Evaluationof Phosphorus Rateand Mixing Depthonthe Growthand Establishment of Kentucky bluegrass(Poapratensis L.) in Sand-Based Systems

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모래 조건에서 캔터키블루그래스의 생장과 정착에 대한 인산의 양과 혼합 깊이가 미치는 영향

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ABSTRACT

Phosphorus (P) is one of the essential elements of the phospholipids that are involved in the formation of plant cell membranes. Phosphorus is highly immobile in soils and is often a limiting nutrient for plant growth. Phosphorus mobility and availability varies with several factors such as application frequency, placement in the soil, and the amount of irrigation or precipitation. This study was conducted to evaluate the effect of P applications at level of 0, 146, and 293 kg · ha^{-1} at four mixing depths (0, 7.6, 15.2, and 22.9 cm)on the growth and establishment of Kentucky bluegrass (*Poapratensis* L.) in a sand-based system.Grass clipping samples were collectedevery two weeks, dried, and weighed. Total root dry weight, root organic matter, and tissue content of P were measured at the end of the study. Leachate was collected weekly and analyzed for total P concentration. No difference was found between application of P to the surface and to the 7.6 cm mixing depth. However, surface application with

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146 and 293 kg P · ha^{-1} produced 8-10% and 16-20% more P in tissue than subsurface applications, respectively

Key words: clipping yield, root dry weight, organic matter, leachate, Kentucky bluegrass, *Poapratensis*L.

INTRODUCTION

Phosphorus (P) is one of the most important elements for grass nutrition (Elizabeth, 2001).). Since P is important for root growthof grass, insufficient P content is unlikely to produce a fully developed root system (Christians, 1998). Taiz and Zeigler (1991) also reported that P deficiency symptoms in turf initially included an undesirable dark green color and purple discoloration due to an excess of the plant pigment anthocyanin.

Phosphorus is highly immobile in most soils and often acts as a limiting factor for establishment of grass (Ben-Gal and Dudley, 2003). Asstarter fertilizers,P are generally applied at the time of grass establishment. Although P is highly immobile in most soils, its mobility and availability can be affected by irrigation, rainfall, application frequency, and placement in the soil profile. This can be a special problem in sand-based system, where movement into the ground water through thedrainage system may occur. This is supported by Beauchemin et al. (1998) who state that sandy and clayey sites showed the highest risk for P transfer into drains in concentrations exceeding the surface water quality standard of 0.03 mg total P · L^{-1}. Sand-based systems have improved resistance to the negative effects of compaction on root aeration and they reduce player injury (Beard, 1973). However, soil fertility management of sand-based root zones can be a problem because of leaching.

Elizabeth (2001) discovered that deep placement of P in no-till cropping systems has shown such placement to be an effective method for maximum P availability.

Limited information is available concerning leaching, uptake, or nutritional requirements of P in sand-based systems during the establishment period. This study was conducted to evaluate 0, 146 and 293 kg P · ha^{-1} at placement depths of 0, 7.6, 15.2, and 22.9 cm in a sand-based system. Clipping dry weight was collected biweekly, weighed and evaluated for P content. Leachate was collected weekly and evaluated for P content. Root dry weight and root organic matter were evaluated at termination of the study.

MATERIALS AND METHODS

This study was conducted for 12-weeks in a greenhouse at Iowa State University Ames, Iowa. The first study was conducted from November 2002 to January 2003 and the second conducted from March 2003 to June 2003.

Local mason sand that met the United States Golf Association (USGA) specification was used as the growingmedium (USGA Green Section Staff, 1993). The sand was packed into a 7.62 cm diameter polyvinyl chloride (PVC) pipe lined with a clear plastic tube. Total energy of 3.03 $J \cdot cm^{-2}$was used for compaction of the root zone. The PVC pipe was capped at the bottom and the plastic tube tied off at the base with fine holes punched to facilitate drainage. The root zone depth was 30.5 cm and the holding tube was 38.1 cm long. The columns were sodded with mature sod of 'Unique' *Poapratensis*L. Greenhouse day/night temperature was 22.2/19.4 ºC. The average light level during the 16 hr photoperiod in the greenhouse was 833.8 microEinsteins $\cdot\ m^{-2} \cdot\ sec^{-1}$.

Pellett and Roberts (1963) nutrient solution designed for cool-season grasses, minus P, was used to provide proper levels of other essential elements in the root zone. Triple super phosphate ($Ca(H_2PO_4)_2$) was used as the P source. Phosphorus was evaluated at 0, 146 and 293 kg $P \cdot ha^{-1}$and at four mixing depths (0, 7.6, 15.2, and 22.9 cm). Phosphorus was applied on 4 November 2002 and 17 March 2003. Grass clippings were taken from each tube at approximately two-week intervals. The clippings were oven-dried at a temperature of 67 ºC for 24 h and weighed. At the end of the study, root dry weight was determined by washing and oven-drying root samples at 67 ºC for 24 h (Steyn, 1959). Organic matter weight for roots was also measured at the end of the study. Oven-dried roots were ashed at 490 ºC for 8 h in a muffle furnace (Jones and Case, 1990) and then weighed to determine organic matter. Total clipping P concentration was determined by using a modified vanadomolybdophosphoric acid method (Kuo, 1990). This procedure was conducted by using a spectrophotometer (Spectronic 20+) following dry ashing at 490 °C in 1N aqua-regia. All leachate solution was collected from a cup under the PVC pipe for final nutrient analysis. Total P leaching concentration was analyzed by using a modified vanadomolybdophosphoric acid method (Kuo, 1990) and a spectrophotometer (Spectronic 20+) was used to conduct the procedure.

The experimental design was a randomized complete block design with a split-plot arrangement. The treatments were whole columns with a factorial arrangement of P rate and mixing depth as subplots, replicated four times. The data were analyzed using the t-test procedures and mean separation was performed by standard error of difference (SED) method of the Statistical Analysis System (SAS, 1987). PROC MIXED was used for multiple factor analyses of variance.

RESULTS AND DISCUSSION

No difference was found in clipping dry weight (Table 1). This is likely due to the fact that the function of P in plants is more related to energy storage and transfer and other physiological functions not directly related to tissue production (Havlin et al, 1999).

Table 1. Summary of analysis of variance from 2002 and 2003 greenhouse study about evaluation of phosphorous rate and mixing depth on the growth and establishment of *poapratensis*L. in sand-based systems.

Source	df	Total clipping dry weight	Root dry weight	Root organic matter	Total leached P	Total P in clippings
Experiment	1	NS	*	*	**	NS
Treatment	8	NS	NS	NS	NS	**
Rate	1	NS	NS	NS	NS	**
Depth	3	NS	NS	NS	NS	**
Rate * Depth	3	NS	NS	NS	NS	NS
Experiment* Treatment	8	NS	NS	NS	NS	NS

*, ** Significant at the α = 0.05 and 0.01 probability level, respectively. NS = not significant.

There were no significant differences in root dry weight and root organic matter (Table 1). The importance of P to root growth is well known and grasses with insufficient P are unlikely to produce a fully developed root system (Christians, 1998). The reason for this lack of rooting response is unknown.

No differences were found in P leached from the columns (Table 1). This varies from the observations of Larry (1999), who found that P leaching increased from 1 to approximately 14 $mg \cdot L^{-1}$ with increasing P rate from 0 to 253 $kg \cdot ha^{-1}$ in a sand-based system. This may also have been due to the very high irrigation level of 8.75 cm per week in the Larry's study (1999). Bacon and Davey (1982) and Kargbo et al. (1991) found that P mobility and availability is affected by relatively high moisture and high irrigation frequency which may lead to higher P loss than low moisture and frequency irrigation, especially in sand-based systems.

Grass treated with 293 kg $P \cdot ha^{-1}$produced 2-30% more P in the tissue than treatments of 146 kg $P \cdot ha^{-1}$, with the exception of the application placed at the 15.2 cm mixing depth (Table 2). Surface applicationsof 146 and 293 kg $P \cdot ha^{-1}$ produced

8-10% and 16-20% more P in tissue than subsurface applications, respectively. However, no difference was found between applications applied to the surface and the 7.6 cm mixing depth.

Table 2. Mean clipping phosphorous (P) (mg · kg^{-2}) of 'Unique' *Poapratensis* L. with factors P rate and mixing depths averaged over replications.

Rate (kg·ha^{-1})	Mixing depth (cm)				SED^z
	0	7.6	15.2	22.9	
Control	1758	–	–	–	103^y
146	2498	2502	2277	2308	130^x
293	2963	2871	2475	2556	

Z SED : Standard error of difference.
y Value means standard error of difference for comparison between control and the other treatment.
x Value means standard error of difference for comparison among all treatments except control.

Phosphorus sufficiency level in mature leaves range from 2000-5000ppm (Mills and Johns, 1991). The treatments in this study produced sufficient P tissue levels ranging from 2277 ppm for 146 kg · ha^{-1} at the 15.2 cm mixing depth to 2963 ppm for surface applied P at a rate of 293 kg · ha^{-1}. The untreated control resulted in tissue levels of 1758 ppm P, which is below the sufficiency level for mature leaves.Under the conditions of this study, there was no advantage to incorporating P in a sand-based media for Kentucky bluegrass sod establishment. Surface applied P increased the tissue levels of P, but had no effect on growth parameters.

In summary, grass treated with 293 kg P · ha^{-1} produced 2-30% more P in the tissue than treatments of 146 kg P · $ha^{-1}$with the exception of the application at the 15.2 cm mixing depth. No difference was found between applications made to the surface and those at the 7.6 cm mixing depth. Surface application with 146 and 293 kg P · ha^{-1} produced 8-10% and 16-20% more P in tissue than subsurface applications, respectively. There was no advantage to incorporating P in a sand-based media for Kentucky bluegrass sod establishment. Surface applied P increased the tissue levels of P, but had no effect on growth parameters.

국문요약

인산은 식물세포막의 형성과 관련 있는 인지질의 주요 구성요소이다. 인산은 토양에서 움직일 수 없기 때문에 자주식물 생장에 저해요인으로 작용하기도 한다. 인산의 이동성과 식물의 이용성은 인산의 시용빈도, 토양에서의 위치, 관수량 및 강우와 같은 다양한 요인에 따라 다르게

나타난다. 본 연구에서는 모래시공 골프장에서 인산의 시용량(0, 146, 293 kg · ha^{-1})이 인산을 혼합하는 깊이(0, 7.6, 15.2, 22.9 cm)에 따라 캔터키블루그래스의 생장과 정착에 미치는 영향을 평가하였다. 그 결과 인산은 토양표면과 7.6cm의 깊이에 시용하였을 때 통계적인 유의성이 발견되지 않았다. 하지만 헥타아르당 146과 293kg을 시용하였을 때 무처리보다 식물 체조직 내에서 8~10%와 16~20%의 인산이 검출되었다.

주요어 : 뿌리건물중, 예지물, 용탈, 유기물, 켄터키블루그래스, *PoapratensisL.*

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