Soil Mineral Nutrients and Microbes Are Responsible for Large Patch Disease Caused by *Rhizoctonia solani* AG2-2 in Zoysiagrass Turf

Tae-Hyun Chang[1], Yeon-Ju Ru[2] and Yong-Se Lee[2]*

[1]*Department of Plant Resources, College of Life Science and Natural Resources, Sangju National University, Sangju, Korea*

[2]*Department of Bioindustry, College of Life and Environmental, Daegu University, Gyungsan 712-714, Korea*

골프장 한국잔디의 *Rhizoctonia solani* AG2-2에 의한 Large Patch 발생 토양에서 근권 미생물과 무기영양 평가

장태현[1] · 류연주[2] · 이용세[2*]

[1]상주대학교 생명자원대학 식물자원학과, [2]대구대학교 생명환경대학 산업바이오전공

ABSTRACT

Mineral nutrients and population dynamics of soil microbes in the root zones of zoysiagrass infected by *Rhizoctonia solani* AG2-2 and that of healthy plants were sampled from ten golf courses using a cup cutter(diameter 10 cm x 8 cm deep). Analysis of variance(ANOVA) showed significant differences in content of NO_3-N(P = 0.05), NH_4-N (P = 0.1), and K(P = 0.1) between infected and healthy samples. The content of NO_3-N in the soils of large patch was 9.49 mg/kg and that in soil of healthy plants was 7.02 mg/kg. However, the content of NH_4-N in the soil of large patch was 12.02 mg/kg whereas 14.40 mg/kg for the soil under the healthy plants. The content of K in the soil of large patch was lower than that of soil of healthy plants. There was few numbers of *Pseudomonas* colonies in the soils of large patch compared to that of healthy plants. These results indicated that the content of NO_3-N, NH4-N, and K and the microbial population dynamics in root zones correlated to occurrence of large patch.

Key words: nitrate, ammonium, pseudomonas, rootzone, zoysiagrass

*Corresponding author. Tel : +82-54-530-5204, Fax : +82-54-530-5153, Mobile : 010-3189-1721
E-mail : thchang@knu.ac.kr

INTRODUCTION

Large patch caused by *Rhizoctonia solani* AG2-2 is a major disease on zoysiagrass(Couch, 2000; Dale, 1978) occurred from late April to late June in Korea(Shim et al, 1994). this disease is a soil-inhabiting fungal pathogen that incites Rhizoctonia blight, a foliar disease regarded as one of the most ecologically important diseases of turfgrass worldwide(Shim et al, 1994).

An outbreak of this disease in Korea is severely reported in southern area more than in northern area from 1989 to 1993. It spread through national wide and became the most dangerous disease in zoysiagrasses(Smiley et al, 1992). The *R. solani* that is pathogen by soil born has weak virulence. However, it has strong pathogenicity(Smith et al, 1989). It occurs at 15-25℃ the pathogen that inhabits under the thatch layer(Smiley et al, 1992; Smith et al, 1957). As pathogen forms the sclerotia under the poor circumstances, the effect of chemical control is low in fields(Smith, 1957).

Large patch severity can be reduced by several cultural practices such as maintain of turf vigor and fertility control such as over plus application of early spring nitrogen fertilizer(Smith et al, 1989). All of the essential mineral elements are reported to influence disease incidence or severity(Huber, 1980). The effect of mineral nutrients on the disease has been determined by observing the effect of mineral amendment on disease severity, comparing mineral concentrations in resistant and susceptible cultivars or tissues, correlating conditions influencing mineral availability with disease incidence or severity, or a combination of all three(Huber, 1980).

Nitrogen, inhibition of disease incidence by nitrogen forms, increase of disease resistance, change of pathogen growth and pathogencity and biological control by interaction of soil microbes or results of combination by these factors, can be effects above(Huber and Waston, 1974). Disease control as a result of modified host resistance may result from fewer pathogen penetrations(Huber et al, 1968) or retarded pathogenesis after penetration(Huber et al, 1968). Reduced disease from altered host resistance generally results from the influence of a specific form of nitrogen on metabolic pathways affecting growth, plant constituents, or exudates rather than a direct effect of the nitrogen(Huber et al, 1968). Several workers have proposed using the fungicidal activity of ammonia for disease control(Smiley et al, 1970). Propagules of *Fusarium* spp. were rapidly destroyed under laboratory conditions and markedly reduced in the field after high rates of NH_4-N injection, yet foot rot of winter wheat was generally increased (Smiley et al,1972).

Control of large patch disease on zoysiagrass has been extremely difficult because no highly resistant cultivars are available. However, for large patch disease

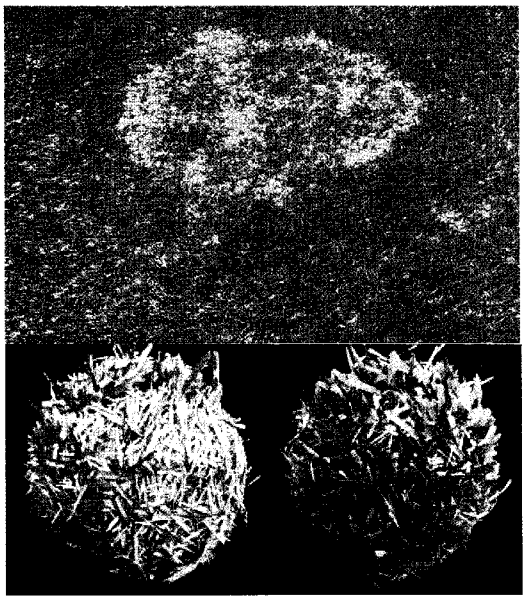
management, like other turf diseases, is highly dependent on chemical fungicide application, but effective chemicals have not been cleared for use in golf courses(Smith et al, 1989). Moreover, application of fungicides is a major of increasing disease management cost. This has stimulated research into alternative disease management strategies such as amount of application fertilizer and role of soil microbes to *R. solini* in zoysiagrass would greatly reduce the costs and environmental impacts of fungicide application. However, there are little research of mineral nutrition, nitrogen form and microbes in soil on occurrence of large patch of golf course.

The objectives of this study were to evaluate effects of correlation between occurrence of *R. solini* and amount of mineral nutrients using analysis of root zone soil in both large patch and healthy turfgrass. The second were to investigate of correlation between occurrence of *R. solini* and amount of microbes in root zone soil of both large patch and healthy plants.

MATERIALS AND METHODS

Sample collection

The samples of large patch and healthy plant(Fig.1) were taken as a cylindrical turf(plug) by using a hole cutter(10-cm-diameter x 8-cm-deep) at large patch diseased and healthy plants on zoysiagrass from ten golf courses and a sport field(Table 1). Both six samples from healthy plants area and from the area of large patch diseased in each fairway were collected from April 20 to May 10.



A B

Fig. 1. Samples(cylindrical turf)collected from large patch diseased and healthy plants using a hole cutter(10 cm diameter x 8 cm deep). (A) Large patch diseased sample (B) Healthy plants sample

Table 1. List of samples used in this experiment

Province	Name of golf course	Collected fairway	Number of samples	Number of golf course
Gyeong sang Buk-do (GB)				5
Gyeongsan	GB-DGCC	East hole 4 and West hole 8	8	
Waegoan	GB-PHCC	Hole 7 and hole 9	12	
Geongju	GB-GJCC	Hole 1 and hole 9	12	
Geongju	GB-BMCC	Hole 8 and hole 10	12	
Geongju	GB-SLCC	Hole 10 and hole 18	12	
Gyeong sang Nam-do (GN),				4(1)[z]
Ulsan	GN-USCC	Hole 1 and hole 9	12	
Jinhea	GN-YWCC	Hole 1 and hole 2	12	
Yangsan	GN-TDCC	Hole 9 and hole 16	12	
Habcheon	Sport field	-	8	
Jeonla Nam-do (JN),				2
South Koangju	JN-SKJCC	Hole 4 and hole 10	6	
Gyeonggi-do (GG)				1
Koangju	GG-GNCC	Hole 4 and hole 15	12	

[z]( ) : number of sport field
Samples were taken on from April.20th to May 10th 2006.

Analysis of soil chemistry

For the investigation of mineral nutrients of samples, we removed the soil of 3 cm below thatch layer of samples by using the knife. Then, the samples were dried under the room temperature for 14 days. After dried, samples that were passed through 2 mm sieve were prepared for analysis of soil chemistry. Each sample of large patch and healthy plants were analyzed with six replications. Analysis of soil chemistry was followed with method of soil chemical analysis(NIAST, 2000). Soil pH and EC were investigated after extracting with 1 to 5 ratios of soil and water. In addition, organics was analyzed by method of burning. Available phosphorus in soil was extracted by method of Lancaster, and exchangeable cations ion was extracted with 1N-ammonium acetate. Micronutrients were extracted with Diethylene Triamine Penta Acetic acid(DTPA). The extracted solutions were analyzed with Induced Coupled Plasma(IPC; Optima3000 SC, Perkin Elmer) after dilution.

Investigation of soil microbes

Three bacteria species, *Pseudomonas* spp., *Actinomycetes* spp. and *Bacillus* spp., were evaluated using sample soil which taken out from soil surface of sample plugs to 3cm. the soil diluted with distilled water by 1 x 10^5 for smear test and cultured in incubator to be adjusted with 27℃ after smearing on agar. A number of colony of

Pseudomonas spp., was survey using *Pseudomonas* spp. isolation agar(Difco.) as a culture media, *Bacillus* spp. was used to culture media which include agar(Difco.), 20.0g; glucose, 1.0g; KH_2PO_4, 0.37g; $CaCl_2.2H_2O$, 0.07g; $(NH_4)_2SO_4$, 1.3g; Yeast extract, 1.0g; $MgSO_47H_2O$, 0.25g; $FeCl_3$, 0.02g; D.D Water/1 ℓ. A count of colony that grows on agar investigated on 2 days after smearing with soil solution. *Actinomycetes* spp. was used to *Actinomycetes* spp. isolation agar(Difco.) that includes nalidixic acid(10 mg/ℓ) and cycloheximide(50 mg/ℓ) to control non-target bacteria grow. Then, smeared on agar after the soil solution sterilized at 60℃ for 30 min. for control to be colony forming of other bacteria, and counted the number of colony after cultured in incubator.

Statistical analysis

All statistical analyses were conducted using general liner models procedure(PROC GLM) in SAS(SAS institute Inc., Cary, NC). The primary parameter analyzed was completed with replications treated as a random effect and mineral nutrients and samples as fixed effects. Means were compared with Fisher's protected least significant differences test at P=0.05. For all primary and derived parameters, analysis of variance(ANOVA) was used to test the significance of main effects and the first order interaction(golf course x sample: large patch disease plugs and healthy plant plugs). The experiments were done once, and the results of each experiment were analyzed separately.

RESULTS AND DISCUSSIONS

The content of mineral nutrients in root zone soil

The significant difference(P=0.05) in this experiment was detected when content of mineral nutrients in root zone soil of large patch diseased and healthy plant samples was investigated(Table 2). Analyses of variance(ANOVA) were detected in content of NO_3-N, NH_4-N and K(Table 3). The content of NO_3-N in the root zone soil of large patch samples was 9.49 mg/kg that was higher than in the soil of healthy plants that was 7.02 mg/kg(Table 2). However, there was a huge difference in content of NO_3-N among golf courses. Especially in GN-YWCC, the content of NO_3-N in soil of large patch was 3.5 times higher than healthy plants. The content of NO_3-N between in root zone soil of large patch and healthy plant from each golf course was a significant difference at five golf courses(Table 4). The distribution of content of the nitrogen

Table 2. Soil chemistry in the root zone soil of large patch diseased and healthy plants

Golf course[x]	Sample[y]	OM (g/kg)	EC1:5 (ds/m)	pH (1:5)	mg/kg				Ex. Cations cmol/kg)				mg/kg			
					NO_3-N	NH_4-N	T-N	Av.P_2O_5	K	Ca	Mg	SiO_2	Fe	Mn	Zn	Cu
GB-DGCC	Patch	29	1.3	6.7	12.2	2.8	15	397.1	5.8	27.7	1.2	37.8	10.3	60.5	2.8	0.4
	Healthy	37	1.9	6.9	8.7	5.8	14.5	333.3	5.1	27.4	1.2	24.1	12.5	59.9	3.0	0.4
GB-FHCC	Patch	34	1.4	7.2	14.6	4.3	18.9	569.6	8.2	42.6	1.0	24.8	5.7	58.9	3.7	0.1
	Healthy	28	1.2	7.0	7.5	7.4	14.9	673.0	6.5	49.7	1.1	22.0	4.8	68.9	4.9	-
GB-GJCC	Patch	38	1.1	6.9	3.4	16.6	20.0	496.5	5.0	25.2	2.2	24.9	14.4	69.9	4.7	0.4
	Healthy	36	1.0	7.0	3.8	12.7	16.5	343.3	8.1	23.0	1.6	25.3	10.8	71.2	8.3	0.4
GB-BMCC	Patch	39	0.7	6.7	4.1	18.9	23.0	384.5	5.2	26.1	1.6	31.6	12.3	48.0	7.0	0.5
	Healthy	27	0.7	6.6	2.4	18.3	20.7	272.3	4.6	19.0	1.6	28.9	12.6	41.3	5.5	0.7
GB-SLCC	Patch	39	1.0	6.6	5.2	19.6	24.8	648.5	7.4	27.3	1.6	26.9	17.0	45.5	6.6	0.4
	Healthy	35	1.3	6.6	3.6	19.1	22.7	726.7	4.4	22.0	1.4	16.7	19.3	49.0	7.8	0.6
GN-USCC	Patch	43	0.9	6.6	11.5	12.4	23.9	425.2	6.2	21.0	1.3	21.8	5.4	100.5	3.5	0.4
	Healthy	45	0.9	6.3	7.2	15.3	22.5	319.6	7.0	19.6	1.3	35.8	8.4	72.9	5.0	0.5
GN-YWCC	Patch	28	1.2	6.3	26.6	12.3	38.9	409.8	5.0	14.7	0.8	13.2	10.2	50.2	9.2	0.6
	Healthy	36	0.6	6.2	7.2	15.9	23.1	261.0	8.1	11.8	1.1	39.9	6.8	45.5	7.1	0.5
GN-TDCC	Patch	33	1.0	7.3	6.8	18.1	24.9	428.2	5.2	43.9	0.9	18.2	7.4	35.5	3.5	0.2
	Healthy	32	1.4	6.9	4.5	18.1	22.6	465.0	6.7	38.5	1.0	22.8	5.4	56.4	2.5	0.1
GN-HCSF	Patch	17	0.8	6.3	18.0	8.4	26.4	206.7	5.3	8.3	0.8	47.5	20.1	37.3	3.1	0.5
	Healthy	16	0.6	7.1	7.6	5.6	13.2	220.6	5.7	9.8	0.9	26.4	14.3	36.0	3.0	0.5
JN-SkJCC	Patch	40	0.6	6.6	8.3	7.1	15.4	169.0	3.7	17.6	0.6	15.3	10.6	52.5	3.1	0.4
	Healthy	34	0.6	6.6	8.2	8.5	16.7	137.1	2.6	14.8	0.5	31.8	8.8	41.5	3.0	0.3
GG-GNCC	Patch	28	1.3	6.7	31.9	10.6	42.5	418.0	8.7	20.7	1.1	25.8	13.1	51.0	2.4	0.6
	Healthy	34	1.0	6.7	33.5	9.3	42.8	354.6	15.8	18.9	1.0	20.2	10.9	49.8	3.0	0.5
Mean	Patch	33.8	1.01	6.71	9.5	12.0	21.5	414.1	5.8	24.8	1.18	23.7	11.8	54.7	4.6	0.4
	Healthy	33.1	1.00	6.74	7.02	14.4	21.6	373.3	6.6	22.8	1.14	27.9	10.8	52.9	5.0	0.4
	P value	ns[z]	ns	ns	0.026	0.057	0.072	0.192	0.067	ns	ns	ns	ns	ns	ns	ns

[x] GB: Gyeongbuk, CC: country club, GN: Gyeongnam, JN: Jeonnam, SF: sport field.
[y] Patch- Large patch sample plugs were cut from center of large patch caused by R. solani.
Healthy- healthy sample plugs were cut from healthy turfgrass.
[z] ns=not significant at $P>0.10$.
Values in column contained six replicatationfrom each golf course and one sport field (GN-HCSF), respectively.

Table 3. Effect of mineral nutrients in the root zone soil of large patch diseased and healthy plants

Golf course	mg/kg			Ex. Cations (cmol/kg)	mg/kg
	NO_3-N	NH_4-N	Av. P_2O_5	K	SiO_2
	F value	F value	F value	F value	F value
GB-DGCC	ns	6.96**	ns	ns	ns
GB-FHCC	15.46***[x]	4.82*	ns	7.73**	ns
GB-GJCC	ns	ns	7.32**	27.99***	ns
GB-BMCC	10.05**	ns	ns	ns	ns
GB-SLCC	ns	ns	ns	10.14***	6.82**
GN-USCC	7.67**	8.27**	8.86**	ns	10.79***
GN-YWCC	27.69***	7.81**	20.01***	10.63***	24.21***
GN-TDCC	Ns[y]	ns	ns	ns	4.21*
JN-SKJCC	ns	ns	ns	ns	ns
GG-GNCC	ns	ns	ns	7.44**	ns
GN-HCSF	4.62*	4.05*	ns	ns	ns

[x] *, **, *** = significant at 0.1, 0.05 and 0.01, respectively.
[y] ns = not significant at $P>0.10$.

Table 4. Analysis of variance of macronutrients in the root zone soil of large patch diseased and healthy plants

Source	df	NO_3-N		NH_4-N		K	
		F value	P value	F value	P value	F value	P value
Sampled sites	5	0.41	0.84	1.16	0.2134	2.04	0.082
Golf course	10	17.10	<.0001	18.79	<.0001	14.60	<.0001
Sample (patch and healthy)[x]	1	12.33	0.0008	9.16	0.0050	5.05	0.0121
Sample x Golf course [y]	10	1.36	0.07	0.68	0.7559	5.63	<.0001
Error	83						

[x] *, **, *** = significant at 0.1, 0.05 and 0.01, respectively.
[y] ns = not significant at P>0.10.

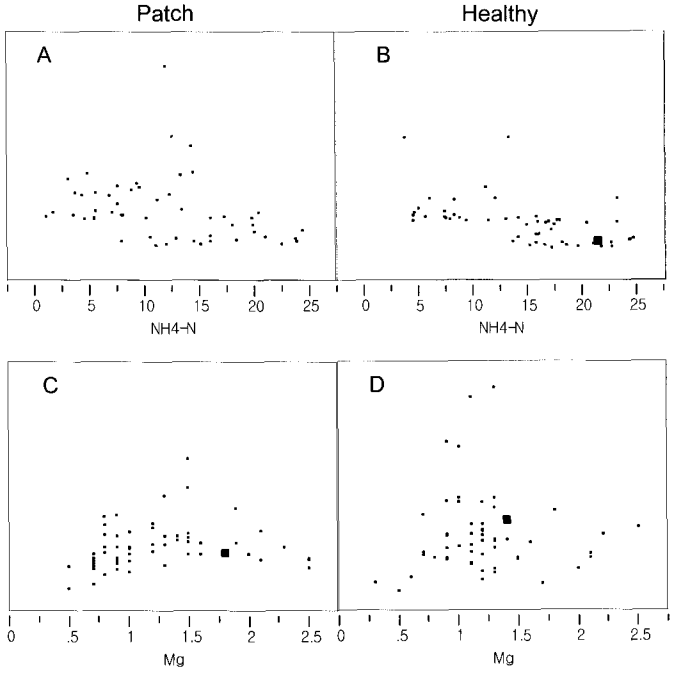


Fig. 2. Distribution of micronutrients between root zone soil of large patch diseased and healthy plants (A) Correlation between content of NO_3-N and NH_4-N in soil of large patch diseased, (B) Correlation between content of NO_3-N and NH_4-N in soil of healthy plants, (C)Correlation between content of K and Mg in soil of large patch diseased, (D) Correlation between content of K and Mg in soil of healthy plants.

among golf course showed that large patch was higher content of NO_3-N than the healthy plants when compared to NH_4-N(Fig. 2, A).

The content of NH_4-N in the soil of large patch diseased was 12.02 mg/kg that was lower than 14.40 mg/kg of NH_4-N in root zone soil of healthy plants(Table 2). ANOVA of NH_4-N content from each golf course showed that there was a significant difference

at five golf courses and a sport field(Table 4). The distribution of content of the nitrogen among samples showed that large patch was lower content of NH_4-N than the healthy plants compared to NH_4-N(Fig. 2, B).

There is to be excess nitrogen that is NH_4-N content of over 200 mg/kg and NO_3-N content of over 100-200 mg/kg in soil of golf course(Hayns, 1986). The plants, fungi, and bacteria can utilize NH_4-N and NO_3-N as well as various organic forms of nitrogen, although some are better adapted to one form or another(Webster, 1959). In most well aerated soil, NO_3-N predominates and plants adapted to such soil grow well with NO_3-N as the sole source of nitrogen. Crops that utilize NH_4-N grow well following fumigation, while crops requiring NO_3-N for optimum growth may be adversely affected(Webster, 1959).

Our result showed that the content of NH_4-N was higher in the root zone soil of healthy plants than in large patch. However, content of NO_3-N was lower in the root zone soil of healthy plants than large patch. ANOVA showded that content(mg/kg) of NH_4-N and NO_3-N in the root zone soil of samples was a significant difference between soil of large patch and soil of healthy plants. The content of NO_3-N in root were excessive at three golf courses of 5 golf courses. Therefore, we suggested that contents of NO_3-N and NH_4-N in the root zone soil might to affect directly or indirectly as a factor to occurrence of large patch. However, there was no evidence that NO_3-N was large patch suppressive. Many plant constituents altered by specific forms of nitrogen have been correlated with resistance or susceptibility to disease (Singh et al, 1971). Ammonium is rapidly assimilated, and it can immediately serve in the synthesis of amino acids. As the NO_3-N must be reduced before assimilation, organic acids may accumulate because the immediate demand for carbohydrate is lessened(Beevers, 1961). Fusarium wilt severity of mexican limes and the numbers of propagules were reduced in media fertilized with NO_3-N(Spiegel and Netzer, 1984). In Israel demonstrated that NH_4-N fertilized muskmelon plants showed 30% more Fusarium wilt compared to NO_3-N fertilized plants(Kiem and Humphrey, 1984).

No significant difference detected that the content of available P_2O_5 in root zone soil of both samples in a whole survey. However, showed tends to higher than contents of available P_2O_5 in soil of large patch compare to soil of healthy plants(Table 2).

The content of available P_2O_5 in the root zone soil of all samples showed that there was not a significant difference. However, there were higher than contents of available P_2O_5 in the soil of large patch compared to soil of healthy plants(Table 2). ANOVA of each golf course detected that there was a significant difference($P=0.05$) content of available P_2O_5 at three golf course(Table 3). Phosphates was commonly changed

available P_2O_5 at pH 6~7 ranges, and good for turfgrass in content of available P_2O_5 at 100-300 mg/kg in soil. We founds that nine golf courses was to be excess content of available P_2O_5 except JN-SKJCC. The content of available P_2O_5 was higher soil of large patch than soil of healthy plants. Phosphate and chloride decrease NO_3-N uptake and increase NH_4-N uptake(Woltz and Jones, 1973). Woltz and Jones(1973) reported that a high level of phosphorus(P) was to be increase the severity of Fusarium wilt of tomato in pot and field experiments and that the combination of high lime plus low P greatly curtailed disease development.

The content of K in root zone soil detected that there was a significant difference (P = 0.1) in that large patch was lower than in the soil of healthy plants(Table 2). ANOVA of each golf course detected that there was a significant difference(P=0.05) content of K at three golf courses(Table 3). The distribution between content of K and Mg that has antagonism in the soil showed that content of K in the soil of large patch was lower than healthy plants(Fig. 2, C.D).

The content of K in the root zone soil of most golf courses was enough. However, some golf course that showed statistically significant difference K content. The K content of large patch soil was lower than K content of healthy plant soil except SLCC and GNCC. We suggested that it might be correlated between K content in soil and occurrence of large patch. Walker and Foster(1946) reported that high N or low K favored disease development, whereas low N or high K retarded it. Tharp and Wadleigh(1939) demonstrated that an increase in K was accompanied by a significant reduction in severity of wilt in cotton. The content of SiO_2 of micronutrients, ANOVA of each golf course detected that there was a significant difference(P=0.05) at four golf courses(Table 4), which had lower content of SiO_2 in soil of large patch than soil of healthy plants(Table 2). Turfgrass might reduced the resistance of disease to cause inhibition factor of growth that high pH might increase NH_4-N absorption. However, the large patch caused by *R. solani* that caused might increase the incidence of disease because of high pathogen activation in low pH soil(Smith et al, 1989).

The population of microbes in root zone soil

ANOVA detected that there was a significant difference(P=0.05) number of colony on *Pseudomonas* spp. among soil microbes(Table 5). There was low a number of colony in soil of large patch when compare to soil of healthy plants. ANOVA of each golf course(Table 6), *Pseudomonas* spp. detected that there were significant difference(P=0.05) at two golf courses. Actinomyces spp. was significant difference(P=0.05) at two golf

Table 5. Analysis for variance of population dynamics of soil microbes in the root zone soil of large patch diseased and healthy plants

Sample	Mean of microbe ($x10^5$)		
	Pseudomonas spp.	*Actinomyses* spp.	*Bacillus* spp.
Patch[z]	13.1	5.4	7.1
Healthy [y]	26.2	6.3	7.8
ANOVA[x] (P = 0.05)			
Source			
Golf course	0.0144	<.0001	0.0058
Sample	0.0032	Ns[w]	ns

[z] Patch- Large patch samples werecut from center of large patch caused by *R. solani* 2-2 (VI.
[y] Healthy- healthy samples were cut from healthy turfgrass.
[x] ANOVA = analysis of variance. Interaction (golf course x sample) was not significant at P=0.05
[w] ns = not significant at $P > 0.10$.

Table 6. Population dynamics of soil microbes in the root zone soil of large patch diseased and healthy plants

Golf course	*Pseudomonas* spp. ($x10^5$)			*Actinomyces* spp. ($x10^5$)			*Bacillus* spp. ($x10^5$)		
	Patch	Healthy	F value	Patch	Healthy	F value	Patch	Healthy	F value
GB-DGCC	8.0	18.1	ns	4.6	3.8	ns	10.4	10.3	ns
GB-FHCC	11.4	13.4	ns	4.3	3.0	ns	5.7	6.2	ns
GB-GJCC	16.8	18.9	ns	7.8	5.6	ns	12.9	7.6	ns
GB-BMCC	23.9	10.9	ns	1.99	21.7	130.89***	17.5	0.9	30.04***
GB-SLCC	12.6	8.4	ns	4.3	0.9	15.49***	4	2.8	ns
GN-USCC	5.0	39.7	35.65***	5.3	2.3	3.55*	3.2	4.2	ns
GN-YWCC	2.1	20.7	13.24* [z]	5.8	10.6	7.38**	1.4	12.2	15.15***
GN-TDCC	16.9	38.1	5.45**	9.5	5.8	ns	7.5	8.5	ns
JN-SKJCC	20.2	18.6	ns [y]	7.2	9.0	ns	2.8	10.6	ns
JN-GNCC	1.4	6.7	5.66*	6.5	3.6	ns	4.5	17	10.97***
GN-HCSF	33.4	39.2	ns	0.8	1.0	ns	—	—	—

z *, **, *** significant at 0.1, 0.05 and 0.01, respectively.
y ns=not significant at $P > 0.10$.
Values in column contained six replicate from each golf courses and sport field (GN-HCSF), respectively.

courses and Bacillus spp. were significant difference (P=0.05) at GN-YWCC and a sport field.

Microbes of *Bacillus* spp., *Actinomyces* spp., and *Pseudomonas* spp. in soil are not pathogenic on lawns. We found that population of those microbes were higher in the soil of healthy plant than large patch. There was no evidence that high population of microbes in soil was large patch suppressive. However, we supported that might be the relationship between population of microbes in soil and occurrence of large patch.

These results suggest that excessive content of NO_3-N and NH_4-N in root zone soil

might be related to occurrence of large patch. Therefore, it may can be improve the level of controlling of large patch of zoysiagrass with reducing content of NO_3-N, NH_4-N and K in golf courses.

국문요약

골프장의 한국 잔디에서 *Rhizoctonia solani* AG2-2 에 의해 발생 되는 large patch의 근권 토양과 건전 잔디의 근권 토양 샘플을 hole cutter (diameter 10cm x 8cm deep)을 이용하여 샘플을 채취하여 무기성분과 미생물을 조사하였다. Large patch와 건전 잔디의 분산분석 결과 NO_3-N(P=0.05), NH4-N(P=0.1) 및 K(P=0.1) 함량에서 중요한 유의차이를 보였다. Large patch가 발생한 토양에 NO_3-N 함량은 9.49 mg/kg로 건전한 잔디의 토양 7.02 mg/kg 보다 높았다. 반면, NH_4-N 의 함량은 large patch 발생한 토양이 12.02 mg/kg 으로 건전한 잔디의 근권 토양 14.40mg/kg 보다 높았다. K 함량은 large patch 토양이 건전한 잔디의 토양보다 낮았다. 근권 토양의 미생물 집락 수를 조사하여 분산 분석한 결과 *Pseudomonas* spp 집락 수에서 중요한 유의차이(P=0.05)를 보였다. Large patch가 발생한 토양에 미생물의 집락 수가 건전한 잔디의 토양에 비하여 낮았다. 이들 결과는 근권 토양에 과다한 NO_3-N, NH_4-N 및 K 함량과 토양미생물의 밀도는 large patch 발병과 관련 이 있을 수 있다고 사료된다.

주요어: 질산염, 암모늄, *Pseudomonas*, 근권, 한국잔디

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