide-based pest management strategy to IPM have to substitute capital with labour. The adoption of IPM will therefore depend, among other things, on the opportunity costs of labour. A simple model analyses the trade-off between IPM and current farmers' best practice in developing countries. Modifications of the model include different forms of labour organization in pest management, such as owner operated and short- and long-term labour contracts. The implications are that agricultural policies, environmental policies, and labour market policies can go hand in hand. Unfortunately, this will be more likely at a higher level of original pesticide use and hence a higher level of environmental costs.

1. Introduction

Rural areas in developing countries have in common that the labour market depends to a large extent on the agricultural sector. Furthermore, most of the rural areas show hidden unemployment. Also, the success of agriculture depends on the environment which is more fragile in most of the developing countries than in industrialized countries (World Bank, 1997). Therefore, international donor agencies have placed high priority on sustainable agriculture and rural development among other objectives to enhance employment, create income, and protect the environment (World Bank, 1997; FAO, 1999).

An important component of sustainable agriculture is integrated pest management (IPM) where farmers are trained to improve their pest management skills (Norvell and Hammig, 1999). Studies have shown that

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farmers used tools that are part of integrated pest management but tend to apply pesticides on a regular basis (further called farmers' best practice, FBP). This simple strategy often leads to an overuse of pesticides in pest and disease control from an individual as well as from a social welfare point of view (e.g. Rola and Pingali, 1993; Waibel and Fleischer, 1998). While IPM is a complex strategy with no exact definition, the main message is to reduce pesticide applications (Morse and Buhler, 1997; Waibel, 1994). The central element of IPM is the observation of the level of pests and diseases, and the application of pesticides only if necessary. The IPM strategy substitutes capital (expenses for pesticides) and low skill labour (time spent on spraying) with high skill labour (observation of pests and diseases) (Fernandez-Cornejo, 1996; Morse and Buhler, 1997; Schillhorn van Veen *et al.*, 1998; Pingali and Gerpacio, 1998; van de Fliert and Proost, 1999). It thus depends on the provision of human capital. The provision of these skills is part of agricultural strategies in many developed as well as developing countries (Waibel, 1999). Beside the expected positive benefits of IPM at farm level, additional external benefits such as less groundwater pollution and reduced loss in biodiversity are expected through reduced application of pesticides as compared to FBP (Fernandez-Cornejo, 1998; Norvell and Hammig, 1999). These benefits are the main argument for government support (Cuyno and Norton, 2000). One successful mode of introducing IPM specifically in developing countries is the use of farmer field schools (FFS) (Schmidt, Steifel, and Hürlimann, 1997). The general approach is to train a group of farmers in IPM during a cropping season. Under the guidance of trainers, farmers implement field trials and compare the results. It is expected that farmers will adopt at least part of the IPM techniques learned at the FFS (Horstkotte-Wesseler, 1999).

Economic research on IPM strategies has so far concentrated on the analysis of costs and benefits (e.g. Waibel *et al.*, 1999), their social costs (e.g. Rola and Pingali, 1993; Antle and Pingali, 1994; Waibel and Fleischer, 1998) and problems of successfully implementing plant protection strategies (e.g. Schillhorn van Veen *et al.*, 1998). Farm households have been modelled explicitly or implicitly by assuming perfect substitution between different kinds of farm labour. Empirical studies on the adoption of IPM in the United States (McNamara, Wetzstein, and Douce, 1991; Fernandez-Cornejo, Beach, and Huang, 1994; Fernandez-Cornejo, 1996, 1998) have shown a significant negative impact of off-farm income on the adoption of IPM, confirming that opportunity costs of labour are an important variable in explaining the rate of adoption.

Government policies have been addressed by several authors, but with the emphasis on regulatory issues of pesticide application, pesticide price policies, and national extension strategies (Waibel, 1994). As IPM is a labour-intensive plant protection strategy, labour market policies will have an impact on the adoption and the costs and benefits of IPM. If those policies are not congruent they could lead to an inefficient allocation of resources. Also, the impact is expected to differ among the various forms of labour organization.

Labour in agriculture is often divided between the owner-operator, his family members, and hired permanent or seasonal workers. Whether a certain task is carried out by the owner or somebody else depends mainly on differences in the opportunity costs and transaction costs of labour (Beckmann, 1996). The fact that the organization of labour may affect the adoption of innovations was first explored by Rosenstein-Rodan (1943) and later formalized by Acemoglu (1997). If hired workers must be trained in order to implement innovations, the problem may arise that 'an entrepreneur who invests in training workers may lose capital if these workers contract with other firms' (Rosenstein-Rodan, 1943; c.f. Bardhan and Udry, 1999, p. 161). This may lead to sub-optimal investments in training and a low rate of innovation.

IPM programs usually avoid this problem by training the owner-operator. However, if it is not the owner-operator who is applying the pesticides, differences in the opportunity costs of labour may also affect the rate of adoption. Low opportunity costs of the person applying the pesticides and high opportunity costs of the decision maker or owner-operator can be important constraints for the adoption of IPM.

In this paper we will focus on the organization of farm labour and its relevance for the adoption of IPM, a topic which has been neglected in earlier studies. First of all, a simple theoretical model will be introduced which describes the circumstances in which an IPM strategy begins to promise more benefits that FBP. Secondly, the organization of agriculture with respect to pest management will be described and the different types of organizational structures introduced into the model. Thirdly, the results of the model will be compared with respect to labour costs and different forms of labour organization. The impact of labour market policies on IPM will be discussed and specifically how they influence the chance of adoption of IPM and how the impact depends on the organizational structure of agriculture. Finally, non-trivial conclusions for agriculture, environmental, and labour market policies will be drawn.

2. The model

The trade-off between FBP and IPM can be modelled for a cost-minimizing farmer, who has to decide whether he wants to continue with his current practice, FBP, or switch to IPM as a perfect substitute while achieving the same yield level, $\bar{y}$. From here on we will use the term 'farmer' as a proxy for the person in the farm-household who will be the member of the farm-household to attend training courses on IPM, who ultimately decides on the pest and disease control strategy in the field, and who decides who will do the spraying. The production function is of perfect substitutes technology $f(IPM, FBP) = IPM + FBP$. The minimum costs of production would be $c(IPM, FBP, \bar{y}) = min\{IPM, FBP\}\bar{y}$, hence the farmer will switch to IPM if it is less expensive than FBP. Adopting IPM will be less expensive, if the benefits, B, from switching to IPM, are greater than the costs, C, of adoption and not if otherwise. The boundary between adoption and non-adoption, IPM_b, is where $B = C$. The adoption of IPM can be written as

$$IPM = \begin{cases} 1 & if \quad B > C \\ 0 & if \quad B > C \end{cases} \tag{1}$$

As farmers are aware about the short-term impacts of pesticides on health (Rola and Pingali, 1993), the benefits of adopting an IPM strategy from the farmers' point of view are reduced pesticide and health costs. Further benefits of reduced pesticide application such as less pollution of ground water and a positive impact on biodiversity are assumed not to be part of the farmers' objective function. The benefits of IPM are modelled by taking the current pesticide (*PC*) and health costs (*HC*) under FBP weighted with the relative application time saved due to the adoption of IPM (*AS*). Deriving the health benefits by weighing the health costs (*HC*) with the relative application time saved (*AS*) assumes that the health costs are a direct result of the exposure to pesticides, which will be reduced with less time spent on spraying. The benefits are assumed to be linear in relative time saved, are additive and should be interpreted as the expected discounted sum. They can be written as

$$B = (PC + HC)AS \tag{2}$$

The pesticide costs, *PC*, are the monetary expenses on pesticides, *PA*, and the time used for spraying, *L*, valued at the opportunity costs of labour spraying pesticides, w_1

$$PC = PA + L \cdot w_1 \tag{3}$$

The health costs, *HC*, are the monetary expenses for medical treatment, *hc*, such as hospital fees and medicine, plus the number of non-working days due to health problems resulting from the application of pesticides, *SD*, valued with the labour costs w_2

$$HC = hc + SD \cdot w_2 \tag{4}$$

Also

$$hc, w^*, w_1, w_2, L, PA, SD \geqslant 0, 0 \leqslant AS \leqslant 1, w^* \geqslant w_1 \tag{5}$$

As the adoption of IPM substitutes capital (expenses for pesticides) and low skill labour (time spent for spraying) with high skill labour (observation of pests and diseases), the cost for the farmer is the time he has to spend to learn and apply the technology, IPM_{ld}, weighted with his own opportunity costs of time, w^*

$$C = IPM_{ld} \cdot w^* \tag{6}$$

Equation (2) to equation (6) can be combined and rearranged to show the boundary between adoption and non-adoption, where IPM_b is the number of labour days at $B = C$

$$IPM_b\, w^* = (PA + Lw_1)AS + (hc + SDw_2)AS$$

$$IPM_b = \frac{(PA + Lw_1)AS}{w^*} + \frac{(hc + SDw_2)AS}{w^*} \tag{7}$$

The farmer will start to adopt IPM as long as the time he has to spend on

IPM, IPM_{ld}, is below the boundary, IPM_b, and not if $IPM_{ld} > IPM_b$. Equation (1) can then be written as

$$IPM = \begin{cases} 1 & \text{if} \quad IPM_{ld} < IPM_b \\ 0 & \text{if} \quad IPM_{ld} > IPM_b \end{cases} \tag{1'}$$

The boundary between adoption, applying IPM, and non-adoption, applying FBP, is the maximum number of days to be spent for an IPM (IPM_{ld}) strategy (see also figure 1):

If the adoption of IPM requires less labour days than the number of labour days saved, it is optimal for the farmer to adopt IPM and he will find himself in the 'adoption' area of figure 1. On the other hand, if the adoption of IPM requires more labour days than benefits converted into the number of labour days, he would be better off not adopting IPM.

Equation (7) includes opportunity costs of labour. The opportunity costs of labour may be the same, but this is not necessarily the case. It is important to note that w^* represents the opportunity costs of the decision maker, because the time spent on IPM, IPM_{ld}, which includes the necessary training on IPM technology, is assumed to be the time spent by the farmer. He would only employ labour for spraying as long as the labour costs are lower than his own opportunity costs for conducting that specific task. If the labour costs are higher than his own opportunity costs he could increase his income by applying the pesticides himself.

The model includes the extreme case of an IPM strategy where no pesticides are applied. This is the case when the amount of application time saved, *AS*, equals 100 per cent. What the model also implies is that the higher the benefits from IPM, the more likely IPM is to be adopted. As the marginal benefits of IPM will be higher the higher the health and pesticide costs of FBP, the rate of adoption will be higher in areas of high pesticide use and high impact on farmers' health. Therefore the success of IPM will be greater in areas of high environmental deterioration.

3. Different forms of labour organization in agriculture

In agriculture, labour is commonly organized in family farms in which

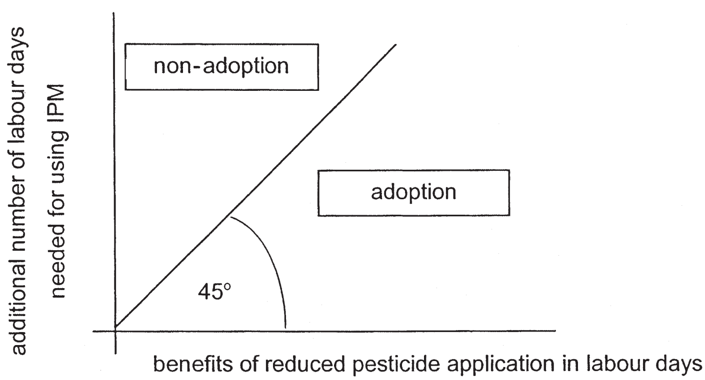

Figure 1. *Boundary between adoption and non-adoption of IPM*

family members conduct both managerial and operational tasks. This is often a transaction cost-minimizing way of labour organization in agriculture (Schmitt, 1991; Roumasset, 1995; Allen and Lueck, 1998; Beckmann, 2000). However, for certain tasks it is quite common that management and operation is divided either between different household members or between household members and hired farm labourers, who are employed either on a contract (short-term) or permanent (long-term) basis (see Hayami and Otsuka, 1993; Beckmann, 1996). Such division of labour arises if the opportunity costs of labour differ between household members or between household members and hired farm labourers[1] in such a way that they outweigh the transaction costs associated with any division of labour (Beckmann, 1996; Roumasset, 1995; Becker and Murphy, 1992). Our model allows for differentiation between these different types of labour organization by assuming different opportunity costs of labour. The model applies also to sharecropping arrangements. In this case the decision maker would be the sharecropper.[2] For simplicity, we do not consider transaction costs here. The following scenarios are possible:

scenario 1: $w^* = w_1 = w_2$
scenario 2: $w^* \geqslant w_1 = w_2$
scenario 3: $w^* \geqslant w_1 \wedge w_2 = 0$

In scenario 1 all opportunity costs are equal. There is no incentive for the division of labour. This describes a family farm, where the person applying the pesticides is also the one who will practice IPM, which is common for small-holder rice production in Southeast Asia (Barker and Herdt, 1985).

Under scenario 2 the opportunity costs are different in that it is advantageous to divide labour. The person applying the pesticides is different from the one conducting the observations on pests and diseases. This is the case where farm labourers or other family members apply the pesticides, which is common for intensive vegetable and fruit production (e.g. Lewis, 1992; Wesseler, 1996) and larger farms.

Scenario 3 is equal to scenario 2, except that the farmer ignores the health costs of the farm labourer (or the member of the family applying pesticides), which can be described as the case where labourers are hired for spraying on a daily basis.

Other possible scenarios would assume non-maximizing behaviour and will therefore not be pursued further.

[1] The opportunity costs of labour can differ with respect to individual characteristics such as sex, age, education, or more general human capital. These differences in the opportunity costs of labour between household members have been recognized in the literature mainly to explain differences in individual off-farm work decisions (e.g. Huffman, 1980; Schluz-Greve, 1995).

[2] The efficient level of input use under sharecropping is less than under an owner-operator tenure system, if all the costs including the opportunity costs of labour but except the share are the same. As the opportunity costs of labour of the sharecropper in general are less than the opportunity costs of the landowner, the efficient amount of other inputs increases. Whether or not the total of the two effects will lead to a higher level of pesticide use under FBP is an empirical question.

4. Changes in opportunity costs of labour and the impact on the adoption of IPM

The three scenarios and the impact of changes in the labour market can be analysed by calculating the partial derivatives. A numerical example, which is based on experiences from agricultural production in the Philippines where all three scenarios can be observed, will be used to illustrate the results. In the example, the labour costs w_1, w_2, w^* are assumed to range from 0 up to 120 pesos per day. The expenses for pesticides, PA, are assumed to be 4000 pesos, the time used for pesticide application, L, 20 days, the health costs, hc, to be 1000 pesos, the number of non-working days, SD, to be ten days and the time saved, AS, to be 20 per cent and all per cropping season and on a per hectare basis. The numbers are close to those provided in the study by Pingali *et al*. (1994) on pesticide use and farmers' health in Philippine rice production.

For the first scenario, the owner-operated farm, the chance of adopting IPM decreases with an increase in labour costs

$$\frac{\partial IPM}{\partial w^*} = -\frac{(PA + hc)AS}{(w^*)^2} \geqslant 0 \tag{8a}$$

$$\frac{\partial IPM}{\partial (w^*)^2} = 2 \cdot \frac{(PA + hc)AS}{(w^*)^3} \geqslant 0 \tag{8b}$$

This is a result one would initially expect. As labour costs increase, the maximum time the farmer would be willing to spend on IPM decreases. Hence the comparative advantage of IPM decreases and (as equation (8b) shows) at a decreasing rate, which is also illustrated in figure 2. In this case labour market policies that increase the opportunity costs of labour would result in a move along the border function to the right. This reduces the maximum amount of time to be spent on IPM if adopted from an economic point of view. Generally speaking, an increase in the opportunity costs of labour will decrease the comparative advantage of IPM and hence the rate of adoption. The rate of change of the comparative advantage of IPM decreases when opportunity costs of labour increase. Therefore, labour policies that increase labour costs, such as minimum wage policies, will decrease the competitiveness of IPM strategies, but at a decreasing rate. This causes a problem for policy decision makers as many countries like Indonesia and the Philippines (Betcherman and Islam, 2001) have adopted an IPM strategy as part of the agriculture policy supported by the FAO and the World Bank while at the same time they have implemented a national minimum wage policy.[3]

The result also indicates an environmental conflict of IPM. In FFSs farmers are trained on IPM. This, it has been argued, not only improves knowledge related to IPM but improves awareness and learning capabilities in general and thus improves the human capital. The increase in

[3] As one reviewer correctly observed, the effectiveness of the minimum wage policy in the agriculture sector is questionable as it is often not enforced. An enforcement of the policy in the non-agricultural sector increases, ceteris paribus, the opportunity costs of labour and leads to our conclusions.

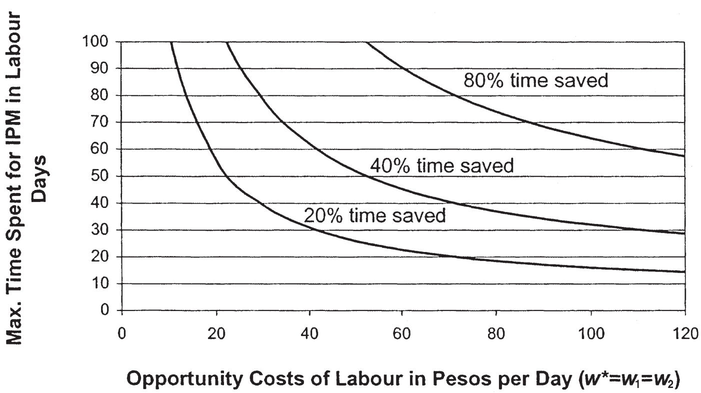

Figure 2. *IPM adoption boundary function of owner-operated pest management*

human capital increases the possibilities for better-paid off-farm work as e.g. Huffman (1980) has shown for the United States. An increase in the off-farm wage rate decreases the competitiveness of IPM. That is, on the one hand, the introduction of successful FFSs, meaning where farmers are well trained on IPM, may lead to less adoption of IPM and less expected *ex-ante* environmental benefits. On the other hand, the increase in off-farm work increases the benefits of FFSs for the farmer even more than if he/she would have adopted IPM. This hypothesis can be tested empirically and if correct would support the argument that FFSs generate measurable benefits also to those who participated in IPM training, but did not adopt the technology.

The second scenario, where the opportunity costs between the decision maker and the person applying the pesticides differ, provides the following partial derivatives

$$\frac{\partial IPM}{\partial w_1} = \frac{(L + SD)AS}{w^*} \geqslant 0 \quad (9a)$$

$$\frac{\partial IPM}{\partial (w_1)^2} = 0 \quad (9b)$$

$$\frac{\partial IPM}{\partial w^*} = -\frac{(PA + L \cdot w_1)AS}{(w^*)^2} - \frac{(hc + SD \cdot w_2)AS}{(w^*)^2} \leqslant 0 \quad (10a)$$

$$\frac{\partial IPM}{\partial w^2} = 2\frac{(PA + L \cdot w_1)AS}{(w^*)^3} + 2\frac{(hc + SD \cdot w_2)AS}{(w^*)^3} \geqslant 0 \quad (10b)$$

Equation (9a) shows that an increase in the opportunity costs of farm labourers will increase the competitive advantage of IPM. The economic interpretation is that the higher the opportunity costs of the farm labourer, the more expensive it is for the farmer to lose farm labour due to health problems from pesticide application. Also, the benefits from saving time on spraying pesticides increase with an increase in the opportunity costs of the farm labour. Hence, the competitiveness of IPM increases with an increase in the health costs and the pesticide application of farm labourers.

The steeper line in figure 3 shows the IPM adoption boundary function under constant opportunity costs of the decision maker and variable labour costs for pesticide application.

The results shown in equations (9a) and (9b) have important implications for labour market policies and the adoption of IPM. An increase in the minimum wage rate of hired farm labour will have a positive constant impact on the comparative advantage of IPM. The division of labour can explain the difference compared to the first scenario. As the farmer is assumed to be the one responsible for observing the field and deciding what kind of pest control strategy will be used, but not the one actually spraying the field, an increase in labour costs in spraying increases the costs of pesticide application and hence increases the comparative advantage of IPM. Therefore, we expect, that the adoption of IPM among farmers with a division in labour among household members or long-term hired labour is higher than among owner-operated farms. The same effect, higher adoption rates, could be achieved by training those members of the households who apply the pesticides on IPM, if this increases the reservation wage.

If the farmer uses only short-term labour for pesticide application, he can ignore the number of days short-term labourers cannot work because of sickness. The monetary expenses of the short-term labour cannot be ignored by the farmer as it can be expected that the short-term labourers will try to recover some of the expenses either by requiring a higher salary in advance or an additional payment at the occurrence of health problems.[4] In this case, shown

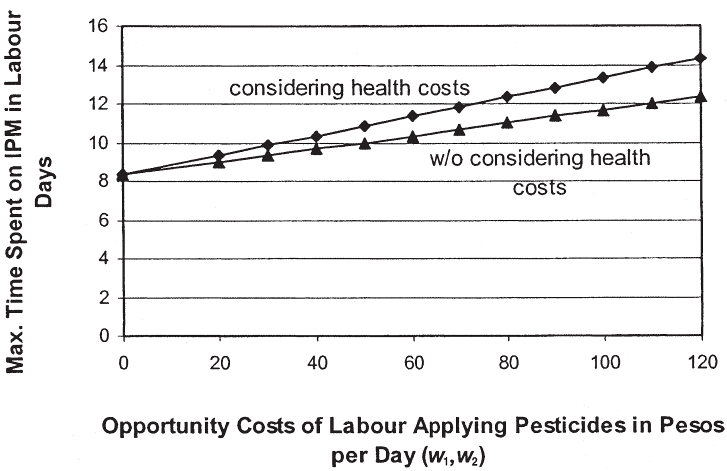

Figure 3. *IPM adoption boundary function when pesticides are applied by family members, permanent farm labour, or short-term hired labour under variable labour costs and constant opportunity costs of the farm manager*

[4] The observation of a higher salary should not be confused with our statement about the wage rates, $w^* > w_1$, as this will still hold. If the opposite will be observed in the field, our interpretation is that hired labour were able to internalize at least some of the health costs and $w^* < w + HC$, with $HC > w^* - w > w - w^*$.

in the third scenario, as the labour costs for spraying increase the comparative advantage of IPM increases at a constant rate (equation (11a)). The explanation is the same as before, but compared to the second scenario the rate of change will be lower as the number of sick days, *SD*, is ignored. Hence, the slope of the boundary function will be less steep compared to the situation including all the health costs and adopting IPM will be less likely (see figure 3).

$$\frac{\partial IPM}{\partial w_1} = \frac{L \cdot AS}{w^*} \geqslant 0 \tag{11a}$$

$$\frac{\partial IPM}{\partial (w_1)^2} = 0 \tag{11b}$$

$$\frac{\partial IPM}{\partial w^*} = -\frac{(PA + L \cdot \mathrm{w}_1 + hc)AS}{(w^*)^2} \leqslant 0 \tag{12a}$$

$$\frac{\partial IPM}{\partial (w_1)^2} = 2\frac{(PA + L \cdot \mathrm{w}_1 + hc)AS}{(w^*)^3} \geqslant 0 \tag{12b}$$

In the case of changing opportunity costs of the farmer the comparative advantage of IPM decreases at a decreasing rate regardless of the three forms of labour organization analysed. However, the rate of change is lower for owner-operated farms and highest for farms where family members or permanent labourers apply the pesticides, as can be seen by comparing equations (8a), (10a), and (12a). The impact of the opportunity costs of the farmer on the adoption of IPM under three different forms of labour organization are illustrated in figure 4. The competitive advantage of IPM is highest under owner-operated pesticide application, followed by family or permanent-hired-labour-operated pesticide application and finally short-term-hired-labour-operated pesticide application. This result offers an additional explanation to the one provided by Griliches (1957) on the adoption of technical change by farmers, which was explained by

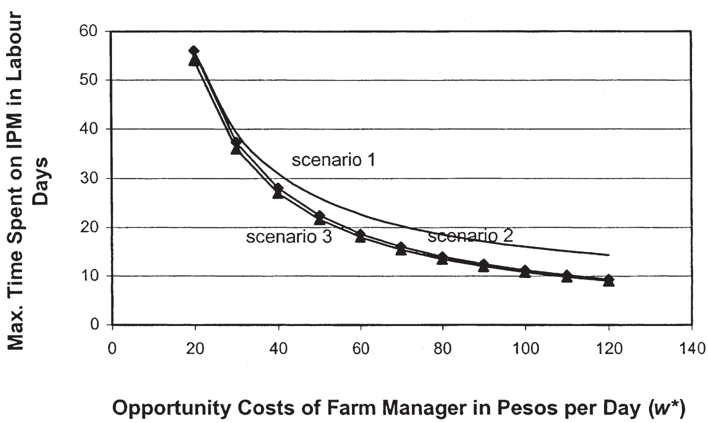

Figure 4. *IPM boundary function when pesticides are applied by farm labour under constant farm labour costs and variable opportunity costs of the farm manager*

differences in profitability due to increases in yield. Our results suggest that also the form of labour organization is important.

In conclusion, the organization of labour has important implications for the adoption of IPM strategies under changing opportunity costs. In a comparative static perspective, low opportunity costs of labour for the decision maker and high opportunity costs for those who apply pesticides will increase the rate of adoption. If, for example, the opportunity costs of the decision maker rise, and he decides to work off-farm, this will reduce the probability of adopting IPM regardless of how the work is organized (figure 4). However, if the work is divided between the decision maker and other household members or hired labour, and their opportunity costs remain unchanged, the probability of adopting IPM will be even lower. Furthermore, the probability of adopting IPM will decrease with an increase in the organization of labour markets. If the pesticides are applied either by other members of the family or by permanent hired labour the probability of adopting IPM will be lower. If the labour market is organized in such a way as to allow the hiring of short-term labour for pesticide application, the probability of adopting IPM will decrease further. Also, the probability of adopting IPM will be greater the higher the labour costs of other family members, permanent and short-term hired labour. This is contrary to the situation where pesticides are applied by the decision maker as explained earlier.

5. Conclusions

This paper presents a model that allows the identification of the threshold at the farm level for adopting an IPM strategy conditional on the organization and the opportunity costs of labour. The results show that under owner-operated pesticide application an overall increase in opportunity costs of labour decreases the competitiveness of IPM compared to FBP. This is a fairly obvious result in view of the known implications of labour market policies on the adoption of IPM. The results change if division of labour is assumed, an observation which is common in agriculture. Depending on the organization of agricultural labour, an increase in labour costs can increase the competitive advantage of IPM. Labour market policies that increase the minimum wage rate of hired farm labour will increase the probability of IPM adoption, while policies that increase the opportunities of the decision maker will decrease the probability of IPM adoption. While under owner-operated pesticide application, the impact of labour market policies in this case would be inversely related to agricultural and environmental policies. We also show that under a differentiated organization of labour, the possibility exists that agricultural policies, environmental policies, and labour market policies can go hand in hand. Unfortunately, this will be more likely at a higher original level of pesticide use and hence a higher level of environmental deterioration.

The results have important implications for further empirical research on the adoption of IPM and *ex-ante* impact assessment. Up to now, the impact of the organization of labour on the rate of adoption of IPM has been largely ignored (e.g. most recently Maumbe and Swinton, 2000).

In empirical research, we would expect that, ceteris paribus, the rate of IPM adoption is lower in regions or farms where the decision maker faces higher opportunity costs of labour (e.g. work off-farm). This result is expected independent from the labour organization. Further, we would expect that, ceteris paribus, the rate of adoption is lower in regions or farms where relatively cheap family or hired labour can be employed for pesticide application.

For *ex-ante* impact assessment, e.g. the introduction of IPM in regions where the original level of pesticide use was low with the aim of preventing an increase in pesticide use in the future (Waibel, 1999, p. 13), it could be stated that this will be less successful in areas with high opportunity costs and for a more differentiated organization of agricultural labour. Additional economic incentives have to be provided to encourage the adoption of IPM under these circumstances.

In this respect, a lot of emphasis has been placed on training farmers on IPM to raise their awareness about IPM in the hope 'that these efforts pay off in experimentation and knowledge creation by farmers themselves, and ultimately to sustained IPM practice by them' (Feder and Quizon, 1999, p. 5). Our findings suggest, that again these pay-offs will be less in regions with high opportunity costs and a more differentiated organization of agricultural labour, but not because farmers are not aware but because of the economic incentives for adoption.

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