

## REFERENCES

- Allen, A.K., Neuberger, A., and Sharon, N. 1973. The purification, composition and specificity of wheat germ agglutinin. Agglutinin. Biochem. J. 131:155-162.
- App, A., Watanabe, I., Alexander, M., Ventura, W., and DeDatta, S.K. 1978. Agron. Abstr. p. 149.
- Bohoöl, B.B., and Schmidt, E.L. 1974. Lectin : a possible basis for specificity in the *Rhizobium* - Legume root nodule symbiosis. Science, 185:269-271.
- Boonjawat, J., Pongsawasdi, P., Bhusawang, P., and Vilaipon, N. 1982. Paddy nitrogen:rhizosphere nitrogen fixation. International Seminar on Productivity of soil ecosystem.
- \_\_\_\_\_. J., Chaisiri, P., Limpananont, J., Soontaros, S., Pongsawasdi, P., Chaopongpang, S., Pornpattkul, S., Wongwaitayaku., B., and Sangduan, L. 1991. Biology of nitrogen-fixing rhizobacteria. Plant and Soil. 137:119-125.
- Bradford, M.M. 1979. A rapid and sensitive method for quantitation of microgram quantities of protein utilizing the principle of protein dye binding. Anal. Biochem. 72:2448-2456.
- Broekaert, W.F., Lee, H.-I., Kush, A., Chau, N.-H., and Raikhel, N. 1990. Wound-induced accumulation of mRNA containing a havein sequence in laticifers of rubber tree (*Hevea brasiliensis*) Proc. Natl. Acad. Sci. USA 87:7633-7637.
- Broglie, K.E., Gaynor, J.J., and Broglie, R.M. 1986. Ethylene regulated gene expression : Molecular cloning of the genes encoding an endochitinase from *Phaseolus vulgaris*. Proc. Natl. Acad. Sci.

- USA 83:6820-6824.
- Buresh, R.J., Casselman, M.E., and Patrick, W.H.Jr. 1980. Nitrogen fixation in flooded soil system, a review. Adv. Agron. 33:149-192.
- Burris, R.H. 1974. Methodology. In The biology of nitrogen fixation. Edited by A. Quispel. North Holland Publishing Co., Amersterdam, New York. pp. 9-33.
- Chaopongpang, S. 1989. Determination of lectin in root and leaf of rice (*Oryza sativa L.*) by Enzyme-linked immunosorbent assay. M.Sc Thesis, Department of Biochemistry, Graduate School of Chulalongkorn University.
- Chrispeels, M.J., and Raikhel, N.V. 1991. Lectins, lectin genes, and their role in plant defense. Plant Cell. 3:1-9.
- Cocking, E.C., Al-Mallaha, M.K., Benson, E., and Davey, M.R. 1990. Nodulation of non-legumes by rhizobia. In Nitrogen Fixation:Achievements and Objectives, P.M. Gresshoff, L.E. Roth, G. Stacey and W.E. Newton, eds (New York : Chapman and Hall) pp. 813-823.
- Davey, M.R., and Cocking, E.C. 1972. Uptake of bacteria by isolated higher plant protoplasts. Nature 239:455-456.
- Dazzo, F.B., and Hubbell, D.H. 1975. Cross-reactive antigens and lectin as determinants of symbiotic specificity in the *Rhizobium*-Clover association. Appl. Microbiol. 30(6):1017-1033.
- Diem, H.G., Schmidt, E.L., and Dommergues, Y. 1978. The use of the fluorescent antibody technique to study the behaviour of a *Beijerinckia* strain in the rhizosphere and spermosphere of rice. In Environmental role of nitrogen fixing blue-green algae and a symbiotic bacteria. Edited by U. Granhall. Ecol. Bull. (Stockholm). 26:312-318.

- Döbereiner, J., and Ruschel, A.P. 1961. Inoculation to rice with nitrogen-fixing bacteria *Beijerinckia*. Dexx. Rev. Bras. Biol. 21:397-407.
- \_\_\_\_\_. J. 1977. Forage grasses and grain crops. Advance in Agronomy. 29:11.
- \_\_\_\_\_. J., Baldani, I.V., and Baldani, V.L.D. 1983. Effects of Azospirillum inoculation on root infection and nitrogen incorporation in wheat. Can. J. Microbiol. 29:924-929.
- Eskew, D.L., Eaglesham, A.R.J., and App, A. 1981. Atmospheric N<sub>2</sub>-fixation and distribution of newly fixed nitrogen in a rice flooded soil system. Plant Physiol. 61(1):45-52.
- \_\_\_\_\_. D.L., Eaglesham, A.R.J and App, A.A. 1979. Agron. Abstr p. 87.
- Goldstein, I.J., and Hayes, C.E. 1978. The lectins : Carbohydrate-binding proteins of plants and animal. Adv. Carbohydr: Chem. Biochem. 35:127-340.
- Haahtela, K., Laakso, T., and Korhonen, T.K. 1986. Associative nitrogen fixation by Klebsiella spp. Adhesion sites and inoculation effects on grass roots. Appl. Environ. Microbiol. 52:1074-1079.
- Hermoso, R., de Felipe, M.R., Vivo, kA., Chueca, A., Lázaro, J.J., and Gorge, J. 1989. Immunogold localization of photosynthetic fructose-1, 6-bisphosphatase in pea leaf tissue. Plant Physiol. 89:381-385.
- Hiller, A., Plazin, J., and Von Slyke, D.D. 1948. A study of conditions for Kjeldahl determination of nitrogen in proteins. J. Biol. Chem. 176:1401-1420.
- Horisberger, M. 1985. The gold method as applied to lectin cytochemistry in Transmission and Scanning Electron Microscopy-

- Tech. in. Immunocytochem. 3:155-178.
- Huesing, J.E., Murdock., L.L., and Shade, R.E. 1990. Effect of wheat germ isolectins on development of cowpea weevil. Phytochemistry 30.
- Hurek, T., REinhold-hurek, B., Van Montagu, M., and Kellenberger, E. 1990. Infection of intact roots of Kallar grass and rice seedlings by Azoarcus. In Nitrogen Fixation : Developments in plant and soil sciences, M. Polzinelli, R. Materassi, and M Vincenzini, eds (Italally, Florence) pp. 235-242.
- Ito, O., Cabrera, D.A., and Watanabe, I. 1980. Fixation of dinitrogen-15 associated with rice plants. Appl. Environ. Microbiol. 39:554-558.
- Jain, D.K., and Patriquin, D.G. 1984. Root hair deformation, bacterial attachment, and plant growth in wheat-*Azospirillum* association. App. 1. Environ. Microbiol. 48:1208-1213.
- \_\_\_\_\_. and Patriquin. D.G. 1985. Characterization of substance produced by *Azospirillum* which causes branching of wheat root hairs. Can. J. Microbiol. 31:206-210.
- Joseph, C.M., and Meeks, J.C. 1987. Regulation of expression of glutamine synthetase in a symbiotic *Nostoc* strain associate with *Anthoceros punctatus*. J. Bacteriol. 152:626-635.
- Koyama T., and App, A. 1979. In "nitrogen and rice" IRRI, Los Banos, Philippines. 95-104.
- Kumari, L.M., Kavimandan, S.K., and Subba Rao, N.S. 1976. Occurrence of nitrogen-fixing *Spirillum* in roots of rice, sorghum, maize, and other plants. Indian J. Exp. Biol. 19:638-639.
- Lee, K.K., Alimago, B., and Yoshida, T. 1977. Plant soil 47:519-526.
- Levanony H., and Bashan, Y. 1991. Active attachment of *Azospirillum brasiliense* to root surface of non-cereal plants and to sand

- particle. Plant and Soil 137(1).
- Limpananont, J. 1987. Role of lectin from rice (*Oryza sativa L.*) in the association between *Klebsiella* spp. and root epidermal cells. Ph.D. Thesis, Department of Biochemistry, Graduate School of Chulalongkorn University.
- Luria, S.E., Adam, J.N., and Teng, R.C. 1960. Transduction of lactose utilizing ability among strains of *Escherichia Coli* and *Shigella dysenteriae* and the properties of the transducing phage particles. Virology. 12:348-390.
- Mishkind, M.L., Raikhel, N.V., Palevitz, B.A., and Keegstra, K. 1982. Immunocytochemical localization of wheat germ agglutinin in wheat. J. Cell. Biol. 92:753-764.
- \_\_\_\_\_. M.L., Palevitz, B.A., and Raikhel, N.V. 1983. Localization of wheat germ agglutinin-like lectin in various species of the Gramineae. Science. 220:1290-1292.
- Murdock, L.L., Huesing, J.E., Nielsen, S.S., Pratt, R.C., and shade, R.E. 1990. Biological effects of plant lectins on the cowpea weevil. Phytochemistry 29:85-89.
- Nayak, D.N., and Rajaramamohan, V. 1977. Nitrogen fixation by *Spirillum* sp. from rice roots. Arch. Microbiol. 115-359-360.
- Okon, Y., and Kapulnik, Y. 1986. Development and function of *Azospirillum*-Inoculated roots. Plant and soil 90:3-16.
- Orr, J., and Haselkorn, R. 1982. Regulation of glutamine synthetase activity in free-living and symbiotic *Anabaena* spp. J. Bacteriol. 152:626-635.
- Palacpac, A.C. 1982. World rice statistics. The International Rice Research Institute, Los Banos, Philippines. pp. 152.
- Patriquin, D.G., Döbereiner, J., and Jain, D.K. 1983. Sites and processes of association between diazotrophs and grasses. Can.

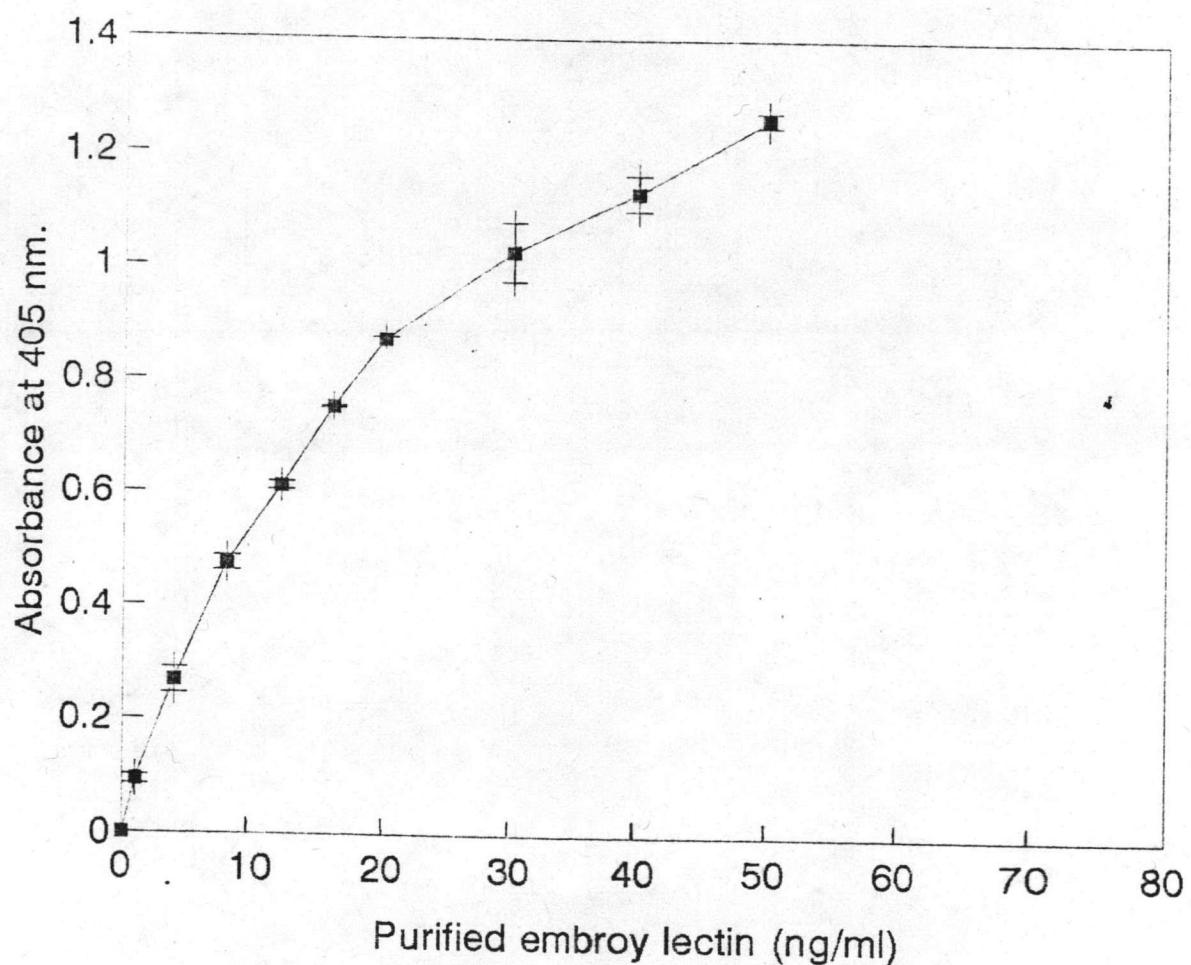
- J. Microbiol. 29:900-915.
- Peumans, W.J., Stinissen, H.M., and Carlier, A.R. 1983. The rice lectin and its relationship to cereal lectin. Biochem. physiol. pflanz. 178(6-7):423-431.
- Poola, I., Seshadri, H.S., and Bhavanandan, V.P. 1986. Purification and saccharide-binding characteristics of a rice lectin. Carbohydr. res. 146(2):205-218.
- Purushothaman, D., Oblisami, G., and Balasun, C.S. 1976. Nitrogen fixation by *Azotobacter* in rice rhizosphere. Madras Agric. J. 63:595-599.
- Raihel, N.V., Paleritz, B.A., and Haigler, C.A. 1986. Abscisic and control of lectin accumulation in wheat seedlings and callus cultures. Plant. Physiol. 80:167-171.
- \_\_\_\_\_. N.V., and Wilkins, T.A. 1989. Expression of rice lectin is governed by two temporally and spatially regulated mRNAs in developing embryos. Plant Cell 1:541-549.
- Rice, R.H., and Etlzer, M.E. 1974. Subunit structure of wheat germ agglutinin. Biochem. Biophys. Res. Commun. 59:414-419.
- Roger, P.A., and Watanabe, I. 1986. Technologies for utilizing biological nitrogen fixation in wetland rice: potentialities, current usage, and limiting factors. Fertilizer Research. 9:39-77.
- Sanchez, F., Padilla, J.E., Perez, H., and Lara, M. 1991. Control of nodulin genes in root-nodule development and metabolism. Annu. Rev. Plant Physiol. Plant Mol. Biol. 42:507-28.
- Shen, Z.W., Sun, C., Zhn, Z., Tang, X.H., and Shen, R.J. 1984. Purification and properties of rice germ lectin. Can. J. Biochem. Cell. Biol. 62:1027-1032.
- Silva, M.F., Da, S., and Döbereiner, J. 1980. Occurrence of *Azospirillum*

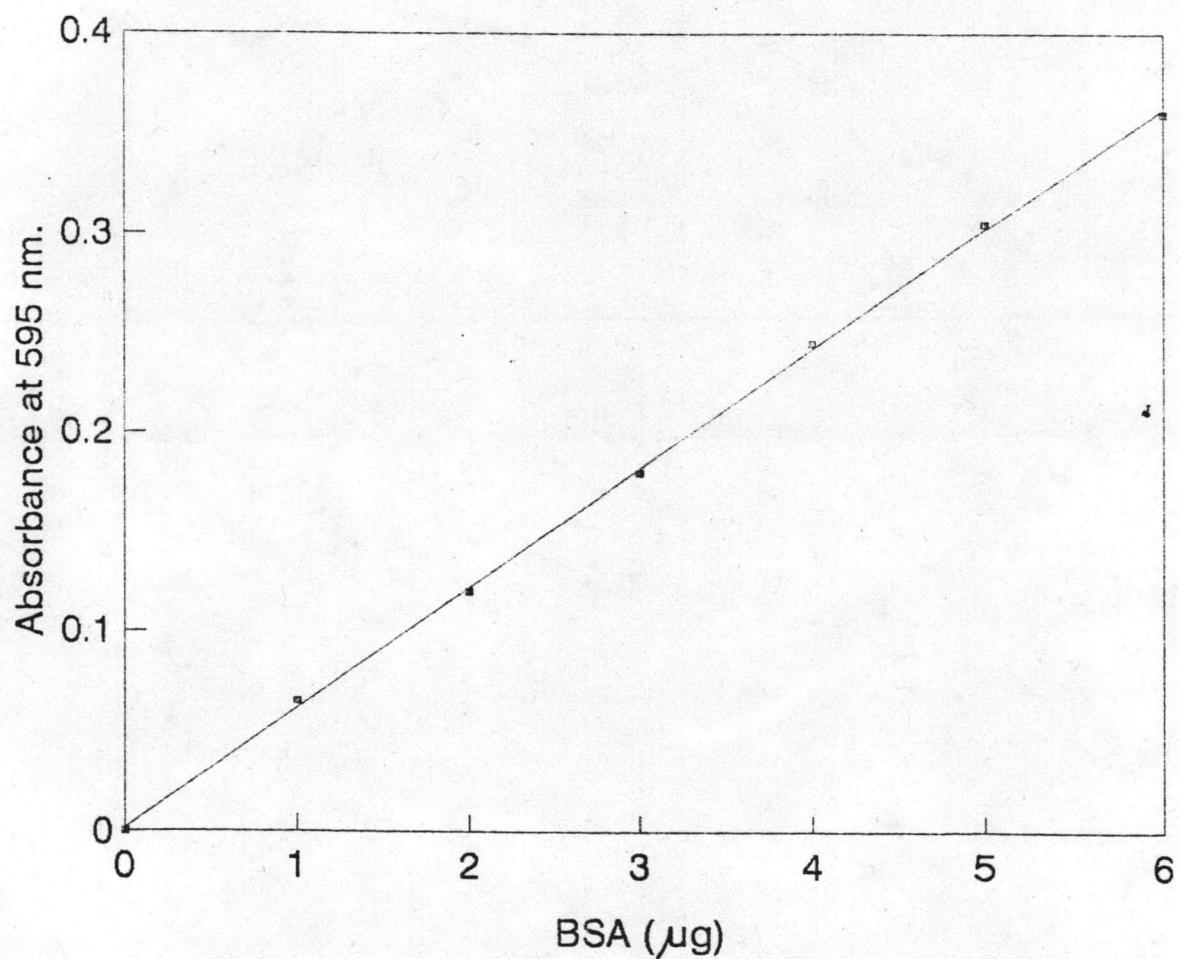
- sp.* in soils and roots. In Limitations and potentials for biological nitrogen fixation in the tropics. Edited by Döbereiner, J., Burris, R.H., and Hollaender, A. Plenum Press, New York and London. p. 372.
- Stanford, A., Bevan, M., and Northcote, D. 1989. Differential expression within a family of novel wold-induced genes in potato. Mol. Gen. Gent. 215:200-208.
- Stinissen, H.M., Peumans, W.J., and Carlier, A.R. 1982. *In vivo* synthesis and processing of cereal lectins. Plant Molec. Biol. 1:271-290.
- \_\_\_\_\_. H.M., Peumans, W.J., Carlier, A.R. 1983. Two-step processing of *In vivo* synthesized rice lectin. Plant. Molec. Biol. 2:33-40.
- \_\_\_\_\_. H.M., Peumans, W.J., and Chrispeels, M.J. 1984(a). Subcellular site of lectin synthesis in developing rice embryos. EMBO J. 3:1979-1985.
- \_\_\_\_\_. H.M., Peumans, W.J., and De Langhe, E. 1984(b). Abscisic acid promotes lectin biosynthesis in developing and germinating rice embryos. Plant Cell Reports 3:55-59.
- \_\_\_\_\_. H.M., Chrispeels, M.J., and Peuman, W.J. 1985. Biosynthesis of lectin root of germinating and adult cereal plants. Planta 164:278-286.
- Swaminathan, M.S. 1984. Rice. Scientific American Jan.:63-71.
- Tabary, F., Balandreau J., and Bourillon R. 1984. Purification of the rice embryo lectin and its binding to Nitrogen-fixing bacteria from the rhizosphere of rice. Biochem-Biophys. Res. Com. 119(2):549-555.
- Tien, T.M., Gaskin, M.H., and Hubbell, D.H. 1979. Plant growth substances produces by *Azospirillum brasiliense* and their effect

- on the growth of pearl millet (*Pennisetum americanum* L.) Appl. Environ. Microbiol. 37:1016-1024.
- Towbin, H., Stachelin, T., Gordon, J. 1979. Electrophoretic transfer of proteins from polyacrylamide gels to nitrocellulose sheets: procedure and some applications. Proc-Natl. Acad. Sci. USA 76:4350-4354.
- Trolldenier, G. 1977. Plant Soil 47:203-217.
- Truchet, G., Roche, P., Lerouge, P., Vasse, J., Camut, S., de Billy, F., Prome, J-C., and Denarie, J. 1991. Sulfated lipo-oligosaccharide signals of *Rhizobium meliloti* elicit root nodule organogenesis in alfalfa. Nature 351:670-673.
- Tsuda, M. 1979. Purification and characterization of a lectin from rice (*Oryza sativa*) bran. J. Biochem (Tokyo). 86(5):1451-1462.
- Umali-Garcia, M., Hubbell, D.H., Gaskin, M.H., and Dazzo, F.B. 1980. Association of *Azospirillum* with grass roots. Appl. Environ. Microbiol. 39:219-226.
- Vose, P.B. 1983. "Developments in nonlegum N<sub>2</sub>-fixing systems. Can. J. Microbiol. 29:837-850.
- Watanabe, I.K., Lee, K., Alimago, B.V., Sato, M., Del Rosario, D.C., and De Guzman, M.R. 1977. Biological nitrogen fixation in paddy fields studied by in situ acetylene reduction assays. IRRI Res. Pap. Ser. 3.
- \_\_\_\_\_. I., Barraquio, W.L.; de Guzman, M.R., and Cabrera, D.A. 1979. Appl. Environ. Microbiol. 37:813-819.
- Weaver, P.K., Wall, J.D. and Gest, H. 1975. Arch. Microbiol. 105:207-216.
- Yoshida, T., and Ancajas, R.R. 1973. Nitrogen-fixing activity in upland and flooded rice fields. Soil Sci Soc Am Proc. 37:42-46.

- You, C.B., and Qiu, Y.S. 1982. Nitrogen fixation of *Alcaligenes faecalis* in association with rice seedling. Sci. Agricul. Sin. 15:1-5.
- \_\_\_\_\_, and Wang, H.X. 1990. Rhizosphere nitrogen fixation in wetland rice Acta Phytophysiologica Sinica 16(2) : 209-214.

## Appendix I STANDARD CURVE OF ELISA



**Appendix II BSA STANDARD CURVE**

## APPENDIX III

Table 1 Effect of *Klebsiella R15* on root lectin content of different stage of growth

Days after germination	Condition*	Total lectin (ng/50 plants) <sup>a</sup>		
		KDML105	NMS4	RD7
7	0	169.67 ± 35.16	137.27 ± 19.83	348.12 ± 20.5
14	-	31.80 ± 3.47(a) <sup>#</sup>	74.87 ± 17.31(a)	193.17 ± 21.0(a)
	+	45.21 ± 6.50(b)	91.23 ± 33.29(a)	242.22 ± 16.0(b)
21	-	36.06 ± 3.93(a)	49.71 ± 15.31(a)	104.88 ± 18.0(a)
	+	45.39 ± 1.88(b)	105.09 ± 30.64(b)	170.45 ± 23.93(b)
28	-	10.01 ± 4.57(a)	48.44 ± 24.98(a)	40.12 ± 30.60(a)
	+	35.10 ± 2.89(b)	77.13 ± 18.99(b)	86.74 ± 32.28(b)

\* 0 = before inoculation, - = no-inoculation, + = inoculation

a values presented are the mean of three repeated experiments ± SE

# Number accompanied by the same letter in each column do not differ significantly at P ≤ 0.05

## APPENDIX IV

Table 2 Effect of *Klebsiella R15* on shoot lectin content of different stage of growth

Days after germination	Condition*	Total lectin (ng/50 plants) <sup>a</sup>		
		KDML105	NMS4	RD7
7	0	30.89 ± 2.39	60.34 ± 19.17	216.50 ± 21.56
14	-	2.20 ± 0.35(a) <sup>#</sup>	7.59 ± 1.21(a)	24.96 ± 0.81(a)
	+	3.91 ± 0.49(a)	11.86 ± 0.51(b)	37.48 ± 2.82(a)
21	-	5.26 ± 1.24(a)	7.43 ± 1.58(a)	27.05 ± 1.02(a)
	+	4.69 ± 0.54(a)	10.74 ± 2.99(a)	31.63 ± 2.28(a)
28	-	3.47 ± 0.89(a)	12.38 ± 5.25(a)	4.14 ± 0.96(a)
	+	7.03 ± 0.65(b)	9.64 ± 5.05(a)	13.78 ± 6.60(a)

\* 0 = before inoculation, - = no-inoculation, + = inoculation

a values presented are the mean of three repeated experiments ± SE

# Number accompanied by the same letter in each column do not differ significantly at P ≤ 0.05

## SIMPLE CORRELATION &amp; LINEAR REGRESSION

=====

\* DEPENDENT VAR -&gt; DAY

\* INDEPENDENT VAR -&gt; ET1

- 1). R = .9864789
- 2). R^2 = .9731407
- 3). t-TEST = 13.45938
- 4). XBAR = 6
- 5). YBAR = 1480.286
- 6). SD of X = 10.583
- 7). SD of Y = 2591.209
- 8). SD of X.Y = 424.6686
- 9). SD of Y.X = 1.734429
- 10). EQUATION Y = 31.07153 + 241.5357 X
- 11). EQUATION X = 3.596974E-02 + 4.028972E-03 Y
- 12). NO.of CASE = 7

## SIMPLE CORRELATION &amp; LINEAR REGRESSION

=====

\* DEPENDENT VAR -&gt; DAY

\* INDEPENDENT VAR -&gt; ET2

- 1). R = .9899356
- 2). R^2 = .9799724
- 3). t-TEST = 15.64148
- 4). XBAR = 6
- 5). YBAR = 1497.214
- 6). SD of X = 10.583
- 7). SD of Y = 2759.225
- 8). SD of X.Y = 390.4821
- 9). SD of Y.X = 1.497694
- 10). EQUATION Y = -51.37537 + 258.0983 X
- 11). EQUATION X = .3152319 + 3.796897E-03 Y
- 12). NO.of CASE = 7

## SIMPLE CORRELATION &amp; LINEAR REGRESSION

=====

\* DEPENDENT VAR -&gt; DAY

\* INDEPENDENT VAR -&gt; ET3

- 1). R = .9709479
- 2). R^2 = .9427397
- 3). t-TEST = 9.073069
- 4). XBAR = 6
- 5). YBAR = 1447.328
- 6). SD of X = 10.583
- 7). SD of Y = 2288.365
- 8). SD of X.Y = 547.5855
- 9). SD of Y.X = 2.532419
- 10). EQUATION Y = 187.639 + 209.9482 X
- 11). EQUATION X = -.4990019 + 4.490343E-03 Y
- 12). NO.of CASE = 7

### BIOGRAPHY

Chetsadaporn Pitaksutheepong was born on July 9, 1966. She conferred her Bachelor degree of Science in Biochemistry from Chulalongkorn University in 1989 and continued her study in the Master program at the same Department.

