APPENDICES

APPENDIX A

EQUATIONS USED IN THE (SoSiMet) METHANE MODEL

Methane Consumption Sector

Accumulation_of_CH4_Consunption(t) = Accumulation_of_CH4_Consunption(t - dt)
+ (Consumption_Rate) * dt
INIT Accumulation_of_CH4_Consunption = 0

INFLOWS:

Consumption_Rate =
(Atmospheric_CH4)*(Atmospheric_CH4*(.33+Atmospheric_CH4))*(7.76/
(7.76+.44))*Enviromental_Function*F_OM*3600*24
Atmospheric_CH4 = (0.000075/16*12)*1000

DOY = COUNTER(1,365)

Enviromental_Function = F_SMC*F_Soil_pH*F_Soil_Temp

Soil_Organic_Matter = 0.265

Soil_pH = 6.8

F_OM = GRAPH(Soil_Organic_Matter)
(0.00, 0.025), (1.00, 0.07), (2.00, 0.07), (3.00, 0.08), (4.00, 0.09), (5.00, 0.15), (6.00, 0.22), (7.00, 0.305), (8.00, 0.42), (9.00, 0.605), (10.0, 0.905)

F_SMC = GRAPH(Soil_Moisture)
(0.00, 0.00), (5.00, 0.00), (10.0, 0.01), (15.0, 0.025), (20.0, 0.385), (25.0, 0.655), (30.0, 0.83), (35.0, 0.86), (40.0, 0.76), (45.0, 0.37), (50.0, 0.00), (55.0, 0.00), (60.0, 0.00), (65.0, 0.00), (70.0, 0.00), (75.0, 0.00), (80.0, 0.00), (85.0, 0.00), (90.0, 0.00), (95.0, 0.00), (100, 0.00)

F_Soil_pH = GRAPH(Soil_pH)
(4.00, 0.00), (4.50, 0.00), (5.00, 0.00), (5.50, 0.025), (6.00, 0.075), (6.50, 0.365), (7.00, 0.7), (7.50, 0.835), (8.00, 0.85), (8.50, 0.785), (9.00, 0.365), (9.50, 0.005), (10.0, 0.00)

F_Soil_Temp = GRAPH(Temp)
(-5.00, 0.00), (0.00, 0.00), (5.00, 0.005), (10.0, 0.005), (15.0, 0.065), (20.0, 0.275), (25.0, 0.63), (30.0, 0.845), (35.0, 0.87), (40.0, 0.825), (45.0, 0.43), (50.0, 0.005), (55.0, 0.00), (60.0, 0.00), (65.0, 0.00), (70.0, 0.00)

Soil_Moisture = GRAPH(DOY)
(1.00, 34.5), (2.00, 34.5), (3.00, 36.5), (4.00, 34.0), (5.00, 34.0), (6.00, 33.5), (7.00, 33.5), (8.00, 32.5), (9.00, 32.5), (10.0, 32.5), (11.0, 32.5), (12.0, 34.0), (13.0, 35.0), (14.0, 35.0), (15.0, 38.0), (16.0, 39.5), (17.0, 39.5), (18.0, 41.5), (19.0, 33.0), (20.0, 35.5), (21.0, 38.5), (22.0, 38.5), (23.0, 35.5), (24.0, 37.5), (25.0, 38.5), (26.0, 40.5), (27.0, 41.5), (28.0, 35.5), (29.0, 39.0), (30.0, 39.0), (31.0, 38.0), (32.0, 41.0), (33.0, 42.5), (34.0, 41.0), (35.0, 38.5), (36.0, 42.0), (37.0, 43.0), (38.0, 43.0), (39.0, 43.0), (40.0, 39.0), (41.0, 39.0), (42.0, 38.0), (43.0, 35.5), (44.0, 35.0), (45.0, 42.5), (46.0, 43.5), (47.0, 43.5), (48.0, 39.5), (49.0, 37.5), (50.0, 40.0), (51.0, 41.5), (52.0, 41.5), (53.0, 44.0), (54.0, 42.0), (55.0, 37.0), (56.0, 35.5), (57.0, 38.0), (58.0, 41.0), (59.0, 43.0), (60.0, 44.0), (61.0, 44.5), (62.0, 43.5), (63.0, 40.5), (64.0, 36.5), (65.0, 37.0), (66.0, 42.5), (67.0, 40.0), (68.0, 42.5), (69.0, 42.5), (70.0, 42.5), (71.0, 43.0), (72.0, 38.5), (73.0, 43.0), (74.0, 38.0), (75.0, 35.5), (76.0, 30.0), (77.0, 35.5), (78.0, 36.0), (79.0, 36.0), (80.0, 32.5), (81.0, 36.5), (82.0, 39.5), (83.0, 39.5), (84.0, 37.0), (85.0, 32.0), (86.0, 32.5), (87.0, 33.5), (88.0, 40.0), (89.0, 42.0), (90.0, 43.0), (91.0, 43.0), (92.0, 42.5), (93.0, 37.0), (94.0, 32.5), (95.0, 37.5), (96.0, 37.5), (97.0, 34.5), (98.0, 40.0), (99.0, 43.0), (100, 44.0), (101, 44.0), (102, 44.0), (103, 43.5), (104, 43.0), (105, 42.5), (106, 33.0), (107, 31.5), (108, 31.5), (109, 40.0), (110, 39.5), (111, 39.5), (112, 38.5), (113, 32.5), (114, 32.5), (115, 34.5), (116, 36.0), (117, 39.0), (118, 41.0), (119, 42.5), (120, 44.5), (121, 42.5), (122, 42.5), (123, 44.0), (124, 45.0), (125, 45.0), (126, 40.0), (127, 43.5), (128, 43.0), (129, 41.5), (130, 34.5), (131, 39.0), (132, 40.0), (133, 41.5), (134, 43.0), (135, 43.5), (136, 43.5), (137, 38.0), (138, 39.5), (139, 40.0), (140, 39.5), (141, 39.0), (142, 38.0), (143, 36.5), (144, 35.0), (145, 34.0), (146, 39.5), (147, 43.5), (148, 41.5), (149, 43.5), (150, 33.0), (151, 42.0), (152, 33.5), (153, 34.0), (154, 38.0), (155, 40.5), (156, 42.5), (157, 40.0), (158, 36.0), (159, 38.0), (160, 41.0), (161, 38.0), (162, 41.0), (163, 41.0), (164, 38.0), (165, 36.0), (166, 35.5), (167, 38.0), (168, 40.5), (169, 41.0), (170, 41.0), (171, 41.0), (172, 41.5), (173, 42.0), (174, 40.5), (175, 38.0), (176, 36.5), (177, 38.0), (178, 41.5), (179, 41.0), (180, 35.5), (181, 35.5), (182, 37.0), (183, 38.0), (184, 40.0), (185, 40.0), (186, 40.5), (187, 38.0), (188, 39.5), (189, 41.0), (190, 43.0), (191, 43.0), (192, 43.0), (193, 42.0), (194, 40.5), (195, 38.0), (196, 40.5), (197, 40.0), (198, 38.0), (199, 33.5), (200, 35.0), (201, 35.5), (202, 38.0), (203, 40.5), (204, 38.0), (205, 35.0), (206, 38.0), (207, 34.0), (208, 34.5), (209, 36.0), (210, 38.0), (211, 39.5), (212, 38.0), (213, 33.0), (214, 38.0), (215, 38.0), (216, 41.0), (217, 38.0), (218, 40.5), (219, 38.0), (220, 38.0), (221, 33.5), (222, 38.0), (223, 38.0), (224, 36.0), (225, 39.5), (226, 38.0), (227, 35.5), (228, 40.5), (229, 41.5), (230, 38.0), (231, 42.0), (232, 42.5), (233, 41.5), (234, 41.0), (235, 35.5), (236, 38.0), (237, 43.5), (238, 43.0), (239, 42.0), (240, 35.0), (241, 38.0), (242, 43.0), (243, 38.0), (244, 43.0), (245, 42.0), (246, 38.0), (247, 41.0), (248, 38.0), (249, 35.5), (250, 38.0), (251, 33.5), (252, 35.5), (253, 38.0), (254, 42.0), (255, 38.0), (256, 45.5), (257, 45.0), (258, 45.5), (259, 38.0), (260, 38.0), (261, 35.5), (262, 42.0), (263, 42.0), (264, 40.0), (265, 38.0), (266, 35.0), (267, 38.0), (268, 41.5), (269, 41.5), (270, 38.0), (271, 41.5), (272, 38.0), (273, 35.0), (274, 38.0), (275, 40.5), (276, 38.0), (277, 35.0), (278, 40.5), (279, 38.0), (280,

42.0), (281, 38.0), (282, 41.0), (283, 38.0), (284, 36.0), (285, 38.0), (286, 41.0), (287, 38.0), (288, 41.0), (289, 35.5), (290, 38.0), (291, 40.5), (292, 38.0), (293, 42.0), (294, 38.0), (295, 43.0), (296, 44.5), (297, 38.0), (298, 44.5), (299, 44.5), (300, 38.0), (301, 40.5), (302, 38.0), (303, 39.5), (304, 38.0), (305, 38.0), (306, 41.5), (307, 41.5), (308, 38.0), (309, 33.5), (310, 38.0), (311, 42.0), (312, 38.0), (313, 41.5), (314, 43.0), (315, 41.5), (316, 43.0), (317, 40.0), (318, 42.5), (319, 35.5), (320, 38.0), (321, 38.0), (322, 42.0), (323, 34.0), (324, 41.0), (325, 38.0), (326, 39.5), (327, 39.5), (328, 38.0), (329, 39.0), (330, 40.5), (331, 38.0), (332, 44.0), (333, 38.0), (334, 38.0), (335, 35.5), (336, 38.0), (337, 44.0), (338, 41.5), (339, 41.5), (340, 41.5), (341, 42.0), (342, 42.0), (343, 43.5), (344, 38.0), (345, 44.5), (346, 41.5), (347, 38.0), (348, 40.5), (349, 35.0), (350, 38.0), (351, 40.0), (352, 38.0), (353, 38.0), (354, 38.0), (355, 40.0), (356, 42.0), (357, 42.0), (358, 38.0), (359, 40.5), (360, 42.0), (361, 39.5), (362, 42.0), (363, 36.5), (364, 38.0), (365, 38.0)

Temp = GRAPH(DOY)
(1.00, 16.5), (2.00, 17.5), (3.00, 16.5), (4.00, 17.0), (5.00, 17.5), (6.00, 16.8), (7.00, 17.0), (8.00, 16.8), (9.00, 17.2), (10.0, 17.2), (11.0, 17.2), (12.0, 17.4), (13.0, 17.2), (14.0, 16.8), (15.0, 17.0), (16.0, 17.0), (17.0, 17.2), (18.0, 17.2), (19.0, 16.8), (20.0, 17.2), (21.0, 17.0), (22.0, 17.4), (23.0, 17.0), (24.0, 17.4), (25.0, 17.2), (26.0, 17.2), (27.0, 18.0), (28.0, 20.0), (29.0, 20.0), (30.0, 21.2), (31.0, 21.4), (32.0, 21.2), (33.0, 21.2), (34.0, 21.2), (35.0, 21.4), (36.0, 21.0), (37.0, 20.8), (38.0, 20.8), (39.0, 20.8), (40.0, 21.6), (41.0, 20.8), (42.0, 20.8), (43.0, 21.2), (44.0, 21.2), (45.0, 20.8), (46.0, 21.4), (47.0, 20.8), (48.0, 20.8), (49.0, 21.4), (50.0, 20.6), (51.0, 21.6), (52.0, 21.0), (53.0, 21.0), (54.0, 21.6), (55.0, 21.0), (56.0, 20.8), (57.0, 20.8), (58.0, 21.4), (59.0, 21.2), (60.0, 21.2), (61.0, 20.8), (62.0, 20.8), (63.0, 21.4), (64.0, 21.2), (65.0, 21.0), (66.0, 20.8), (67.0, 20.8), (68.0, 21.6), (69.0, 20.6), (70.0, 20.8), (71.0, 20.8), (72.0, 19.4), (73.0, 20.8), (74.0, 20.8), (75.0, 21.0), (76.0, 20.4), (77.0, 20.0), (78.0, 19.6), (79.0, 19.6), (80.0, 20.8), (81.0, 20.6), (82.0, 19.6), (83.0, 19.2), (84.0, 19.6), (85.0, 21.4), (86.0, 21.2), (87.0, 21.6), (88.0, 22.0), (89.0, 21.0), (90.0, 18.4), (91.0, 23.0), (92.0, 23.0), (93.0, 24.6), (94.0, 21.0), (95.0, 24.0), (96.0, 26.2), (97.0, 23.4), (98.0, 24.4), (99.0, 23.6), (100, 22.0), (101, 24.6), (102, 23.4), (103, 24.0), (104, 23.0), (105, 23.2), (106, 23.0), (107, 24.2), (108, 24.4), (109, 25.0), (110, 25.0), (111, 25.0), (112, 26.0), (113, 26.6), (114, 25.6), (115, 25.4), (116, 25.8), (117, 25.2), (118, 27.6), (119, 27.6), (120, 24.8), (121, 23.4), (122, 22.8), (123, 21.2), (124, 21.4), (125, 22.0), (126, 23.0), (127, 22.8), (128, 22.2), (129, 22.2), (130, 22.2), (131, 21.6), (132, 21.4), (133, 21.0), (134, 21.2), (135, 21.2), (136, 19.8), (137, 20.4), (138, 22.2), (139, 22.6), (140, 23.0), (141, 23.2), (142, 22.8), (143, 22.4), (144, 23.0), (145, 22.6), (146, 22.6), (147, 22.4), (148, 22.4), (149, 22.4), (150, 22.0), (151, 22.0), (152, 22.4), (153, 22.8), (154, 23.2), (155, 23.0), (156, 23.0), (157, 23.2), (158, 23.2), (159, 23.0), (160, 22.2), (161, 22.0), (162, 22.0), (163, 22.0), (164, 22.8), (165, 22.2), (166, 22.0), (167, 22.2), (168, 22.2), (169, 22.8), (170, 22.4), (171, 21.8), (172, 22.2), (173, 21.8), (174, 21.8), (175, 21.8), (176, 21.2), (177, 21.8), (178, 21.6), (179, 21.6), (180, 22.2), (181, 23.6), (182, 23.2), (183, 22.6), (184, 20.8), (185, 23.2), (186, 23.4), (187, 23.2), (188, 22.6), (189, 23.2), (190, 22.8), (191, 22.8), (192, 23.6), (193, 22.6), (194, 21.8), (195, 20.8), (196, 23.0), (197, 22.6), (198, 22.4), (199, 21.8), (200, 23.0), (201, 22.8), (202, 23.6), (203, 23.6), (204, 23.4), (205, 23.2), (206, 23.4), (207, 23.4), (208, 22.6), (209, 23.0), (210, 22.8), (211, 22.8), (212, 22.8), (213, 22.8), (214, 23.4), (215, 23.2), (216, 22.6), (217,

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Methane Production Sector

Active_LAI(t) = Active_LAI(t - dt) + (Expansion_rate - Decay_rate2) * dt
INIT Active_LAI = .015

TRANSIT TIME = varies

INFLOW LIMIT = 1

CAPACITY = 1

INFLOWS:
Expansion_rate = LAI

OUTFLOWS:

Decay_rate2 = CONVEYOR OUTFLOW

TRANSIT TIME = Active_LAI/20

Methane_Production(t) = Methane_Production(t - dt) +
(Net_methane_production_rate) * dt

INIT Methane_Production = 0

INFLOWS:

Net_methane_production_rate = M_product-Methane_Oxidation_Rate

Rice_Growth(t) = Rice_Growth(t - dt) + (Growth_Rate) * dt

INIT Rice_Growth = 100000

INFLOWS:

Growth_Rate = (Radiation_absorbed_by_canopy*Radiation_use_efficiency)*1000

Soil_OM(t) = Soil_OM(t - dt) + (- Decay_rate) * dt

INIT Soil_OM = (0.6618*0.4449)*1000*1000

OUTFLOWS:

Decay_rate = Pool_I+Pool_II

Canp_Reflect = 0.22-(0.22-0.1)*EXP(-Active_LAI/2)

C_Tranfer_Rate_to_Root = .35

DOY = COUNTER(1,365)

F_temp = EXP((0.334)*(Temperature-23))/(1+EXP((0.334)*(Temperature-23)))

LAI = IF(Temperature_Sum>0) THEN (0.015*EXP(.003*Temperature_Sum)) ELSE (0)

Methane_Oxidation_Rate = M_product*(0.4+(0.5*(Rice_growth/RDMm)))

Microbial_Biomass = (Pool_I*0.4)+(Pool_II*0.3)

M_product = ((Pm*Simple_C_Supply_Rate*Total_control_factors)/12)*16

pH = IF(Water_Depth>0) THEN (((6.8-5.7)/25*Water_Depth)+5.7) ELSE(5.7)

Pm = 0.47

Pool_I = IF(Water_Depth>0) THEN((Soil_OM*0.75)/1000*43.84)ELSE(0)

Pool_II = IF(Water_Depth>0) THEN((Soil_OM*0.25)/1000*0.44)ELSE(0)

Radiation_absorbed_by_canopy = Daily_Sola*(1-Canp_Reflect-(1-0.1)*EXP (-(1-0.25)*0.6*Active_LAI))

Radiation_use_efficiency = 1.95

RDMm = 933222

Rice_C_Rhizodep_Rate = C_Tranfer_Rate_to_Root*Rice_growth

Simple_C_Supply_Rate = Rice_C_Rhizodep_Rate+((Microbial_Biomass*0.6*0.4)+ (Microbial_Biomass*0.4*0.3))

Total_control_factors = F_temp*F_dept*F_pH*F_Rh

Daily_Sola = GRAPH(DOY)
(0.00, 26.4), (1.00, 26.4), (2.00, 26.4), (3.00, 26.5), (4.00, 26.6), (5.00, 26.6), (6.00, 26.6), (7.00, 26.7), (8.00, 26.7), (9.00, 26.8), (10.0, 26.8), (11.0, 26.9), (12.0, 26.9), (13.0, 26.9), (14.0, 27.0), (15.0, 27.1), (16.0, 27.2), (17.0, 27.3), (18.0, 27.4), (19.0, 27.6), (20.0, 27.7), (21.0, 27.8), (22.0, 27.9), (23.0, 28.0), (24.0, 28.1), (25.0, 28.2), (26.0, 28.3), (27.0, 28.4), (28.0, 28.5), (29.0, 28.6), (30.0, 28.8), (31.0, 28.9), (32.0, 29.0), (33.0, 29.1), (34.0, 29.2), (35.0, 29.3), (36.0, 29.4), (37.0, 29.6), (38.0, 29.7),

(39.0, 29.9), (40.0, 30.0), (41.0, 30.2), (42.0, 30.3), (43.0, 30.5), (44.0, 30.6), (45.0, 30.8), (46.0, 30.9), (47.0, 31.0), (48.0, 31.2), (49.0, 31.3), (50.0, 31.5), (51.0, 31.6), (52.0, 31.8), (53.0, 31.9), (54.0, 32.1), (55.0, 32.2), (56.0, 32.4), (57.0, 32.5), (58.0, 32.6), (59.0, 32.8), (60.0, 32.9), (61.0, 33.0), (62.0, 33.1), (63.0, 33.3), (64.0, 33.4), (65.0, 33.5), (66.0, 33.6), (67.0, 33.8), (68.0, 33.9), (69.0, 34.0), (70.0, 34.1), (71.0, 34.3), (72.0, 34.4), (73.0, 34.5), (74.0, 34.6), (75.0, 34.8), (76.0, 34.9), (77.0, 35.0), (78.0, 35.1), (79.0, 35.3), (80.0, 35.4), (81.0, 35.5), (82.0, 35.6), (83.0, 35.7), (84.0, 35.7), (85.0, 35.8), (86.0, 35.9), (87.0, 36.0), (88.0, 36.1), (89.0, 36.2), (90.0, 36.3), (91.0, 36.4), (92.0, 36.4), (93.0, 36.5), (94.0, 36.6), (95.0, 36.7), (96.0, 36.8), (97.0, 36.9), (98.0, 37.0), (99.0, 37.1), (100, 37.1), (101, 37.2), (102, 37.3), (103, 37.4), (104, 37.4), (105, 37.5), (106, 37.5), (107, 37.6), (108, 37.6), (109, 37.7), (110, 37.7), (111, 37.8), (112, 37.8), (113, 37.9), (114, 37.9), (115, 38.0), (116, 38.0), (117, 38.1), (118, 38.1), (119, 38.2), (120, 38.2), (121, 38.3), (122, 38.3), (123, 38.4), (124, 38.4), (125, 38.5), (126, 38.5), (127, 38.5), (128, 38.5), (129, 38.6), (130, 38.6), (131, 38.6), (132, 38.6), (133, 38.6), (134, 38.6), (135, 38.7), (136, 38.7), (137, 38.7), (138, 38.7), (139, 38.7), (140, 38.7), (141, 38.8), (142, 38.8), (143, 38.8), (144, 38.8), (145, 38.8), (146, 38.8), (147, 38.9), (148, 38.9), (149, 38.9), (150, 38.9), (151, 38.9), (152, 38.9), (153, 38.9), (154, 38.9), (155, 38.9), (156, 38.9), (157, 38.9), (158, 38.9), (159, 38.9), (160, 38.9), (161, 38.9), (162, 38.9), (163, 38.9), (164, 38.9), (165, 38.9), (166, 38.9), (167, 38.9), (168, 38.9), (169, 38.9), (170, 38.9), (171, 38.9), (172, 38.9), (173, 38.9), (174, 38.9), (175, 38.9), (176, 38.9), (177, 38.9), (178, 38.9), (179, 38.8), (180, 38.8), (181, 38.8), (182, 38.8), (183, 38.8), (184, 38.8), (185, 38.8), (186, 38.8), (187, 38.8), (188, 38.8), (189, 38.8), (190, 38.8), (191, 38.7), (192, 38.7), (193, 38.7), (194, 38.7), (195, 38.7), (196, 38.7), (197, 38.7), (198, 38.7), (199, 38.6), (200, 38.6), (201, 38.6), (202, 38.6), (203, 38.6), (204, 38.5), (205, 38.5), (206, 38.5), (207, 38.5), (208, 38.5), (209, 38.4), (210, 38.4), (211, 38.4), (212, 38.4), (213, 38.3), (214, 38.3), (215, 38.3), (216, 38.3), (217, 38.3), (218, 38.2), (219, 38.2), (220, 38.2), (221, 38.1), (222, 38.1), (223, 38.0), (224, 38.0), (225, 37.9), (226, 37.9), (227, 37.8), (228, 37.8), (229, 37.7), (230, 37.7), (231, 37.6), (232, 37.6), (233, 37.5), (234, 37.5), (235, 37.4), (236, 37.4), (237, 37.3), (238, 37.3), (239, 37.2), (240, 37.2), (241, 37.1), (242, 37.1), (243, 37.0), (244, 37.1), (245, 37.1), (246, 37.2), (247, 37.2), (248, 37.3), (249, 37.3), (250, 37.4), (251, 37.4), (252, 37.5), (253, 37.5), (254, 37.6), (255, 37.6), (256, 37.7), (257, 37.7), (258, 37.8), (259, 37.8), (260, 37.9), (261, 37.9), (262, 38.0), (263, 38.0), (264, 38.1), (265, 38.1), (266, 38.2), (267, 37.9), (268, 37.7), (269, 37.4), (270, 37.1), (271, 36.9), (272, 36.6), (273, 36.3), (274, 36.1), (275, 35.8), (276, 35.5), (277, 35.3), (278, 35.0), (279, 34.8), (280, 34.5), (281, 34.2), (282, 34.0), (283, 33.7), (284, 33.4), (285, 33.2), (286, 32.9), (287, 32.6), (288, 32.4), (289, 32.1), (290, 32.0), (291, 31.9), (292, 31.7), (293, 31.6), (294, 31.5), (295, 31.4), (296, 31.2), (297, 31.1), (298, 31.0), (299, 30.9), (300, 30.7), (301, 30.6), (302, 30.5), (303, 30.4), (304, 30.2), (305, 30.1), (306, 30.0), (307, 29.9), (308, 29.7), (309, 29.6), (310, 29.5), (311, 29.4), (312, 29.2), (313, 29.1), (314, 29.0), (315, 28.9), (316, 28.8), (317, 28.6), (318, 28.5), (319, 28.4), (320, 28.3), (321, 28.2), (322, 28.1), (323, 28.0), (324, 27.8), (325, 27.7), (326, 27.6), (327, 27.5), (328, 27.4), (329, 27.3), (330, 27.2), (331, 27.0), (332, 26.9), (333, 26.8), (334, 26.7), (335, 26.7), (336, 26.6), (337, 26.6), (338, 26.5), (339, 26.5), (340, 26.5), (341, 26.4), (342, 26.4), (343, 26.3), (344, 26.3), (345, 26.3), (346, 26.2), (347, 26.2), (348, 26.1), (349, 26.1), (350, 26.0), (351, 26.0), (352, 26.0), (353, 25.9), (354, 25.9), (355, 25.8),

(356, 25.8), (357, 25.9), (358, 25.9), (359, 26.0), (360, 26.0), (361, 26.1), (362, 26.1), (363, 26.2), (364, 26.2), (365, 26.2)

F_dept = GRAPH(Water_Depth)
(0.00, 0.00), (1.00, 0.375), (2.00, 0.61), (3.00, 0.745), (4.00, 0.83), (5.00, 0.9), (6.00, 0.94), (7.00, 0.98), (8.00, 0.99), (9.00, 1.00), (10.0, 1.00), (11.0, 1.00), (12.0, 1.00), (13.0, 1.00), (14.0, 1.00), (15.0, 1.00), (16.0, 1.00), (17.0, 1.00), (18.0, 1.00), (19.0, 1.00), (20.0, 1.00), (21.0, 1.00), (22.0, 1.00), (23.0, 1.00), (24.0, 1.00), (25.0, 1.00), (26.0, 1.00), (27.0, 1.00), (28.0, 1.00), (29.0, 1.00), (30.0, 1.00)

F_pH = GRAPH(pH)
(0.00, 0.00), (0.5, 0.00), (1.00, 0.00), (1.50, 0.00), (2.00, 0.00), (2.50, 0.00), (3.00, 0.00), (3.50, 0.00), (4.00, 0.00), (4.50, 0.00), (5.00, 0.00), (5.50, 0.00), (6.00, 0.04), (6.50, 0.11), (7.00, 0.46), (7.50, 0.855), (8.00, 0.855), (8.50, 0.155), (9.00, 0.00), (9.50, 0.00), (10.0, 0.00), (10.5, 0.00), (11.0, 0.00), (11.5, 0.00), (12.0, 0.00), (12.5, 0.00), (13.0, 0.00), (13.5, 0.00), (14.0, 0.00)

F_Rh = GRAPH(Rh)
(-240, 1.00), (-230, 1.00), (-220, 0.91), (-210, 0.34), (-200, 0.05), (-190, 0.025), (-180, 0.01), (-170, 0.01), (-160, 0.01), (-150, 0.00), (-140, 0.00), (-130, 0.00), (-120, 0.00)

Rh = GRAPH(Water_Depth)
(1.00, -120), (1.97, -155), (2.93, -171), (3.90, -180), (4.87, -184), (5.83, -188), (6.80, -190), (7.77, -191), (8.73, -191), (9.70, -191), (10.7, -191), (11.6, -191), (12.6, -191), (13.6, -190), (14.5, -190), (15.5, -191), (16.5, -190), (17.4, -190), (18.4, -189), (19.4, -188), (20.3, -190), (21.3, -190), (22.3, -189), (23.2, -189), (24.2, -190), (25.2, -190), (26.1, -188), (27.1, -190), (28.1, -190), (29.0, -190), (30.0, -189)

Temperature = GRAPH(DOY)
(0.00, 16.5), (1.00, 16.5), (2.00, 17.5), (3.00, 16.5), (4.00, 17.0), (5.00, 17.5), (6.00, 17.5), (7.00, 18.0), (8.00, 17.5), (9.00, 18.5), (10.0, 19.0), (11.0, 17.5), (12.0, 16.0), (13.0, 18.0), (14.0, 18.8), (15.0, 20.0), (16.0, 21.3), (17.0, 20.0), (18.0, 20.0), (19.0, 19.0), (20.0, 19.5), (21.0, 19.3), (22.0, 19.5), (23.0, 18.8), (24.0, 17.8), (25.0, 16.5), (26.0, 17.0), (27.0, 18.0), (28.0, 18.0), (29.0, 19.5), (30.0, 21.0), (31.0, 31.0), (32.0, 21.8), (33.0, 21.0), (34.0, 21.0), (35.0, 21.0), (36.0, 20.8), (37.0, 20.0), (38.0, 20.0), (39.0, 20.0), (40.0, 20.0), (41.0, 20.5), (42.0, 20.5), (43.0, 20.5), (44.0, 21.0), (45.0, 20.5), (46.0, 21.0), (47.0, 20.8), (48.0, 20.7), (49.0, 20.6), (50.0, 20.5), (51.0, 19.0), (52.0, 20.0), (53.0, 20.8), (54.0, 21.3), (55.0, 21.5), (56.0, 20.5), (57.0, 20.8), (58.0, 21.0), (59.0, 21.5), (60.0, 18.5), (61.0, 20.8), (62.0, 20.5), (63.0, 20.3), (64.0, 21.3), (65.0, 20.3), (66.0, 19.8), (67.0, 21.0), (68.0, 20.5), (69.0, 20.8), (70.0, 21.5), (71.0, 20.5), (72.0, 21.3), (73.0, 19.8), (74.0, 19.0), (75.0, 23.0), (76.0, 23.0), (77.0, 20.5), (78.0, 20.3), (79.0, 21.5), (80.0, 21.5), (81.0, 22.5), (82.0, 23.3), (83.0, 23.3), (84.0, 24.0), (85.0, 21.5), (86.0, 21.5), (87.0, 22.5), (88.0, 22.5), (89.0, 20.0), (90.0, 18.3), (91.0, 23.0), (92.0, 21.8), (93.0, 23.8), (94.0, 24.8), (95.0, 26.3), (96.0, 23.8), (97.0, 24.0), (98.0, 23.3), (99.0, 22.0), (100, 24.5), (101, 25.0), (102, 25.3), (103, 25.5), (104, 25.0), (105, 24.5), (106, 21.0), (107, 23.0), (108, 24.5), (109, 25.3), (110, 25.0),

(111, 26.0), (112, 25.7), (113, 25.5), (114, 26.5), (115, 27.3), (116, 27.5), (117, 25.5),
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(132, 21.2), (133, 19.5), (134, 21.5), (135, 23.3), (136, 24.5), (137, 24.5), (138, 24.2),
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(167, 24.0), (168, 23.3), (169, 23.0), (170, 24.5), (171, 23.8), (172, 22.8), (173, 22.8),
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(181, 25.0), (182, 25.0), (183, 26.0), (184, 26.5), (185, 25.3), (186, 25.0), (187, 23.0),
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(195, 23.0), (196, 22.8), (197, 23.8), (198, 23.8), (199, 23.8), (200, 23.8), (201, 23.3),
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(230, 22.5), (231, 24.0), (232, 24.5), (233, 25.0), (234, 25.8), (235, 25.3), (236, 23.5),
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(335, 17.7), (336, 17.3), (337, 17.3), (338, 20.8), (339, 21.8), (340, 18.5), (341, 18.3),
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(349, 19.0), (350, 19.5), (351, 18.0), (352, 16.3), (353, 14.5), (354, 12.8), (355, 12.0),
(356, 10.5), (357, 9.50), (358, 13.3), (359, 7.50), (360, 8.80), (361, 9.20), (362, 10.0),
(363, 11.8), (364, 13.8), (365, 12.5)

Temperature_Sum = GRAPH(DOY)
(0.00, 0.00), (1.00, 0.00), (2.00, 0.00), (3.00, 0.00), (4.00, 0.00), (5.00, 0.00), (6.00,
0.00), (7.00, 0.00), (8.00, 0.00), (9.00, 0.00), (10.0, 0.00), (11.0, 0.00), (12.0, 0.00),
(13.0, 0.00), (14.0, 0.00), (15.0, 0.00), (16.0, 0.00), (17.0, 0.00), (18.0, 0.00), (19.0,
0.00), (20.0, 0.00), (21.0, 0.00), (22.0, 0.00), (23.0, 0.00), (24.0, 0.00), (25.0, 0.00),
(26.0, 0.00), (27.0, 0.00), (28.0, 0.00), (29.0, 0.00), (30.0, 0.00), (31.0, 0.00), (32.0,
0.00), (33.0, 0.00), (34.0, 0.00), (35.0, 0.00), (36.0, 0.00), (37.0, 0.00), (38.0, 0.00),
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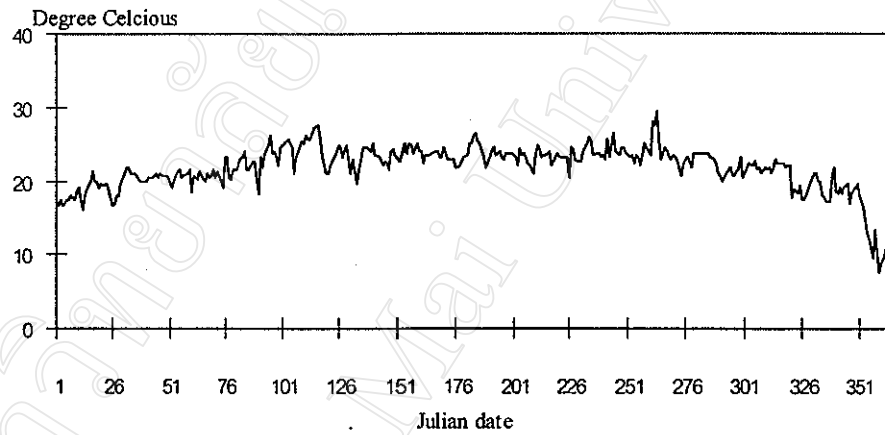
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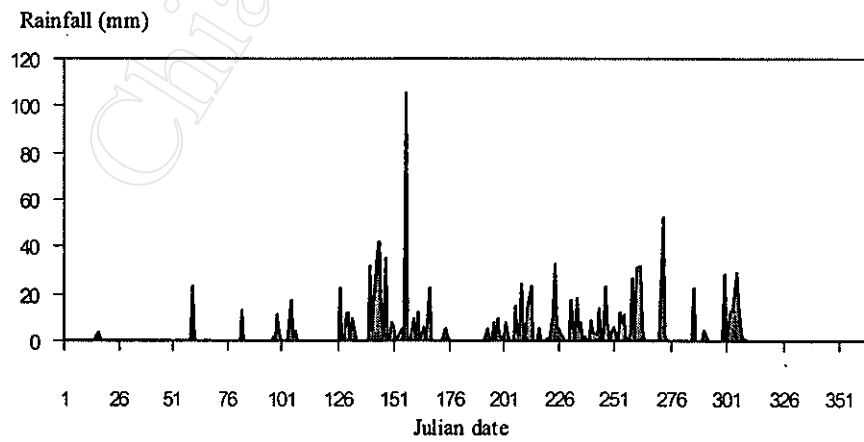
APPENDIX B

AUXILIARY DATA

Weather Data

Appendix Figure 1 Daily average temperature of Wat Chan sub-district, 1999
Source: Royal Project, Wat Chan site, Chiang Mai province.

Appendix Figure 2 Daily rainfall of Wat Chan sub-district, Mae Chaem District, 1999
Source: Royal Project, Wat Chan site, Chiang Mai province.

Appendix Table 1 Weather data of Charng Kerng sub-district, Mae Chaem district. 1999.

Month	Average temperature (oC)			Rainfall (mm)	Evaporation (mm)	Velocity (km h^{-1})	Humidity (%)
	Max.	Min.	Ave.				
Jan	30.8	15.2	23.0	0.0	86.6	5.5	76.4
Feb	30.4	17.1	23.8	0.0	105.1	8.0	65.8
Mar	30.5	18.1	24.3	0.0	158.6	19.9	61.2
Apr	28.6	19.8	24.32	75.5	106.5	9.6	76.0
May	25.6	19.0	22.3	222.8	55.6	6.6	78.0
Jun	24.6	19.5	22.1	198.1	41.7	8.5	86.4
Jul	25.0	20.2	22.6	130.6	46.1	7.3	85.6
Aug	23.9	19.9	21.9	231.7	42.1	7.9	85.3
Sept	25.1	20.0	22.6	214.9	71.4	3.8	86.9
Oct	25.0	19.3	22.2	226.3	83.6	5.0	84.3
Nov	24.7	17.0	20.9	37.1	64.0	5.2	81.8
Dec	23.4	12.8	18.1	4.4	61.3	7.8	76.0
Total	-	-	-	1341.4	922.6	-	-
Mean	26.5	18.2	22.3	-	-	7.9	78.6

Source: Mae Chaem watershed research station, Baan Tap sub-district, Mae Chaem district, Chiang Mai province.

Soil Data

Soil Characteristics of Deciduous forest

Appendix Table 2 Soil profile descriptions of deciduous forest.

Soil horizontal	Description
A 0-10 cm	Brown (7.5YR 5/2) sandy, large amount of ashes on the soil surface due to forest fire in last summer, some dark patchy decomposed and burned organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, clear boundary, common fine tabular pores, few root channels, and moderately fine roots, many rocks, and with a field of pH 6.6.
B 10-40 cm	Light brown and appears reddish (7.5YR 6/4) sandy, weak fine subangular blocky structure, nonsticky, nonplastic, clear boundary, common fine and big tabular pores, few big root channels, and moderately fine roots, few rocks, and with a field of pH 6.8.
B 40-75 cm	Light brown and appears reddish (7.5YR 6/4) sandy, weak fine subangular blocky structure, nonsticky, nonplastic, clear boundary, few fine and big tabular pores, few big root channels, and moderately fine roots, few rocks, and with a field of pH 6.8.
B 75-130 cm	Light brown and appears reddish (7.5YR 6/4) sandy, weak fine subangular blocky structure, nonsticky, nonplastic, clear boundary, few fine tabular pores, few big root channels, and moderately fine roots, many rotting rocks, and with a field of pH 6.8.

Appendix Table 3 Soil physical and chemical characteristics of deciduous forest.

Horizon	A	B	Bt	C
Depth (cm)	0-20	20-40	40-60	>60
pH 1:1H_2O	4.61	4.71	6.05	4.99
pH 1:1KCl	3.92	3.75	3.83	3.84
CEC	16.3	15.96	13.47	16.49
OM(%)	3.98	0.91	0.37	0.31
N (%)	0.167	0.068	0.042	0.045
P(ppm)	2.50	1.00	1.00	1.00
K(ppm)	209.16	63.0	45.36	27.72
Ca(ppm)	100.0	37.5	25.0	37.5
Mg(ppm)	48.75	7.50	5.00	3.75
Na(ppm)	300.0	85.0	80.0	80.0
BS(%)	17.05	4.88	4.53	3.88
Sand (%)	17.24	12.24	6.44	21.24
Silt (%)	35.36	31.96	73.48	32.56
Clay (%)	47.4	55.80	20.08	46.20

Soil Characteristics of rice field

Appendix Table 4 Soil profile descriptions of rice field.

Soil horizontal	Description
A 0-20 cm	Grey (10Y 2/5) sandy to loam, some dark patchy decomposed organic matter, weak fine subangular blocky structure; no mottles, appears to have large blocky pore in the dry season, nonsticky, nonplastic, clear boundary, no pores, few root channels, and moderately fine roots, no rocks, and with a field of pH 6.4.
B 20-40 cm	Grey (10Y 2/5) sandy to loam, weak fine subangular blocky structure; many mottles, appears to have large blocky pore in the dry season, nonsticky, nonplastic, clear boundary, no pores, no root channels, and no roots, no rocks, and with a field of pH 5.6.
B 40-60 cm	Grey (10Y 2/5) sandy to loam, weak fine subangular blocky structure; many mottles, appears to have large blocky pore in the dry season, nonsticky, nonplastic, clear boundary, no pores, no root channels, and no roots, no rocks, and with a field of pH 5.5.
B >60 cm	Grey (10Y 2/6) sandy to loam, weak fine subangular blocky structure; many mottles, appears to have large blocky pore in the dry season, nonsticky, nonplastic, clear boundary, no pores, no root channels, and no roots, no rocks, and with a field of pH 6.0.

Appendix Table 5 Soil physical and chemical characteristics of rice field.

Horizon	A	B	Bt	C
Depth (cm)	0-20	20-40	40-60	>60
pH 1:1H$_2$O	5.70	6.76	6.83	7.00
pH 1:1KCl	5.42	5.18	6.18	6.23
CEC	19.93	16.26	14.42	14.03
OM(%)	3.83	1.38	1.25	0.60
N (%)	0.129	0.083	0.060	0.042
P(ppm)	20.00	8.50	2.50	2.50
K(ppm)	85.68	78.12	136.08	108.52
Ca(ppm)	1900.00	1225.00	1450.00	962.50
Mg(ppm)	157.50	107.50	125.00	102.50
Na(ppm)	125.00	85.00	165.00	155.00
BS(%)	58.05	46.74	64.90	47.46
Sand (%)	37.44	57.04	45.84	48.24
Silt (%)	33.36	22.16	27.16	30.56
Clay (%)	29.20	20.80	27.00	21.20

Soil Characteristics of Orchard Field

Appendix Table 6 Soil profile descriptions of orchard field.

Soil horizontal	Description
Ap 0-20 cm	Brown (10YR 5/1) sandy with many rocks on the surface, few dark patchy decomposed organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, no mottles, clear boundary, no pores, few root channels, and many fine roots, many rocks, and with a field of pH 5.6.
Bl 20-85 cm	Brown (10YR 4/4) sandy with many rocks, weak fine subangular blocky structure; nonsticky, nonplastic, no mottles, clear boundary, no pores, no root channels, and many fine roots, many rocks, and with a field of pH 6.8.
B >85 cm	Brown (10YR 4/6) sandy with many rocks, weak fine subangular blocky structure; nonsticky, nonplastic, no mottles, clear boundary, no pores, no root channels, no roots, many rocks, and with a field of pH 6.2.

Appendix Table 7 Soil physical and chemical characteristics of orchard field.

Horizon	A	B	Bt
Depth (cm)	0-20	20-85	85+
pH 1:1H$_2$O	7.06	6.01	5.45
pH 1:1KCl	6.65	4.89	4.53
CEC	20.98	10.36	17.44
OM(%)	6.14	0.57	0.27
N (%)	0.265	0.064	0.053
P(ppm)	50.00	3.50	1.00
K(ppm)	519.12	75.60	133.56
Ca(ppm)	1600.00	150.00	225.00
Mg(ppm)	210.00	50.00	67.50
Na(ppm)	580.00	185.00	140.00
BS(%)	64.82	35.38	15.13
Sand (%)	20.24	65.24	34.14
Silt (%)	18.36	20.16	21.66
Clay (%)	61.40	14.60	44.20

Soil Characteristics of Pine Forest

Appendix Table 8 Soil profile descriptions of pine forest.

Soil horizontal	Description
A 0-15 cm	Red (10R 3/1) sandy, large amount ashes on the surface due to past summer forest fire, some dark patchy decomposed and burned organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, clear boundary, common fine tabular pores, some root channels, and moderately fine roots, no rocks, and with a field of pH 6.8.
B15-25cm	Red (10R 3/4) sandy, weak fine subangular blocky structure; nonsticky, nonplastic, clear boundary, no pores, few root channels, and moderately fine roots, no rocks, and with a field of pH 6.8.
B 25-80 cm	Red (10R 4/6) sandy, weak fine subangular blocky structure; nonsticky, nonplastic, clear boundary, no pores, few big root channels, and moderately few roots, no rocks, and with a field of pH 7.0.

Appendix Table 9 Soil physical and chemical characteristics of pine forest.

Horizon	A	B	Bt
Depth (cm)	1-15	15-25	25-85
pH 1:1H_2O	5.25	5.22	5.13
pH 1:1KCl	4.55	4.17	4.17
CEC	17.70	9.70	6.16
OM(%)	0.265	0.053	0.044
N (%)	0.265	0.053	0.044
P(ppm)	38.00	3.50	1.50
K(ppm)	42.84	17.64	12.60
Ca(ppm)	312.50	50.00	31.25
Mg(ppm)	76.25	32.50	10.00
Na(ppm)	65.00	20.00	40.00
BS(%)	14.63	6.80	7.14
Sand (%)	28.24	48.24	64.04
Silt (%)	14.36	32.56	18.76
Clay (%)	57.40	19.20	17.20

Soil Characteristics of One-year Fallow

Appendix Table 10 Soil profile descriptions of one-year fallow.

Soil horizontal	Description
Ap 0-10 cm	Grey (10R 5/1) sandy, small amount burned leaf litter on the surface, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, many root channels, and many fine roots, no rocks, and with a field of pH 6.8.
Bl 10-60 cm	Grey (10R 5/2) sandy, some dark patchy decomposing organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, few root channels, and few fine roots, no rocks, and with a field of pH 6.8.
B 60-130 cm	Red (10R 5/3) sandy, weak fine subangular blocky structure; nonsticky, no small amount un-decomposed leave litter on the surface, some dark patchy decomposing organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, many root channels, and many fine and big roots, no rocks, and with a field of pH 6.8.

Appendix Table 11 Soil physical and chemical characteristics of one-year fallow.

Horizon	A	B	Bt
Depth (cm)	1-10	10-60	60-130
pH 1:1H$_2$O	4.89	5.24	4.94
pH 1:1KCl	4.27	4.42	4.55
CEC	25.04	16.26	13.51
OM(%)	0.265	0.102	0.053
N (%)	0.265	0.102	0.053
P(ppm)	3.00	1.50	1.00
K(ppm)	88.20	37.80	22.68
Ca(ppm)	150.00	37.50	37.50
Mg(ppm)	35.00	6.25	2.50
Na(ppm)	175.00	70.00	80.00
BS(%)	8.10	3.94	4.59
Sand (%)	46.44	71.84	38.64
Silt (%)	29.44	14.56	22.16
Clay (%)	24.12	13.60	39.20

Soil Characteristics of Four-year Fallow

Appendix Table 12 Soil profile descriptions of four-year fallow.

Soil horizontal	Description
Ap 0-10 cm	Brown (2.5YR 2.5/1) sandy, small amount burned leaf litter on the surface, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, many root channels, and many fine roots, no rocks, and with a field of pH 6.8.
Bl 10-35 cm	Brown (2.5YR 3/6) sandy, some dark patchy decomposing organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, few root channels, and few fine roots, no rocks, and with a field of pH 6.8.
B 35-90 cm	Brown (2.5YR ¾) sandy, weak fine subangular blocky structure; nonsticky, no small amount un-decomposed leave litter on the surface, some dark patchy decomposing organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, many root channels, and many fine and big roots, no rocks, and with a field of pH 6.8.

Appendix Table 13 Soil physical and chemical characteristics of four-year fallow.

Horizon	A	B	Bt
Depth (cm)	1-10	10-35	35-90
pH 1:1H_2O	5.37	5.42	5.44
pH 1:1KCl	4.90	4.41	4.67
CEC	23.47	13.37	13.11
OM(%)	0.345	0.095	0.061
N (%)	0.345	0.095	0.061
P(ppm)	7.50	1.00	1.00
K(ppm)	178.92	32.76	17.64
Ca(ppm)	687.50	37.50	25.00
Mg(ppm)	140.00	3.75	2.50
Na(ppm)	245.00	65.00	50.00
BS(%)	26.16	4.31	4.65
Sand (%)	66..24	34.84	29.84
Silt (%)	22.56	21.96	6.36
Clay (%)	11.20	43.24	63.80

Soil Characteristics of Seven-year Fallow

Appendix Table 14 Soil profile descriptions of seven-year fallow.

Soil horizontal	Description
Ap 0-10 cm	Grey (10R 3/1) sandy, large amount un-decomposed leaf litter on the surface, some dark patchy decomposing organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, many root channels, and many fine roots, no rocks, and with a field of pH 6.8.
Bl 10-45 cm	Grey (10R 3/3) small amount un-decomposed leave litter on the surface, some dark patchy decomposing organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, many root channels, and many fine and big roots, no rocks, and with a field of pH 6.8.
B 45-100 cm	Red (10R 3/4) sandy, weak fine subangular blocky structure; nonsticky, no small amount un-decomposed leave litter on the surface, some dark patchy decomposing organic matter, weak fine subangular blocky structure; nonsticky, nonplastic, not clear boundary, common fine tabular pores, many root channels, and many fine and big roots, no rocks, and with a field of pH 6.8.

Appendix Table 15 Soil physical and chemical characteristics of seven-year fallow.

Horizon	A	B	Bt
Depth (cm)	1-10	10-45	45-100
pH 1:1H$_2$O	4.96	5.26	5.37
pH 1:1KCl	4.18	4.43	4.52
CEC	22.29	12.46	13.64
OM(%)	0.307	0.113	0.072
N (%)	0.307	0.113	0.072
P(ppm)	2.00	1.00	1.00
K(ppm)	57.96	20.16	17.64
Ca(ppm)	50.00	25.00	25.00
Mg(ppm)	13.75	3.75	2.50
Na(ppm)	80.00	40.00	45.00
BS(%)	3.86	8.06	2.93
Sand (%)	15.24	58.44	52.24
Silt (%)	44.36	19.96	14.56
Clay (%)	39.40	21.60	33.20

CURRICULUM VITAE

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