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Greenhouse environments analysis - Distributions and Variations of Temperature, Relative humidity, Illumination, Carbon dioxide and Wind velocity -

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ABSTRACT

For satisfactory greenhouse culture, environmental factors must be kept in proper conditions. Therefore, it is important to know relations between environmental conditions and greenhouse systems. In this study, the environment variations and distributions in different types of greenhouses were measured and analyzed. The elements of environment analyzed were temperature, relative humidity, illumination, carbon dioxide and wind velocity. The analyzed greenhouse types were three different types. One of them, A type, was propagation model type by government and the other one, B type, was multiple continuous arches type which was made by farmers himself. The last one, C type, was single arch type which has no environment control system without manual temperature keeping method. The results of this study can be used for reasonable greenhouse environments managements and control.

Key Words: Greenhouses, Environments, variations, distributions, temperature, relative humidity, illumination, carbon dioxide, wind velocity.

INTRODUCTION

In Korea, the area of the protected horticulture was about 42,500 ha in 1990 and it is increasing tendency for good quality productions. For satisfactory greenhouse culture, environmental factors such as temperature, relative humidity, illumination, carbon dioxide and wind velocity, must be kept in proper conditions. Therefore, it is important to know relations between environmental conditions and greenhouse systems. Concerning to these subjects, there are some papers about modelling and simulation of greenhouse environments(Suh, 1986 and Park, 1986), effectiveness of thermal curtain and cover system(Joel, 1976, Ido, 1980, Pitam, 1989, and Kim, 1991 and 1992), development of thermal storage system in plastic greenhouse(Kim, 1990 and Song, 1991), predicting temperatures in ventilated greenhouse(Walker, 1965), condensation, resultant humidity and its control in greenhouses(Walker, 1968), environment management of protected hoticulture(Mihara Yoshiaki, 1972).

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In this study, the environment variations and distributions in three different types of greenhouses were measured and analyzed for reasonable environments control. The results of this study can be used for the greenhouse building and managements.

MATERIALS AND METHODS

The analyzed greenhouse types were three different types. One of them, A type, was propagation model type by government and the other one, B type, was multiple continuous arches type which was made by farmers himself. The last one, C type, was single arch type which has no environment control system without manual temperature keeping method. The detail specifications of the greenhouses for measurements was shown in table 1.

Table 1. Specifications of greenhouses for measurements

	A type (multi-auto)	B type (multi-regular)	C type (single)
Dimension	5 arches($2375m^2$) 95m * 25m * 6m	5 arches($2375m^2$) 95m * 25m * 4m	1 arches($427m^2$) 95m * 4.5m * 2.15m
Materials	vinyl house	vinyl house	vinyl house
Plants	Denphare(3 yrs) 70,000 plants	Carnation(2 Mons) 30,000 plants	Cumcuber(3 momths) 880 plants
Heater	130,000 * 2 kcal/hr	STC9201 1 unit	None
Thermal curtain	2 layer(inner) 2 layer(upper)	1 layer(inner) 2 layer(upper)	vinyl tunnel + straw mat
CO_2 Generator	LPG 3.8-4.5 kg/hr 2500mmH_2O, 2 units	None	None
Circulating fan	$50m^3$/min *55 units	None	None
Ventilation	Fan 4 units	Window	None
Conputer control system	One system	None	None

The measured greenhouses were located in Chinju city and the environmental factors was measured at 7 a.m.~ 7 p.m., 16. 12. 1992. The specifications of the measuring instruments was showed in table 2. The measuring point was 20 points for temperature, relative humidity, illumination and wind velocity, 5 points for carbon dioxide. The time interval for measurements was about 45 minutes.

Table 2. Specification of measuring instruments

Instruments	Model and Specification
Alcohol thermometer	Hot and wet bulb temperature, Range: -10 - 50 °C Small fan for measuring of wet bulb temperature
Surface thermometer	Model: HIOKI 3412, Range: -50 - 999 °C, Type:K(CA)
Anemometer	Model:Solomat MPM 500e, Range: 0-127 m/s
Lux meter	Model:dm-28, TAKEMURA ELEC., Range:0-500,000 Lux
Sound level meter	CS142C, CASTLE ASSOCIATES, Range:40-120 dB
CO_2 Detector	GASTEC 801, 300-5000(10000 at half stroke) ppm

RESULTS AND DISCUSSIONS

The weather conditions of Chinju city at the day for measurement were as follows: 1) mean temperature -1.0 °C, 2) mean relative humidity 70.3 %, 3) percentage of sunshine 50%, 3) solar radiation 8.38 MJ/m^2/300mins.

Operating situations of the environment control equipments can be summarized as shown in table 3.

Table 3. Operation situations of environment control things on greenhouses

	A (multi-auto)	B (multi-regular)	C (single)
Heater	Off 1 unit 10:00-16:17 1 unit 08:25-17:20	Off 08:58-17:15	NONE
Thermal curtain	Open 09:57-16:10	Open 09:33-15:30	09:17-16:40 Straw mat open 10:30-16:00 Tunnel vinyl open
Circulating fan	10:40-16:10 On	None	None
CO_2 Generator	10:30-10:45 On 11:00-11:15 On	None	None
Window		11:45-14:00 Side windows open	12:53-16:40 upper windows open

The temperature variations from 7:00 a.m. to 7:00 p.m. was shown in Fig.1(a) at the center of the greenhouses. For A type, the temperature range was about 18.5~25.2°C and the difference between maximum and minimum temperature was 6.7°C. For B type, the temperature range was about 12.0~25.0°C and the difference between maximum and minimum temperature was 13.0°C. A type was kept at comparatively small temperature variation range because it had double internal curtains and double vinyl covers for well insulation. For C type, the temperature range was about -4.0 ~29.0°C and the difference between maximum and minimum temperature was 33.0°C. Because of poor insulation, it changed rapidly depending on solar altitude.

The temperature distributions were shown in Fig.1(b)-1(e). For A type at 10:00 a.m. and 14:00 p.m., the distribution ranges were about 18.4~20.8°C and 21.6~24.6°C eachly. For B type, the distribution ranges were about 10.4~16.4°C and 16.5~24.5°C eachly. The differences between maximum and minimum temperature were 2~3°C for A type and 6~8°C for B type. Therefore, it became to know that A type was kept at constant temperature level because of the good insulation and the air circulation fans and also temperature distribution was affected by entrance door position, warm air carrying duct system and direction of greenhouse, et cetra.

The relative humidity variations at the center of the greenhouses was shown in Fig.2(a). The range was 85~100% for A and B type when that of outside air was 50 ~85%. That of A type was lower than that of B type and C type was varied very rapidly depending on time. The relative humidity distributions were shown in Fig.2(b)-2(c). The distribution ranges at 10:00 a.m. were about 92~93% and 96~99% for A type and B type. For C type, the difference between maximum and minimum relative humidity was 15%. These were depending on heat and water balances and existance of circulating fans, et cetra. According to the data, A type was desirable for environment control.

The carbon dioxide variations at the center of the greenhouses was shown in Fig.3. The carbon dioxide contents in greenhouse is recommended to be 3~5 times of contents of outside air according to the Office of Rural Development (1992). The range was 500~1000ppm for A and B type when that of outside air was 300~400ppm. For A type, two carbon dioxide generators were operated during 10:30~10:45 and 11:00~11:15 a.m.. For B type, about 20 tons of leaf mold was buried in the bottom of greenhouse. And for C type, the range was 950~2200ppm because straw was buried in the bottom and the dimension of cave was 30 cm of depth and 30 cm of width. Especially it became very high near 11:00 a.m. because the tunnel vinyl was openned at 10:30 a.m. According to the data, carbon dioxide generator has to be used for A type regularly.

The illumination variations were shown in Fig.4. That of the outside was up to 60000 Lux and about 50000 Lux for C type which had only one vinyl cover. For A and B type that had two vinyl covers, it reached 40000 Lux which was about 33% reduction value comparing to that of outside. The reduction will be increasing depending on time because of dust and contaminations, et cetra. Therefore the cover materials and the structures has to be checked regularly and developed.

The wind velocity distribution at 12:00 a.m was shown in Fig.5(a)-5(b). For A type, the range was 0.1~0.22 m/s and over 0.22 m/s at right hand side of the

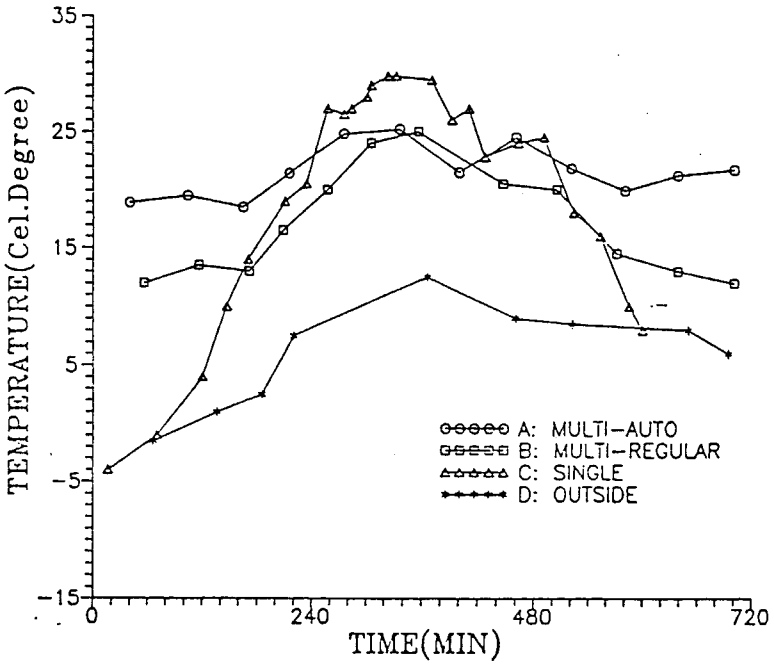

Fig.1(a) Temperature history of greenhouse depending on time from A.M.7:00

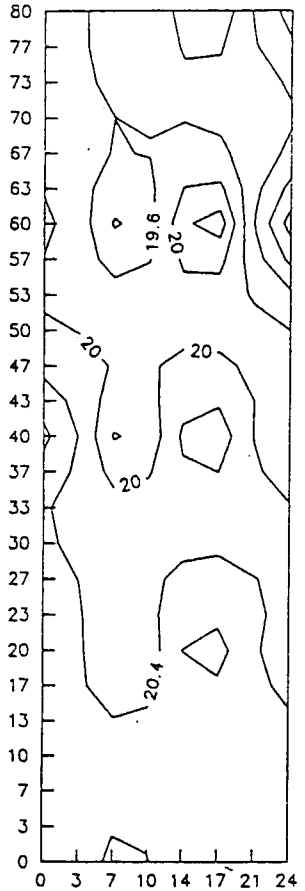

Fig.1(b) Temperature distribution in the A type(multi-auto) greenhouse at 10:00

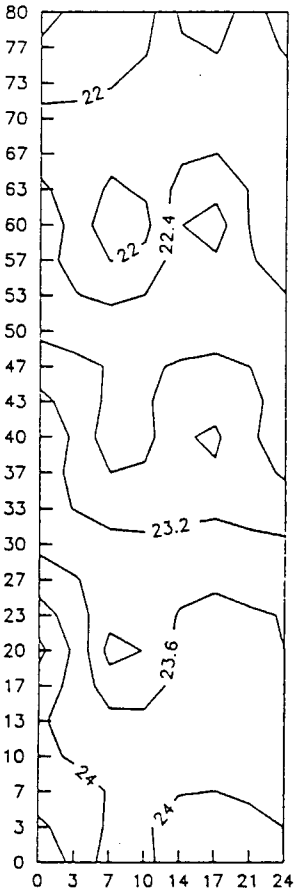

Fig.1(c) Temperature distribution in the A type(multi-auto) greenhouse at 14:00

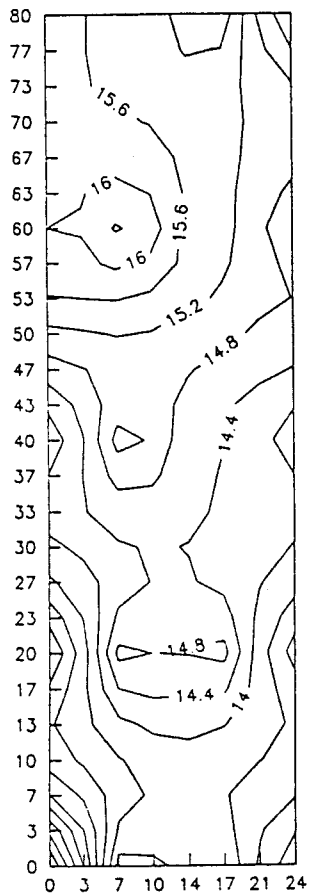

Fig.1(d) Temperature distribution in the B type(multi-regular) greenhouse at 10:00

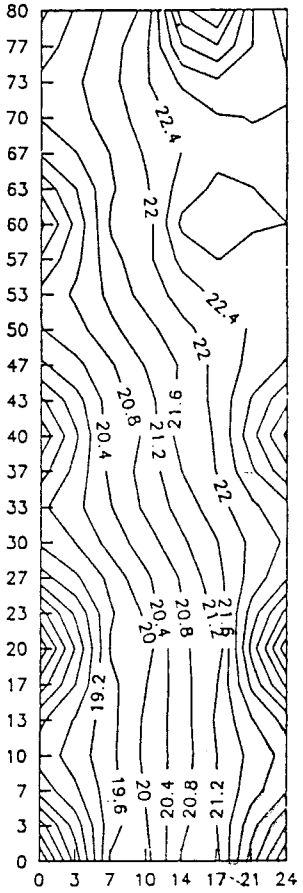

Fig.1(e) Temperature distribution in the B type(multi-regular) greenhouse at 14:00

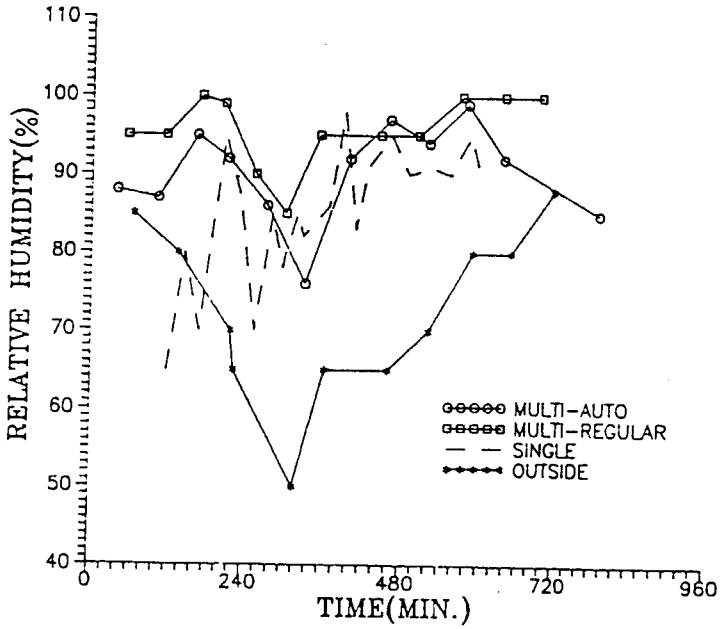

Fig.2(a) Relative humidity history of greenhouse depending on time from A.M. 7:00

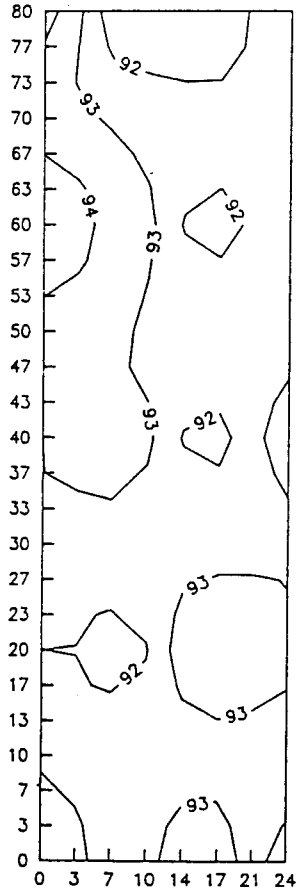

Fig.2(b) Relative humidity distribution in the A type(multi-auto) greenhouse at 10:00

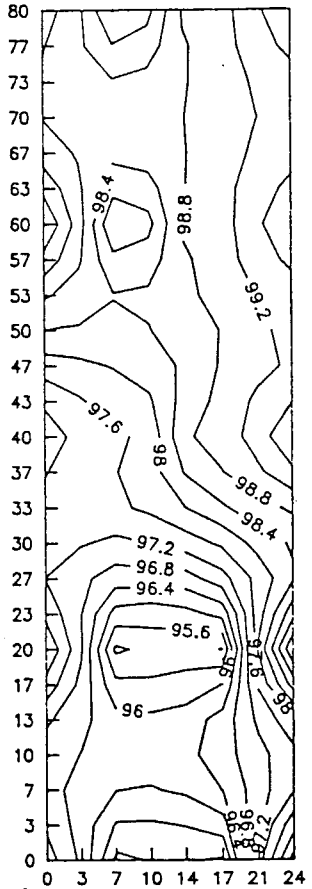

Fig.2(C) Relative humidity distribution in the B type(multi-regular) greenhouse at 10:00

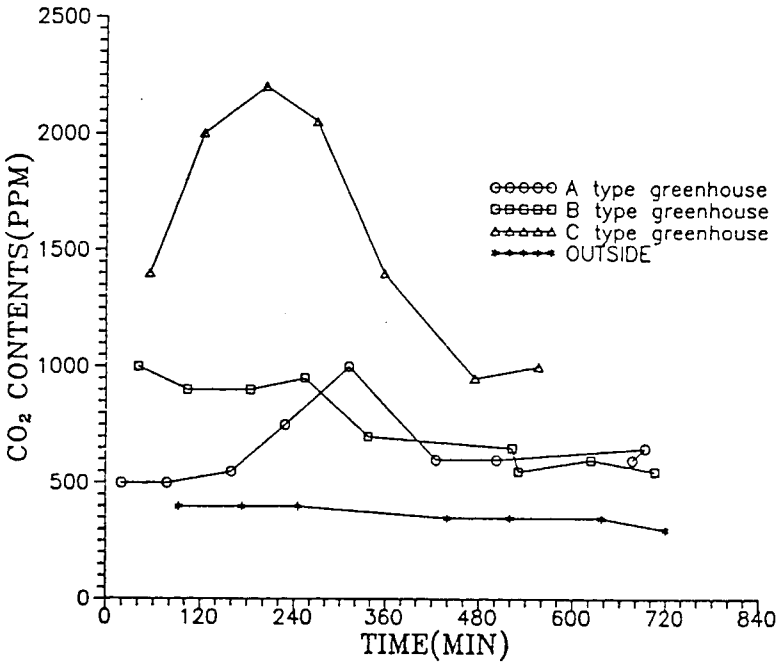

Fig.3 CO_2 CONTENTS history of greenhouse depending on time from A.M. 7:00

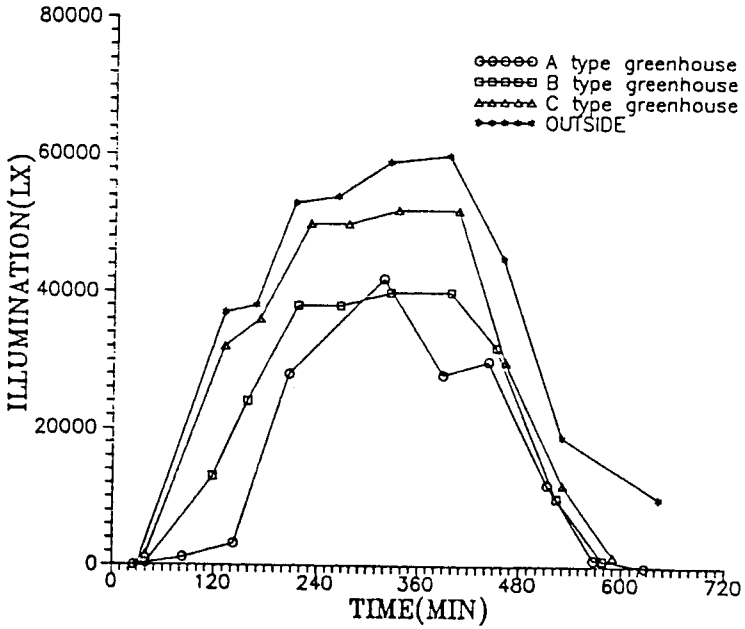

Fig.4 History of the intensity of illumination at the center of the greenhouse from A.M. 7:00

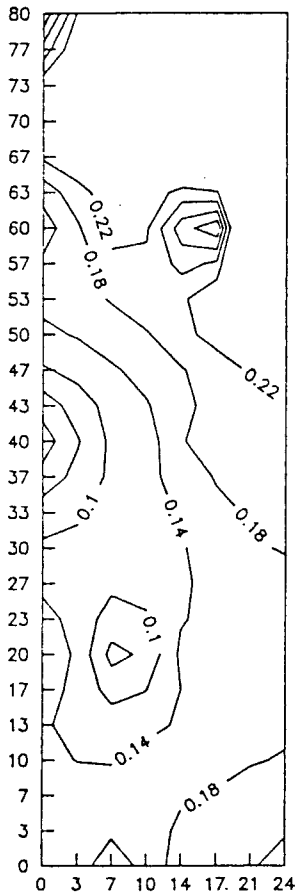

Fig.5(a) Wind velocity distribution in the A type(multi-auto) greenhouse at 12:00

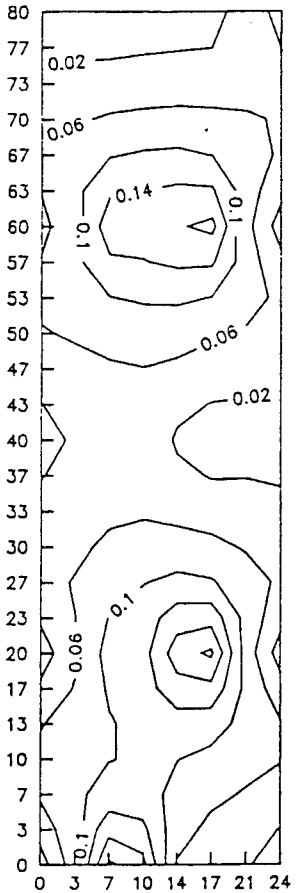

Fig.5(b) Wind velocity distribution in the B type(multi-regular) greenhouse at 12:00

upper part of greenhouse because the entrance door was positioned at that area. And wind direction was inclined because 55 fans were operated to the inclined direction. Therefore the wind direction of the fans have to be changed for being equalized wind velocity. Comparatively the air flow in B type was lower and it was up to 0.14 m/s.

CONCLUSIONS

Among three different type greenhouses, the propagation model type by government was in best environmental conditions. But it has to change the wind direction of the air circulation fans and use carbon dioxide generator.

REFERENCES

1. Ido Seginer, et al. 1980. Rational operation of greenhouse thermal curtains. TRANSACTIONS of the ASAE 23:1240-1245
2. Joel C.Simpkin, et al. 1976. Reducing heat losses in polyethylene covered greenhousees. TRANSACTIONS of the ASAE. NO.19(4):714-719
3. Kim, S. T., et al. 1992. Experimental study on thermal curtain of agricultural structures. J. of Gyeongsang Nat. Univ., 31(1):153~165.
4. Kim, Y. B., et al. 1991. Effectiveness analysis of thermal curtain characteristics on greenhouse heating loads. J. of Gyeongsang Nat. Univ., 30(2):141~148.
5. Kim, Y. B., J. C. Park and Y. Paek. 1993. Experimental analysis for environments variations of greenhouses. J. of the KSAM. 18(1):60~70.
6. Kim, Y. H., H. K. Koh and M. K. Kim. 1990. Development of thermal storage system in plastic greenhouse(I). J. of the KSAM. 15(1):14~22.
7. Mihara Yoshiaki. 1972. Environment management of protected hoticulture.
8. Park, J. B. 1986. Analysis of solar radiation and simulation of thermal environment in plastic greenhouse. Seoul Nat. Univ. Ph.D. Thesis.
9. Pitam Chandra and L.D.Albright 1989. Analytical determination of the effect on greenhouse heating requarements of using night curtains. TRANSACTIONS of the ASAE 23(4):994-1000
10. Suh, W. M. 1986. Modelling of a greenhouse equipped with a solar rocked system and with carbon dioxide enrichment. Doctoral thesis. KANSAS STATE UNIV.
11. Suh, W. M., Y. B. Min and Y. C. Yun. A study on the development of greenhouse temperature control system by using micro-computer. J. of the KSAM. 15(2): 134~142.
12. Song, H. K., Y. S. Ryou, Y. B. Kim and Y. H. You. 1991. Greenhouse heating characteristics of solar energy-latent heat storage system. Research reports of ITERA. 7(1):79~132.
13. The Office of Rural Development. 1992. House automation.
14. Walker, J. N. 1965. Predicting temperatures in ventilated greenhouse. TRANSACTIONS of the ASAE 8(3):445-448
15. Walker, J. N., et al. 1968. Condensation and resultant humidity in greenhouses during cold weather. TRANSACTIONS of the ASAE 11:263-266
16. Walker, J. N., et al. 1968. Control of high humidity in greenhouses during warm weather. TRANSACTIONS of the ASAE 11:267-269