Production and Economic Factor Analysis for the Low Input Sustainable Agriculture(LISA) of Red Pepper

Hwang Young-Hyun* · Choi Jung* · Kim Chung-Sil* and Kim Byung-Do**

〈CONTENTS〉

ABSTRACT

The total amount of dry matter for the green manure crops was great wheat〉 rye〉 barley〉Italian ryegrass in that order. The green manure crops were verified to have the reducing effect of injury of successive cropping in pepper, mainly reducing the occurance of the most important pepper disease, *Phytophthora capsisi,* and enhancing the pepper quality in the fruit length and diameter. The direct seeding using current commercial pepper variety was proved as not economical one.

In the first year of compost application, the growth and yield of red pepper were rather somewhat decreasing compared with those of check plot applied with organic fertilizers. Compost application increased the content of organic matter in soil, which suggested compost could be applied for the sustainable purposes.

In preference analysis about taking the new technique, the smaller farmer's cultivation area the more they wanted to accept the LISA. In the economical and technological fator analysis, the LISA farming, compared with the conventional one, could be possible to save 12% in the inorganic fertilizer expenses but wasted 412% ant 163% in both organic fertilizer and operator labor expenses, respectively. At the same time, the LISA decreased 16% in production cost but increased 225% and 139% in organic fertilizer

*College of Agr., Kyungpook National University, Taegu 702-701, Korea.
**College of Natural Resources, Youngnam University, Kyungsan 712-749, Kyungbuk, Korea.

quantity and operator labor hours. Since there was a great deal of difference in technological and economic factors from two farming methods, LISA multi-goal decision modeling is further required.

Key Words : Pepper, LISA, Green manure crops, Composts, LISA modeling

I. INTRODUCTION

The relative low yield of red pepper crop in Korea is mainly attributed to the long been lasted traditional poor cultural methods since 17 centuries (Kim et. al, 1968). Because the income from the pepper cropping is relatively high compared with other competitive upland crops, all the peppers are cultivated as continuous cropping with large amount of fertilizer application. When a single crop is continously cultivated in a soil, necessary elements, especially the micro elements which are unique to the crop are apt to be deficient(Arima, 1985). At the same time, it encourages the hamful diseases and pests(Bhowmik and Doll, 1982, Cochran et. al, 1982, Craig and Frank, 1980), and also brings the different soil response caused by the changes in physical and chemical properties of the soils. In the upland soils of continuous cropping, many kinds of salts are accumulated(ASI, 1988) and every sort of factors can bring the combined inhibiting phenomenum of crop growth(Matchkuchi, 1987). The disorder of continuous cropping will bring not only the reduction of disease resistance also quality deterioration and unstable productivity(Hori, 1986). It is ture that the counter- measures of reducing the disorder of continous cropping of hot pepper is urgently needed because the disorder of continous cropping is gradually increasing due to the concentrated use of upland soils in the major red pepper producing area. The continous nurient supply is necessary in pepper crops because it is a crop needed much fertilizers and has long growing periods.

The application of compost could give more effect on the yield and the quality of crops(ASI, 1988). Compost should be applied onto cultural soils in order to produce the high quality of agriculture products as well as to reduce fertilizer and pesticide pollution. It is well-known that compost is an excellent soil conditioner improving physio-chemical properties of soils.

For the reasons, pepper needs additional fertilizers which is practically impossible because nearly all of pepper is cultivated with polyethylene firlm mulching(Kim et. al,

1968). When pepper is grown without additional fertilization, yield is greatly reduced by the falling of flowers and fruits(Lee et. al, 1987, Matchkuchi, 1987). Therefore, these problems can be recovered by the application of enough composts which contain all kinds of nutrients, complements, and the high water and fertilizer holding capacity. At the same time, composts are generally degraded slowly and enhancing the soil temperature by suppling the nutrients for a long time(Hori, 1986). The application of compost leads to recover the soil fertility by returning the organic matters to the soils and, at the same time, can be one of the most effective way of sustainable agriculture reducing the dependance of agriculture on other inputs such as protectants and fertilizers by circulating the sub-materials produced in the agro-ecosystems.

The rotational cropping known as a countermeasure of the injury of sucessive cropping is not only protect the disease increase but also enlarge the soil-microbial population and be much helpful to prevent the adverse effect to the crop roots by intensifing the antagonistic interaction of soil-microorganisms(Ishigawa et. al, 1971). Kim and Lee(1992) reported that the leaving of crop residues on the soil surface decreased remarkably the amount of fungal population in the soils, especially in hot-pepper crop. Meyer et. al(1986) reported that bacteria, actonomycetes, and fungi which inhabitate around the crop root systems can affect the absorbing ability of nutrients and water for the crops, especially by the amount of fungi(Domergues et. al, 1978) because its total amount is relatively great over that of bacteria and actonomycetes(Lynch and Panting, 1980).

Although the productivity in organic farming was much less than that in conventional farming, the management income was almost the same in both farmings(Kim, 1977). High positive correlation was recognized between the preference of organic framing and the farmer's school career(Kin & Kim, 1993) and between that and the size of farm land(Kim, 1996).

The objective of this study was to develop the LISA(Low Input Sustainable Agriculture) modeling of red pepper based on soil improvement by the selection of appropriate green manure winter crops which will reduce the injury of successive croppings, the evaluation of the effects of compost application, and pilot pepper farm survey.

Ⅱ. MATERIALS AND METHODS

1. Effect of green manure on the growth and yield of pepper

This experiment was carried out at Youngyang-eup, one of the most famous pepper producing areas in Korea. The green manure crops tested in the experiment were milk-vetch (*Astragalus sinicus* L.), rye(*Secale cereale* L.), wheat(*Triticum aestivum* L.), barley(*Hordeum vulgare* L.), and Italian ryegrass(*Lolium spp.*). The major cultural practices of green manures including of pepper are shown in Table 1. Twenty five tons of compost/ha were applied to the pepper fields before ploughing as farmers in the area. The transplanted pepper was shown in seedling pots on Feb. 14 in the heated green house and transplanted on May 6 in the fields. Nitrogen as form of urea and potasium were split applied both in basal and additional ones. The basal fertilization were made with 100kg of urea and 50kg/ha of potassium. The 3 times of additional ferlization was made ; 60kg of urea and 30kg/ha of potassium per each time were fertilized at 20, 50, and 80 days after transplanting, respectively. The growth and yield of green manure crops was measured on May 6 and pepper was harvested at 3 times, September 5, 20, and October 20. The growth of peppr trees were measured after the fruit harvest. The experimental plot was layed out in completely randomized block design with 3 replications.

Table 1. Planting dates, planting densities, and fertilizer application for the selection of green manure crops

Crops	Planting date	Planting density	Fertilizer* $N-P_2O_5-K_2O$/ha	Manure (t/ha)
Pepper : Direct seeding	April 23	60 x 30cm	190 -110 -150	25
Transplanting	Feb. 14	75 x 30cm	190 -110 -150	25
Milk-vetch	Oct. 27	40 dl/ha	190 -110 -150	
Rye	Oct. 27	100 kg/ha	100 - 80 - 80	
Wheat	Oct. 27	120 kg/ha	60 - 50 - 50	
Barley	Oct. 27	140 kg/ha	60 - 50 - 50	
Italian reygrass	Oct. 27	200 l /ha	200 -100 -100	

2. Effect of compost on the growth and yield of pepper

The chemical properties of the soil and the compost used are shown in Table 2. The field plots were treated with 3 levels of the compost ; 10, 20, and 30 t/ha with basal fertilizers at the rate of 120(N) : 100(P_2O_5) : 120(K_2O) kg/ha. The plot of control was

treated with only chemical fertilizers at the rate of 240(N) : 200(P_2O_5) : 230(K_2O) kg/ha. The experimental plots were layed in completely randomized design with 3 replications. Analysiss of soil, plant and compost were performed by the method of Agricultural Sciences Institute(ASI, 1988)

Table 2. Chemical properties of the compost and soil used

Sample	pH	EC (ds/m)	T-N (%)	Av.P_2O_5 (mg/kg)	O.M (%)	Ex.-Cations(cmole/kg)		
						K	Ca	Mg
Soil	6.3	2.65	0.3	167	1.32	0.43	6.87	2.88
Compost	7.0	2.43	0.8	2,712	24	1.25	5.12	1.33

3. Analysis of management and economic factors for LISA

The field survey for 36 red pepper LISA farms in Youngyang county in Kyungpook Province was made from July 1 to Setember 15 in 1996. The results of management and economic factor analysis were made by both inquiry forms and direct visit to the farms. The inquiry forms included the present status of LISA and major obstacles of LISA pepper farms, the comparison of productivity for the conventional vs LISA, and the econmic analysis LISA farms of pepper.

Ⅲ. RESUTLS AND DISCUSSION

1. Effect of green manures on the growth and yield of pepper

1) Growth and yield of green manure crops

One of the green manure corps out of 5 tested crops, milk-vetch was completely winter-killed though the temperature during the winter was more or less than that of normal year, thus vetch was inferred to be impossible to be grown in the area. The relative dry weight for the rest of 5 green manure crops tested was higher in rye>wheat> barley > and Italian ryegrass in that order. The fresh and dry weight of rye were 40.2 and 4.1 ton/ha, respectively.

Table 3. Comparison of growth characters of different kind of winter crops.

Kind of winter crops	Plant height (cm)	Branch number	Upper parts		Underground parts		Total dry weight (t/ha)
			Fresh weight (t/ha)	Dry weight (t/ha)	Fresh weight (t/ha)	Dry weight (t/ha)	
Milk-vetch	-	-	-	-	-	-	-
Rye	86.2	4.9	40.2	4.08	5.39	1.35	5.42
Wheat	51.0	4.6	22.8	3.31	6.07	2.38	5.70
Barley	43.9	4.0	10.5	1.40	2.11	0.36	1.77
Italian ryegrass	17.4	4.3	0.4	0.04	0.22	0.04	0.08
L.S.D.(5%)····· .	8.0	0.9	5.95	1.42	2.97	1.24	1.24

2) Effect of green manure crops

(1) Degree of diseases

The most torublesome disease of pepper, *Phytophthora capsisi*, is significantly decreased by pre-cultivated green manure crops as shown in Table 4. On the contrary, the degree of virus showed somewhat higher, but not significantly, in the plots of green manure crops. The rest of important pepper diseases such as white leaf spot, ripe rot, and black mold did not show any difference between the check and the green manure plots. In a word, the disease occurance was not affected by pre-cultivated green manures but phytophthora blight which is the most important pepper disease was greatly decreased. Hwang and Kim(1995) also pointed out that *Phytophthora capsisi* was greatly reduced by non-host crop such as peanut, sesame, onion, and welsh onion. The control mechanism by non-host crops was the inhibition of mycelial growth, sporangium formation, and zoospore release of *Phytophthora capsici*(Lee et. al, 1990, Lee et. al, 1991).

Table 4. Comparison of degree of diseases for the different kind of winter crops.

Green manure crops	Degree of diseases (0 - 9)				
	White leaf spot	Ripe rot	Virus	Phytophthora blight	Black mold
Check	9.0	0	1.7	4.7	1.0
Rye	9.0	0	2.3	2.0	1.0
Wheat	9.0	0	3.0	1.3	0.7
Barley	9.0	0.7	2.7	2.7	1.7
Italian ryegrass	9.0	0	3.3	2.0	1.7
L.S.D. (5%)····· .	0	0.4	1.6	1.8	1.6

(2) Fruit yield of pepper

No significant diffence between the check and the green manure plot in the number of fruits

and fruit yield was recorded(Table 5). But the length and width of fruit were significanltly increased in all plots of green manure crops, especially in the plots of rye and wheat.

Though the fruit yield was not much increased in the first year crop after the green manure cultivation during the winter season, the high quality pepper, longer and heavier fruits but less disease inffected, can possiblly be produced.

Table 5. Comparison of amount of harvested pepper in the different kind of winter crops

Green manure crops	Number of harvested fruits (1,000/ha)	Fresh weight of fruits (kg/ha)	Dry weight of fruits (kg/ha)	Fruit length (cm)	Fruit diameter (cm)	Plant dry weight (kg/ha)
Check	3,087	17,044	6,153	6.1	1.4	247
Rye	2,863	16,647	6,010	8.1	1.6	248
Wheat	3,180	19,433	7,015	8.1	1.7	257
Barley	3,177	19,740	7,126	7.8	1.6	208
Italian ryegrass	3,040	18,397	6,641	7.7	1.6	206
L.S.D. (5%)·····	358	2,776	1,480	0.47	0.19	19.0

(3) Direct planting

One of the most troublesome obstacles in pepper production is high production costs compared with other competing summer corps. Some of the costs are from the transplanting, the suppling of stakes for lodging, and the occasional hand harvesting. To reduce the production costs, the direct seeding of pepper was practiced for the machinary planting in the future. As shwon in Table 6, the direct seeding resulted much poorer fresh and dry pepper yield than the present conventional transplanting and the transplanting after the green-manure crop (rye) cultivation. Therefore, the direct seeding is not advisable unless the proper variety is developed along with the improvement of appropriate cultural practices. The poorer growth and fruit yield of direct seeding compared with those of transplanting was mainly from the shorter growth duration ; the direct planting was made on April 23 while the transplanting was seeded on Feb. 14 in the greenhouse. Lee(1957) practiced the transplanting of direct seeded pepper on April 6 to enhance the growth and fruit yield but made no success. Compared with the direct seeding, primed and pregerminated seed treatment increased the mean rates of emergence in pepper(Sundstrom et al. 1987). Related with the low temperature at early planting time, Choi(1985) reported much varietal differences in low-temperature germinability and better germinability in local collections than foreign introductions.

Table 6. Comparison of pepper yield in different cropping patterns

Cropping pattern	No. of harvested fruits (1,000/ha)	Fresh weight of fruits (kg/ha)	Dry weight of fruits (kg/ha)	Fruit length (cm)	Fruit diameter (mm)	Plant dry weight (kg/ha)
Transplanting with no pre-green manure crop(conventional)	2,810	1,525	639	6.8	1.4	287
Direct seeding	723	290	66	7.2	1.4	74
Rye + pepper transplanting	2,557	1,589	585	7.2	1.6	258
L.S.D. (5%)····· .	610.2	138.4	69.5	0.5	0.2	27.1

2. Effect of compost on the injury of continuous cropping

1) Fruit yield of pepper

The dry weight of matured red fruits per plant in growing period is shown in Table 7. The growth and yield of pepper for the polts of compost were more or less inferior to those of check(inorganic fertilizer) but no significant difference was recorded. But, in general, increasing the application level of compost produced positive effects on dry weight of matured red fruits.

Table 7. Dry weight of matured red fruits per plant in growing period

Amount of compost(t/ha)	Harvesting time					Total
	Agust 16	Agust 23	Sept. 7	Sept. 20	Oct. 5	
			- (g/plant) -			
NPK* + 0	20.4	16.6	13.9	18.5	8.0	77.4
0 + 10	14.7	11.2	12.2	16.0	7.3	61.4
0 + 20	15.9	14.2	14.0	17.3	8.1	69.5
0 + 30	16.8	14.9	15.3	18.7	8.4	74.1
L.S.D. (5%)····· .	3.28	4.77	3.81	1.90	1.04	9.75

* NPK=120(N)+100(P_2O_5)+120(K_2O) kg/ha was applied as basal fertilizer.

2) The change of soil properties

The soil properties after the harvest of plant are shown in Table 8. The organic matter content in soils was found to be higher in the compost plot than the control plot. The chemical properties of soils after the red pepper cultivation were the same in all treatments except the compost plots where there were lower in available phosphate but higher organic matter than the check plot. After the red pepper cultivation, the EC value

was increased from 2.65ds/m to 2.73ds/m in the check plot while it was decreased to 2.25, 2.24, 2.42ds/m in the plots of 10, 20, and 30t/ha of compost, respectively. Dome(1980) and Motoshige & Kiyoshi(1978) also reported the application of organic matter can accelerate the sueful bacterial multiplication, maintain the desity of microorganisms at a certain level, and reduce the fungal invasion. At the same time, it can alleviate the effects of growth inhibitors by enhancing the decomposion efficiency of microorganisms.

Table 8. Chemical properties of soils after the red pepper cultivation

Amount of compost(t/ha)	pH (1:5)	T-N (%)	EC (ds/m)	Av.P2O5 (mg/kg)	O.M (%)	Ex-cation(cmol/kg)		
						Ca	Mg	K
NPK* + 0	6.3	0.25	2.73	252	1.55	6.22	2.58	0.53
0 + 10	6.2	0.24	2.25	137	1.63	6.31	2.53	0.43
0 + 20	6.3	0.24	2.24	146	1.75	6.34	2.43	0.47
0 + 30	6.3	0.26	2.42	157	1.90	6.47	2.51	0.55
L.S.D. (5%)····· .	0.18	0.03	0.62	14.7	0.17	0.51	0.12	0.15

* NPK=120(N)+100(P_2O_5)+120(K_2O) kg/ha was applied as basal fertilizer.

3. Analysis of management result and economic factors

By the management analysis (Table 9), the average total major products, total revenue, intermidiate expenses, operating expenses, average farm income, and added value were 1,654 kg/ha, 20,600 thousand won/ha, 3,303 thousand won/ha, 3,977 thousand won/ha, 16,623 thousand won/ha, and 17,297 thousand won/ha, respectively. The Main indicators such as agricultural income and capital returns, value added were calculated as follows ; 1) agricultural income = total revenue - operation expenses, 2) agricultural capital returns = agricultural income - operator labor expenses, 3) added value = total revenue - intermediate expenses

The total revenue, agricultural income, and added value of LISA farming were 59%, 73%, 60% higher than the conventional farming's, respectively. On the contrary, total major product and agricultural capital returns of hot pepper LISA farming were 16% and 14% lower than conventional farming's, respectively. The expense for the organic fertilizers in LISA was 412% higher than the conventional farming but those of inorganic fertilizers and pesticides for the LISA were 22% and 40% lower than the conventional one, on the contrary. But, operator labour expenses was higher in LISA farming.

Table 9. Management results of hot pepper farming for the LISA husbandries in Youngyang area

Classification	LISA farming[1]		Conventional farming[2]		A/C	B/D
	Quantity (/ha) [A]	Price (1,000won/ha) [B]	Quantity (/ha) [C]	Price (1,000won/ha) [D]		
Total revenue	2,584 kg	20,600	3,810 kg	12,929	0.68	1.59
.Total of major product	1,654 kg	3,303	1,980 kg	12,765	0.84	1.51
.Total of by-products	930 kg	1,300	1,830 kg	164	0.51	7.91
Operating expenses		3,997		2.873		1.38
.Intermediate expenses		3,309		2,112		1.57
Seed	8.6 dl	486	8.6 dl	435	1.08	1.12
Inorganic fertilizer	1,568 kg	272	1,768 kg	350	0.89	0.78
Organic fertilizer	16,286 kg	969	5,014 kg	189	3.25	5.12
Pesticides		157		262		0.60
Fuel·light·motor		205		137		1.49
Material		731		383		1.91
Small farm equipment		121		4		5.23
Machinery depreciation		184		186		0.90
Facilities depreciation		111		117		6.69
Repairs		162		149		1.09
Others		5		-		0.89
.Hiring expenses				-		1.38
.Hiring labour expenses	253	674	338	761	0.75	1.73
Operator labour expenses	4,497	12,406	1,881	10,056	2.39	1.60
Income		16,623		11.817		
Value added		17,297		77.8		
Rate of income(%)		80.7				

Source : 1) Mean values surveyed in this study
2) RDA, 「Standard income of agricultural and livestock products」, 1995

The technological analysis of hot pepper LISA farming and conventional farming is shown in Table 12. The major production of LISA was 16% lower than that of conventional farming. At the same time, the inorganic fertilizer quantity of LISA farming was also 11% lower than conventional farming's. On the contrary, the organic fertilizer quantity expenses and family labor hour was 225% and 139% higher than those of conventional farming. The productivity surveyed from this study was more or less than that of previous one(Kim, 1997).

For the economic factor, there were salient difference between the LISA and the conventional farming in view of the rate of factor costs and the rate of technical substitution.

The major difference of farm income between the LISA and the conventional farming was derived from the difference in the production costs. Therefore, it is required that

technological improvement as well as multi-goal decision making model for the hot pepper LISA farming should be developed to find out the necessary policy program and the optimal input-output level in each farming by decision making model. At the same time, the scientific criteria should be presented to arrange various unscientific technologies for the LISA used by farmers in the major pepper producing areas at present.

Table 10. The principal input-output index of hot pepper LISA farming vs conventional farming

Classification	Hot pepper LISA farming[1)]	Hot pepper conventional farming[2)]	A/B
	Quantity [A]	Quantity [B]	
Major product quantity (kg/ha)	1,654	1,980	0.84
By-product quantity (kg/ha)	930	1,830	0.51
Productivity (kg/ha)	2,584	3,810	0.68
Seed quantity (dl/ha)	8.6	8	1.08
Inorganic fertilizer quantity(kg/ha)	1,568	1,768	0.89
Organic fertilizer quantity (kg/ha)	16,286	5,014	3.25
Hired labor hour (hr/ha)	253	338	0.75
Family labor hour (hr/ha)	4,497	1,881	2.39

Source : 1) Mean values surveyed in this study
2) RDA, 「Standard income of agricultural and livestock products」, 1995

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고추의 LISA 模型開發을 위한 技術·經濟的 要因分析

황영현 · 최정 · 김충실 · 김병도

적 요

고추 연작지에서의 녹비작물의 효과를 구명하기 위하여 자운영을 포함한 5개 녹비작물을 동계간에 재배한 결과 자운영은 월동한 개체가 전연없이 동계간에 모두 동사하였으며 나머지 4종류 녹비작물의 건물중은 호밀〉 밀〉 보리〉 이탈리안 라이그라스의 순이었는데, 호밀의 경우 ha당 건물중이 4.1톤이었다. 녹비작물 재배는 고추의 연작장해, 특히 고추 연작지에서 가장 문제가 되는 고추역병(*Phytophthora capsisi*)의 발생을 경감시키는 효과가 있는 것으로 나타났으며, 果長과 果直徑이 증가하여 고품질의 고추생산이 가능하였다.

1년차로 퇴비만을 시용한 경우 고추의 생육과 수량은 화학비료를 시용한 구에 비하여 떨어지는 결과를 보였으나 퇴비시용량이 증가할수록 그 차이가 줄어들었으며 토양중의 유기물 함량이 높아져 퇴비의 지속적 肥效가 인정되었다.

고추영농의 경우 저투입지속농업(LISA)과 일반관행농업을 비교해 보면, 수익-비용 분석결과를 중심으로 한 주요 경제적요인과 기술적요인 양측 모두 뚜렷한 차이가 있었다. 따라서 LISA에 의한 고추영농을 발전시키려면 단순히 기술진보 뿐만 아니라 다양한 현실적 목표를 조화시킬 수 있는 LISA 고추영농에 필요한 다목표 의사결정모형을 개발할 필요가 있는 것으로 나타났다.