수산경영론집, Vol. XXXII No. 1(2001. 6)

Risk and The Economics of Acid Chemical Use in Korean Laver Farming

Park, Seong Kwae

김 養殖에 있어서 酸 利用의 生產危險과 經濟性에 관한 研究

박 성 쾌*

<Contents>

Ⅰ. Introduction

To understand laver culture farmers willingness to adopt chemicals in place of environmentally sound laver culture technologies, it must be recognized that laver culture farmers are economic decision makers in the complex, uncertain environment within which they must operate. In general, laver culture farmers face two types of risks : price risk and yield (or quality) risk.[1] Price variability is beyond their control

---

* 부경대학교 해양산업정책학부

[1] Risk and uncertainty classification of Wald (1947) is more sound in sequential analysis than Knights (1964). Wald risk is a situation in which specifications for a kind of

but its uncertainty can be reduced or eliminated if contracting with processors can be made before starting production, while yield and quality risks can be reduced in part by growers production strategies. Thus, an important part of the decision problem facing them is to choose an efficient and safe weed control strategy and other production inputs to deal with these production risks.

When we define ecological laver culture system as the setting up and maintaining of a self-sustaining, environmentally and economically acceptable system, which integrates many forms of culture ground use (Martha 1987), inorganic chemical use (i.e., hydrochloric acid: HLC) in culture fisheries (i.e., laver culture) may have been the good, the bad, and the uncertain. By all accounts, laver culture productivity increased significantly in the last half century largely due to the introduction of new technologies and recently expanded use of chemicals such as HCL. More recently, however, some laver culture practices, including increased chemical use, are viewed as having a major impact on the lager ocean ecosystem and as being an important source of coastal environmental point/non point pollution which it is believed places serious stress on the ocean environment. A recent notification of the Ministry of Maritime Affairs and Fisheries for encouraging organic acid use instead of HCL and the associated guideline of the Korean Fisheries Cooperative Federation reveal serious public concern about laver culture ground contamination by the HCL use. It is also questioned whether the high rates of productivity growth that have characterized modern laver culture can be sustained with such technologies that disrupt the ocean ecosystem. While there is no doubt that laver culture does affect the ocean biosphere, it is not clear how these effects should be valued and traded-off with other social objectives.

The overall concern regarding the possibility of long-term improvements in both ocean environmental quality and laver culture productivity has led to heightened interest in research that incorporate ocean environmental impacts into evaluation of the social benefits and social costs of laver culture technologies and policies.

This paper is organized as follows. The second section includes a discussion of the laver culture technology and yield probability distribution. The third section presents

---

knowledge for a given decision have been met. Uncertainty has to be divided into two parts, i.e., (i) a learning situation in which the specifications are not met but in which it pays to meet them and (ii) situations in which it does not pay to try to meet the specifications. The latter case includes cases for which neither information acquisition nor decision takes place as well as situations in which outside circumstances force decisions. In this study, concepts of risk and uncertainty are used interchangeably.

decision attention is focused on chemical use on the intensive margin. The last section summarizes the content and provides concluding remarks.

Ⅱ. Culture Technology and Yield Probability Distribution

Risk (or uncertainty) is an inherent phenomenon in laver cultures and other fisheries. Weather conditions, weeds, the development and adoption of new technology and public policies, interact to create a unique decision making environment for fishermen. These factors induce yield and quality variability and thus affect the laver culture managers production decisions.

An important source of risk in laver culture is lowering quality from weed infestation since if weed problems take place, both yield and quality would have to be seriously affected during the period from the beginning of culture to the harvest stage(Antle 1983a). Weed infestation directly affects the proportion of laver quality and thus a growers profit. Hence the growers seaweed control and other input decisions are directed toward securing maximum production with higher quality.

The relationship between profit, the amount of quality crop (Q_q), gross output (Q), and quality loss from weed occurrance (D) can be given in term of production inputs by

$$
\begin{aligned}
(1)\quad \Pi &= Q^q(A,\ L) - P_aA - P_lL \\
&= Q\ (A,\ L)V(A,\ L) - PaA - P_lL
\end{aligned}
$$

where and P_s are profit and input prices (P_a and P_l) normalized by output price P_y (i.e., $P_y/P_y=1$, R_a (acid price)/$P_y=P_a$, R_l((wage)/$P_y=P_l$),[2] $V=[1-D(A,\ L)]$, D= percentage of weed infestation, A=inorganic or organic acid input,[3] and L=labor input.

In addition to A and L, other inputs are related to yield and weed infestation (i.e., sea lettuce), although not all directly affect the yield and quality of product cultured. Such inputs include cropping patterns and cultivating methods. These inputs can be viewed as factors associated with the yield and quality variability to laver culture crop. For simplicity in this presentation, all variables other than acid chemicals and

---

[2] In this case, output price is known (or non-stochastic) so normalization of profit by output price is convenient for expressing a growers decision problem as a function of moments of the output distribution.

[3] There are a variety of acid chemicals, being used in laver culture farming. They can be categorized into two types of acids, hydrochloric acids and organic acids.

labor are assumed to be applied in an optimal manner. The model can be generalized to allow choice of all variable inputs.

The grower views gross output(Q), damage rate(D), and net output(Q^q) as random variable due to risk and uncertainty surrounding weather conditions and weed intensity during the culturing season. Thus, the laver grower is faced with single means. The probability distributions of the variables are related to the growers decisions. Therefore, the random variables can be defined as follows:

Means: M_1, M_1^q, M_1^d and
Distributions: $Q \sim f(Q|A, L)$
$Q^q, D \sim h(Q, D|A, L)$.

Since $Q^q=Q(1\text{-}D)$, the distribution of Q^q is related to those of Q and D (or V)(e.g., if Q and (1-D) are independent and lognormally distributed, then Q is lognormally distributed. However, it is not easy to assume their independency). It is noted from laver plant biology that the assumption of dependence between Q and D may be reasonable. Laver growth passes through several stages in the course of an entire growth: seedling establishment, vegetative growth, maturing stages all differ in nutrient requirements and susceptibility to weed occurrance. The near-harvesting time is when laver farmers are very concerned with seaweed infestation and when such seaweed infestation affects most seriously yield and quality. Under the jointness of Q and D, we can define the marginal distributions of Q and D as follows:

$$(2) \quad h_1(Q|A, L)= \int h(Q, D|A, L)dD$$

and

$$h_2(Q|A, L)= \int h(D, Q|A, L)dQ$$

However, it is in fact extremely difficult to analyze production decision problems under joint probability distribution of Q and D, and Q is directly affected by D and indirectly through A. Thus, the seaweed problem can be modeled, based on the distribution of Q conditional on inputs:

$$(3) \qquad Q \sim f(Q \mid A, L, D(A))$$

The random variable(Q) is non-negative and lower/upper bounded. Therefore, all moments for variable Q exist and the moments uniquely determine the conditional probability distribution on production inputs. It follows that all economically relevant characteristics of the culture technology must be embodied in the relationships between inputs and moments. Therefore, the laver growers behavior under culture risk can always be defined in terms of the moments of the probability distributions of Q (see Antle 1983b). Since the Q distribution is defined as f(Q|A, L, D(A)) or f(Q|A, L), the moments of Q are expressed as

$$(4)\quad M_1 = \int Q\, f(Q \mid A, L)\, dQ \text{ and}$$

$$M_i = \int (Q - M_1)^i f(Q|A, L)dQ,\ i \geq 2.$$

The yield and the shape characteristics of Q probability distribution (M_1 and M_i, $i \geq 2$) are hypothesized to be of concern to the laver culture farmer because Q is directly related to D and hence to the growers economic returns. The growers decisions on input combinations may result in different probability

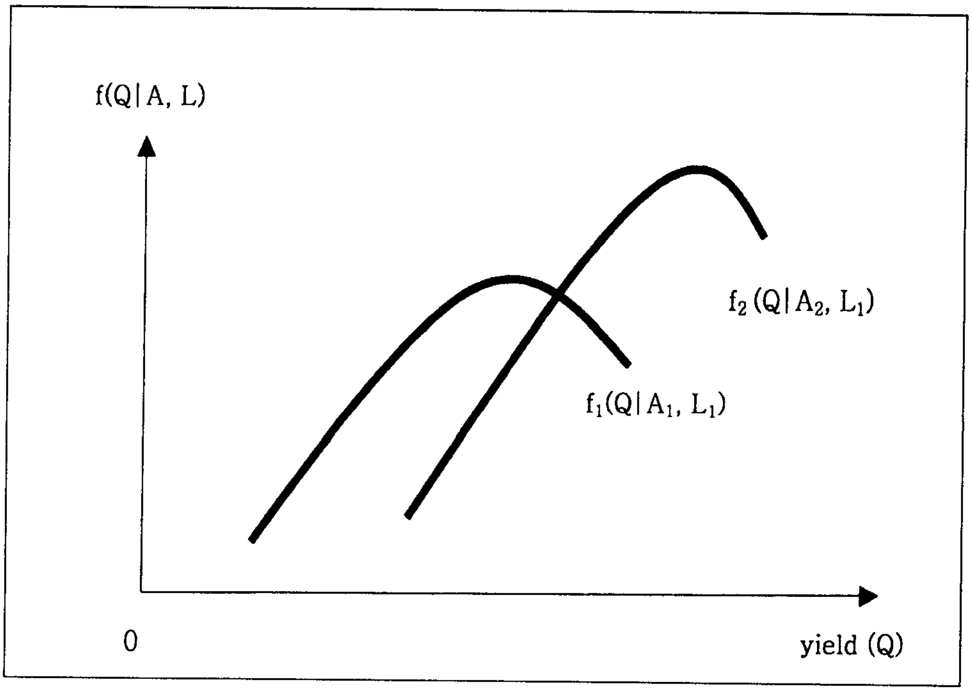

Figure 1 Yield probability distribution with different input combinations[4]

---

[4] A_1 and A_2 are hydrochloric acid and organic acid, respectively. Labor input is held constant in the two different input combinations.

distributions of yield and weed infestation. For example, as shown in figure 1 one input combination (A_1, L_1) can result in a quite different probability distribution of Q from another (A_2, L_1). If input combination (A_2, L_1) is more effective in reducing the variance of Q and cutting off the downside tail of the Q distribution than (A_1, L_1), the grower would choose the seaweed control strategy, which is associated with input combination (A_2, L_1).

Note that by attempting to move the Q distribution towards the right, the grower is cutting off the lower tail of the Q distribution. This kind of behavior (often called aversion to downside risk) has been ascribed to a disaster avoidance motive (Menezes et.al., 1980).

Ⅲ. Analysis of Laver culture Risk

1. Risk as a Cost

Pure risk does not, or need not, have impact of a nature to affect decision-making and input use. Since pure risk involves complete knowledge of the mean and modal outcomes (all parameters or moments of the distribution can be estimated in a statistical sense), losses and gains which grow out of risk phenomena can be incorporated into the laver culture farms cost schedule, and have the bearing on decision-making (Hardy 1931, Greene 1977). For example, if the laver culture farmer loses 1 unit out of each 100, the cost of weed infestation can be added to the cost of the remaining 99 units and the marginal returns from laver culture can be so reckoned. Incorporation of losses growing out of pure risk into the laver culture farms cost structure is possible only in the case of weed infestation or similar phenomena where the number of occurrences is great enough within the laver culture farm that the probability of loss can be established. In some localized areas, storm damage occurs so frequently and regularly (the number of observations is great enough that the mean expected loss can be established for a single culture farm over a short period) that culture farmers simply consider the loss as a cost inherent in the laver culture environment and do not bother to insure. Risk also can be incorporated into the cost structure of the laver culture business even where the number of cases is not great enough to allow prediction of loss on the nature of a uncertainty for a single laver culture farm.

2. Measuring Degree of Risk or Uncertainty

Laver culture farmers have definite notions about physical yields. The manner in which laver culture farmers interpret the degree of risk or uncertainty is difficult to ascertain. Evidently the magnitude of variation in yield is one basis. Another basis is that of loss: enterprises, which result in frequent losses, are looked upon as being more risky or uncertain than those which less frequently result in losses (even though variability may be greater for the latter). From the study conducted on expectations and uncertainty the researcher is prone to believe that laver culture farmers do associate risk and uncertainty with historic parameters of yield distributions. There is evidence that the past forms an important foundation upon which expectations of the future are based (see Heady 1952).

Because the concept of degree of uncertainty is important for planning purposes, it is useful to examine the characteristics of probability distributions, which may suggest the degree of uncertainty (or, conversely, the degree of confidence), which surround yield expectations. The several parameters of the expected or subjective probability distributions can serve as important measure of uncertainty.

One measure of uncertainty for a subjective probability distribution is the dispersion of expectations. In a statistical context dispersion may be represented as the variance, standard deviation, or range of expected values. If the dispersion, range, standard deviation, or variance of expected yield for a laver culture crop is zero, the culture farmer is certain about its estimate of yields: his expectation is single valued since he considers that only one yield is possible. If the dispersion of expected outcomes is very great, anticipations are multi-valued and the degree of uncertainty, in the mind of the laver culture farmer, is very great. The skewness of the dispersion of the distribution may also reflect the degree of uncertainty or loss prospects. Skewness indicates whether the various possible expected yields are arranged symmetrically about the mean or are dispersed in some uneven or asymmetrically manner. The Kurtosis (degree of peakedness of flat-toppedness of the yield distribution curve) also expresses the degree of confidence in yield expectations (Day 1965).

One point from the discussion above should be emphasized in respect to expectations, subjective probability distributions, and the degree of uncertainty.

The distributions, to the extent to which they are used by laver culture farmers, which characterize expectations do not have the same connotations as empirical distributions which define games of chance, quantitative yield distributions, or sample observations from an existing population of events. The latter phenomena imply repeated trials. Under economic planning and expectations, there may be no opportunity for repeated trials. If the laver culture farmer goes broke, when plans are fashioned on the basis of a subjective probability distribution defining his expectations, he may not be able to obtain funds or capitals to make another trial.

3. Expected Utility Hypothesis

In this study it is hypothesized that the grower chooses production inputs to maximize expected utility of profit. Assume that a Taylors series expansion of the underlying the unknown utility function converges. The Taylors series approximation to the unknown true utility function is used to express the expected utility as a function of moments of profit normalized by output price.[5] Terms beyond those involving the third moment of profit are ignored since they add little precision (Anderson, Dillon, and Hardaker 1977). It is also generally recognized that the first three moments of output distribution may be a basis for ascertaining the degree of production risk and uncertainty (Heady 1952, Kendall and Stuart 1969,[6] Anderson 1974, Roumasset 1976, Antle 1983b, Antle and Goodger 1984).

Letting X and P be input and input price vectors, the average growers decision problem can be written in terms of the mean, variance, and third moment of normalized profit by output price as follows:

---

[5] Anderson, Jock R., John L. Dillon, and Brian Hardaker, Agricultural Decision Analysis, Iowa State University Press, Iowa State, pp. 91-94, 1977. Park, Seong K., Econometric Measurement of Pest Management Technology: Risk and Economics of a Worm Monitoring Program for Processing Tomato Production in the Sacramento Valley, University California, Davis, Ph.D. Dissertation, 1985.

[6] Kendall and Stuart(1969) suggest that 「Probability distributions which have a finite number of the lower moments in common will, in a sense, be approximations one to another. We shall encounter many cases where, although we cannot determine a distribution function explicitly, we may ascertain its moments at least up to some order: and hence we shall be able to approximate to the distribution by finding another distribution of known form which has the same lower moments. In practice, approximation of this kind often turn out to be remarkably good, even when only the three or four moments are equated.」

$$(5)\qquad \max EU(\Pi)=U[(M1(X)-W\cdot X),\ M_2(X),\ M_3(X)].$$

Note that M_i, $i = 2, 3$ are the moments of Q since $\Pi = Q-WX$ and thus $(\Pi\text{-}E(\Pi))^i = (Q-M_1)^i$, $i = 2, 3$.

First order conditions for maximizing expected utility are obtained by taking the derivatives of equation (5) with respected to the decision variables and setting the results equal to zero :

$$(6)\quad U_1[dM_1(X)/dX_k]-P_k]+U_2[(dM_2(X)/dX_k)]+U_3[(\ dM_3(X)/dX_k)]=0$$

where U_i is partial derivatives with respect to moment i. Dividing both sides by U1 and transferring P_k to the right hand side, we have

$$(7)\qquad (dM_1/dX_k)+(U_2/U_1)(dM_2/dX_k)+(U_3/U_1)(dM_3/dX_k)=P_k.$$

Multiplying both sides by X_k/M_1, equation (7) can be rewritten in terms of moment elasticities:

$$(8)\qquad n_{1k}+(U_2/U_1)(M_2/M_1)n_{2k}+(U_3/U_1)(M_3/M_1)n_{3k}=(P_kX_k)/M_1$$

where $n_{ik}=(dM_i/dX_k)(X_k/M_i)$, $i=1, 2, 3$.

Equation (8) is the condition for optimal input decisions (on weed control) and can be used to analyze decision-making under laver culture risk. (U_2/U_1) and (U_3/U_1) can be interpreted as Pratts (1984) absolute risk aversion coefficient (r^*) and down- side risk aversion coefficient (r^*), respectively. The terms nik, ($i=2, 3$) denote the marginal impact of input k on moment i. Determination of the sign and magnitude if nik is an empirical question. The expression $[(U_2/U_1)(M_2/M_1)]n_{2k}$ represents marginal adjustment to variance and $[(U_3/U_1)(M_3/M_1)n_{3k}]$ denotes marginal adjustment to skewness (or downside risk) at the optimum. Thus, $[(U_2/U_1)(M_2/M_1)n_2k+(U_3/U_1)(M_3/M_1)n_{3k}]$ is the total marginal risk adjustment factor in equilibrium. These imply that at the optimum the value of expected marginal product, after risk adjustment, is equal to the relative factor share. If a grower is risk-neutral, the relative factor share will be equal to the production elasticity with respect to input k (i.e., in equation (7) the value of expected marginal product equals marginal factor cost). A risk averter taking into account the mean and variance of Q will choose inputs such that the first two terms on the left-hand side of equation (8) equal the right-hand side, while a downside-risk averter will employ production inputs in equilibrium by setting all three terms equal to the relative factor shares.

The sum of two terms involving the derivatives of the second and third moment with respect to input k on the left-hand side of equation (7) is the maximum monetary value which a grower would be willing to pay in order to get the value of expected marginal product, dM_1/dX_k, at the optimum. This is equivalent to the value of input k applied for insurance purpose, compared with risk neutrality. Therefore, the quantity $[dM_2(X)/dX_k+dM_3(X)/dX_k]$ can be interpreted as marginal risk premium. Its magnitude depends on r^*, r^{**} and $dM_i(X)/dX_k$, $i=1, 2, 3$. Equation (8) can be interpreted in the same way. If organic acid and HCL treatments yield the same expected profit, the laver culture farmers would prefer to choose the weed prevention method incurring smaller risk premium.

In laver propagation most input X_k's are determined in the early culture stage. However, chemicals play a role as an intermediate input due to weed occurrences associated with laver growth stages. Both weed infestations and laver growth are influenced by random events such as weather conditions occurring over the growth stages. This leads growers to choose chemicals sequentially over laver growing stages and as a result chemical input becomes an endogenous variable (see Antle 1983a for detailed discussion of this issue).

Ⅳ. Policy and HCL Use on the Intensive Margin[7]

1. Impacts of HCL Use on Welfare

The discussion will be focused on chemical input (X=HCL) use at the intensive margin. Here laver culture ground is assumed to be constant so the distribution of environmental attributes also is held constant at the laver culture ground level. The only behavioral response by laver farmers to policy is to adjust input use. Input adjustments, in turn, affect yield and pollution. Because pollution (Z)

---

[7] All policies can be classified into two basic types; (1) those that affect management decisions at the intensive margin, such as a price support that increases chemical use per unit of culture ground, and (2) those that affect management decisions at the extensive margin, such as diversion requirements for participation in a program that affects total culture ground use (see J. M. Antle and R. E. Just, Effect of Commodity Program Structure on Resource Use and the Environment. In Just R. E. and Bockstael N. (eds) Agriculture Management and Economics; Commodity and Resource Policies in Agricultural System, Springer-Verlag, 1990).

is increasing in input use for a given value of the environmental attribute Φ, an increase in mean HCL use causes an increase in mean pollution whether there is a positive or a negative correlation between Φ and HCL. Two types of relationships may exist between the distributions of HCL and Φ and between HCL and Z when a policy change, such as an increase in an input subsidy or an output support price, causes an increase in mean input use. Holding the mean culture ground attribute constant at a certain level, an increase in the input subsidy increases mean input use, increases mean pollution, and the confidence regions shift to the right. Similarly, mean yield is increasing in mean input use.

Social welfare is assumed to be a function of aggregate mean/variance/skewness of laver yield (M1, M2, and M3), input (X), and pollution (Z),

$$(9) \qquad W=W(M_1(X),\ M_2(X),\ M_3(X),\ X,\ Z(X)).$$

Aggregate input use is included in this function, because of the partial nature of the analysis here, to represent the value to society of inputs drawn away from other sectors of the economy. Alternatively, the welfare criterion could be defined as a function of producer surplus, consumer surplus, and benefit of environmental preservation. With either approach, the function could be specified numerically (see Gardner 1990).

Even though there is no culture ground area adjustment at the extensive margin, a policy change can affect welfare through its effects on input use. Assuming appropriate curvature condition to assure a unique global maximum, the socially optimum level of input use can then be defined as x* satisfying

$$(10) \qquad dW/dX=W_{M1}M_{1,x}+W_{M2}M_{2,x}+W_{M3}M_{3,x}+W_x+W_zZ_x=0$$

where subscripted variables denote partial derivatives, and Mi (i=1, 2, 3), X and Z are aggregate mean/variance/skewness of output, mean input, and pollution per hectare. According to this equation, the marginal social benefit ($W_{M1}\ M_{1,x}+W_{M2}\ M_{2,x}+W_{M3}\ M_{3,x}$) is equated to the marginal social cost ($W_x\ W_zZ_x$) at the social optimum level of input use X^*.

As noted, Zx > 0 when the culture ground is fixed. Given their culture ground in laver farming, profit-maximizing culture farmers may use inputs so that the value of the marginal product plus marginal culture reduction is equal to the input price, normalized by output price. Thus at the population mean, laver culture farmers tend to overuse the input relative to the social optimum because they ignore the social cost of the pollution they create. In other words, profit-maximizing laver culture farmers behave as if $W_z=0$ (see Corner and Sandler 1986)

2. Laver culture Policy on the Intensive Margin

The demand for inputs is an increasing function of input subsidy and /or output price support, so for a variety of input subsidies, profit maximizing culture farmers increase input per unit of culture ground or facility as the risk reducing input (i.e., organic acids) subsidy (or the output price) is increased. Thus, an input subsidy could lead to the application of more organic acids. And less inorganic acids (i.e., HCL) reduces pollution and moves input use closer to the social optimum X^* defined with less Zx. With a fixed culture ground endowment in laver culture pollution is reduced. Similar conclusions can be drawn for any other kind of policy, such as credits, that effectively lower the price of inputs relative to outputs. Since price or subsidy policies can affect laver culturists production decisions, it should be noted that the government subsidized input (organic acid) price (P_{os}), its market price (P_{om}) and HCL market price (P_{hm}) are relevant input prices for laver culturists decision on the intensive margin. Where the laver farmer j prefers to choose lower price input, profit per unit of culture ground or facility is

$$\pi_j=P \cdot Q_J \ \min(P_{os},\ P_{om},\ P_{hm})X_j. \tag{11}$$

Since the laver culture farmers input decisions depend on the P_{os}, P_{om}, and P_{hm}. If the government subsidized prices of organic acids are higher than or equal to HCL price and they are equally effective, P_{os} may not play an effective role in laver culture farmers chemical input decisions. Rather, they may exacerbate marine environmental problems on the intensive margin because of their choosing HCL.

V. Concluding Remarks

A large number of fishing households in the Korean peninsula have long been associated with laver culture farming. Every year laver cultivation without introducing any other culture practices such as rotation have caused many serious problems which lower yield and quality. In addition, the problems make laver culture farmers face continuous production risks and variabilities. In order to reduce or avoid such culture risks, laver culture farmers have to necessarily use toxic chemicals (e.g., HCL). HCL problems come from its following characteristics: (i) it is very difficult to be decomposed in the natural condition, (ii) it has a long residence time in laver and ocean environment and (iii) it has higher specific gravity than water (so it is easily deposited at the sea bottom).

Losses and gains which grow out of risk phenomena in laver culture can be incorporated into the laver culture farms cost calculation, and have the bearing on decision-making. The sum of two terms involving the derivatives of the second and third moment with respect to input k on the left-hand side of equation (7) is the maximum monetary value of expected marginal product, dM_1/dX_k, at the optimum, This is equivalent to the value of input k applied for insurance purposes, compared with risk neutrality. Therefore, the quantity $[dM_2(X)/dX_k+dM_3(X)/dX_k]$ can be interpreted as marginal (symmetric and downside) risk premium. Their magnitudes depend on risk aversion coefficients (r^*, r^{**}) and $dM_i(X)/dX_k$, $i = 1, 2, 3$. Equation (8) can be interpreted in the same way. If organic acid and HCL yield the same expected profit, the laver growers would prefer to choose the weed treatment chemical incurring smaller risk.

In laver culture most inputs are determined in the early culture stage. However, chemicals play a role as an intermediate input due to weed occurrences associated with laver growth stages. Both acid chemical input use due to weed occurrences associated with laver growth are influenced by random events such as weather changes over the growth stages. This leads laver culture farmers to choose chemicals sequentially and as a result chemical input (i.e., HCL) becomes an endogenous variable.

Since price or subsidy policies can affect laver culture farmers production decisions, it should be noted that the government subsidized input (organic acid: OA) price (P_{os}), its market price (P_{om})and HCL market price (P_{hm}) are relevant chemical input prices for marine farmers decisions on the intensive margin. If the government-subsidized price for OA is higher than HCL price, W_{os} may not play an effective role in laver culture farmers input decisions. Rather, it may increase HLC use and thus may exacerbate ocean environmental problems on the intensive margin unless there is a policy sufficiently discouraging toxic chemical use such as hydrochloric acid (HCL).

For sustaining the Korean laver industry and at the same time conserving marine environment, HLC use in laver culture farming should be banned as DDT in agricultural production. Instead, other chemical use (e.g., organic acids) or environmentally sound culture practices (e.g., rotation) should be encouraged through incentive policies such as input subsidies for laver culture farmers or tax exemption for organic acid manufacturing firms. Also, the monitoring and public extension activities should be reinforced.

References

Anderson, Jock R., John L. Dillon, and B. Hardaker. Agricultural Decision Analysis. The Iowa State University Press, 1977.

Anderson, Jock R. Sparse Data, Climate Variability, and Yield Uncertainty in Response Analysis. *Amer. J. Agr. Economics*, 56(1974): 77-83.

Antle, J. M. Sequential Decision Making in Production Models. *Amer. J. Agri. Economics*, 65(1983a): 282-290.

———. Testing the Stochastic Structure of Production: A Fiexble Moment-Based Approach. *J of Bus. And Econ. Statistics*, 3(1983b): 192-201.

Antle, J. M. and W. J. Goodger. Measuring Stochastic Technology: The Case of Tulare Milk Procuction. *Amer. J. Agri. Economics*, 66(1984):342-350.

Antle, J. M. and R. E. *Just. Effects of Commodity Program Structure on Resource Use and the Environment, In Just R. E. and Bockstael N. (eds) Commodity and Resource Policies in Agriculture System*. Springer, 1990.

Corners, R. and Todd Sandler. *The Theory of Externalities, Public Goods, and Club Goods*. Cambridge University Press, 1986

Heady, Earl O. *Economics of Agriculture Production and Resource Use*, Prentice-Hall, Inc., 1952.

Gardner, B. L. *Redistribution of Income through Commodity and Resource Policy. In Just R. E. and Bockstael N. (eds) Commodity and Resource Policies in Agricultural System*. Springer, 1990.

Greene, Mark R. *Risk and Insurance*, South-Western Publishing Co. 1977.

Hardy, C, O, *Risk and Risk-Bearing*, University of Chicago Press, 1931.

Kendall, Maurice G. and Alan Stuart, *The Advanced Theory of Statistics(3rd ed.)*.Hafner Publishing Company, 1969

Knight, Frank H. Risk, *Uncertainty, and Profit*. Kelly, 1921.

Martha, Kiley Worthington. The Changing Fortunes of Communities and Livestock: Ecological Agriculture in the Druimghigha Experiment. *Community Development Journal*, 22(1987): 208-218.

Menezes, C., G. Geiss, and J. Tressler. Increasing Downside Risk. *Amer. Econ. Review*. 66(1980): 904-910.

Park, Seong K., *Econometric Measurement of Pest Management Technology: Risk and Economics of a Worm Monitoring Program for Processing Tomato Production in the Sacramento Valley*, University California, Davis, Ph.D. Dissertation, 1985.

Pratt, J. W. Risk Aversion in the Small and In the Large. *Econometrica,* 32(1964) 122-136.

Roumasset, J. A. *Rice and Risk: Decision Making Among Low-Income Farmers* North-Holland, 1976.

Wald, A, *Sequential Analysis*. John Wiley & Son, 1947.

김 養殖에 있어서 酸 利用의 生産危險과 經濟性에 관한 硏究

박 성 쾌*

초 록

본 논문의 목적은 김 양식 있어서 무기산 또는 유기산 사용 문제와 김 양식 어업인들의 생산위험 회피행위를 고찰하기 위한 이론적 틀을 개발하고, 정책함의를 도출하는데 있다. 김 양식의 생산위험 또는 가격위험은 김 양식 어업인들이 직면하고 있는 가장 중요한 의사결정변수라고 할 수 있으며, 특히 문제가 되고 있는 무기산(또는 폐염산) 또는 유기산은 농업에 있어서 농약처럼 김 양식 어업인들이 생산위험을 최소화하기 위한 일종의 보험 생산요소(insurance production inputs)으로 볼 수 있다.

김 양식 어업인들의 생산위험은 평균(1차 적률 mean), 분산(2차 적률 variance), 왜곡도(3차 적률 skewnesss)에 의해 측정될 수 있으며, 특히 김 양식 어업인들은 확률이 낮을지라도 일단 갯병과 잡태(예: 파래 등)가 광범위하고 심각하게 발생하게 되면 생산물의 심각한 질적 저하가 야기된다는 사실을 경험적으로 인식하고 있다. 따라서 김 양식 어업인들은 평균생산뿐만 아니라 생산의 분산과 하향성 확률 분포를 최소화할 수 있는 생산기술을 이용하게 된다. 이러한 김 양식 어업인들의 위험회피행위를 분석하기 위해 기대효용이론을 채택하고, 미지의 貞效川函數를 테일러 시리즈 확장에 의해 3차 적률까지를 근사치로 이용하였다.

이윤에 대한 기대효용 극대화를 위한 1차 최적조건을 구하면, 어떤 酸(무기산 또는 유기산)을 얼마만큼 이용하느냐 하는 문제는 생산량의 분산과 하향성 분포에 대한 김 양식 어업인들의 위험회피계수의 크기와 생산요소의 탄성치에 의해 결정된다. 특히 하향성 위험회피계수가 높고 3차 적률에 대한 생산요소 酸의 탄성치가 클 경우 김 양식 어업인들은 하향성 위험을 줄이기 위해 상대적으로 강력하고 가격이 저렴한 酸을 더 많이 이용하게 된다. 또한 두 가지 산의 효과가 같다면 무기산/유기산의 시장가격과 정부 酸 가격 정책이 김 양식 어업인들의 酸 종류 선택과 사용량 결정에 유의한 영향을 미치게 될 것이다.

무기산의 사용이 광범위하고 집약적으로 이루어질 경우 김 양식부문에서 폐공업용 염산 이용에 의한 생산위험 감소는 해양생태환경 파괴위험 증가로 이어질 수 있으며 여기에 바로 정부 酸政策의 딜레마가 있다. 따라서 김 양식의 생산성 증대와 환경보전의 균형 유지에 대한 확고한 정책목표가 필요하며, 이러한 정책목표가 흔들릴 경우 酸 문제에 대한 정부정책은 생산성 증대와 환경보전 어느 한쪽 부문에 심각한 왜곡현상을 초래할 수 있다.