PROCEEDINGS

of

1953 TURF CONFERENCE

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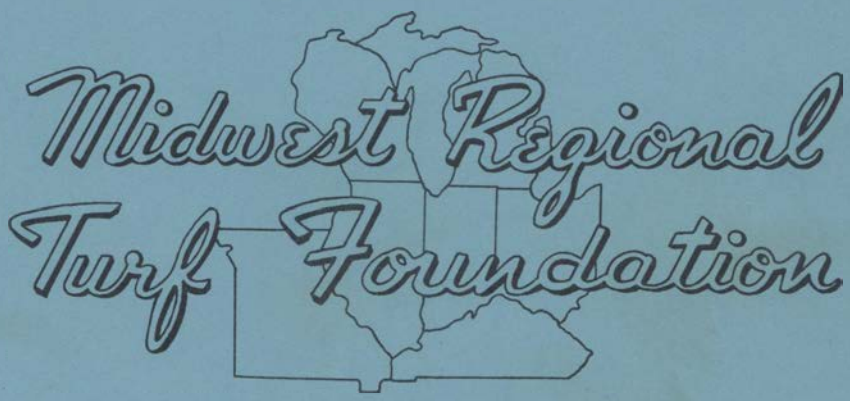

and

PURDUE UNIVERSITY

LAFAYETTE, INDIANA

March 2, 3 and 4, 1953

Table of Contents

Compiled Courtesy of

WEST POINT PRODUCTS CORPORATION
West Point, Pennsylvania

ATTENDANCE

1.	Allen, Joe	Municipal Golf Course Cincinnati 16, Ohio
2.	Anderson, Clarence W.	1907 Alabama Ft. Wayne, Indiana
3.	Anderson, Ralph T.	Madden Park Golf Course Dayton, Ohio
4.	Arcand, George	
5.	Ashworth, Victor	2301 Division Street Evansville, Indiana
6.	Baker, A. Stuart	2529 Catalpa Drive Dayton, Ohio
7.	Bailey, H. S.	2015 Colfax Street Evanston, Illinois
8.	Barron, Gerald	1400 S. Wolf Road Hillside, Illinois
9.	Becker, Richard	Walworth, Wisconsin
10.	Beckstrom, Carl	R. 1, Box 62E St. Charles, Illinois
11.	Bell, Earl	-6900 Ward Parkway Kansas City 5, Missouri
12.	Bennett, Wayne F.	R. R. 6 Box 39 Kokomo, Indiana
13.	Benson, Arthur	Aurora Country Club Aurora, Illinois
14.	Benvie, George R. Sr.	5168 Paddock Road Cincinnati 37, Ohio
15.	Berggren, Fred	Purdue University Lafayette, Indiana
16.	Bertoni, Andrew A.	Meadowbrook Country Club Northville, Michigan
17.	Bertucci, Adolph	1825 South Telegraph Lake Forest, Illinois
18.	Bertucci, Alfred J.	341 Highwood Avenue Highwood, Illinois
19.	Bild, Peter	Ogden Avenue Lisle, Illinois
20.	Bloch, Alfred	Gate of Heaven Cemetery Box 217 Montgomery, Ohio
21.	Boggs, Morgan	3532 Woodruff Avenue Lousiville, Kentucky
22.	Bohling, Harold J.	8449 Kraay Munster, Indiana
23.	Bohne, C. O.	1609 Ellwood Avenue Louisville, Kentucky
24.	Boone, Howard	Hamilton County Park Dist. Cincinnati, Ohio
25.	Borg, Gus	Illini Country Club Springfield, Illinois
26.	Born, Willard	2841 Consaul Street Toledo, Ohio

27. Boyd, Taylor	Box 21 Station M Cincinnati 27, Ohio
28. Boyer, Harry C.	Losantiville Country Club Cincinnati, Ohio
29. Brandt, James W.	306 W. North Street Danville, Illinois
30. Bretzlaff, Carl	R. R. 16, Box 641 Indianapolis 44, Indiana
31. Brown, Agar M.	Box 106 St. Charles, Illinois
32. Brown, Carl R.	
33. Buckles, Clinton	-R. R. 2 Champaign, Illinois
34. Buckley, Charles	2301 Division Street Evansville, Indiana
35. Bugh, M. L.	State Highway Commission Indianapolis, Indiana
36. Burdett, Paul E.	P. O. Box 241 Lombard, Illinois
37. Butler, Albert	R. 1 Springland Avenue Michigan City, Indiana
38. Cagle, J. C.	Speedway Golf Course Indianapolis, Indiana
39. Canale, Joseph	422 E. Walnut Street Oglesby, Illinois
40. Carter, Harold S.	1824 E. Main Street Danville, Illinois
41. Cavannagh, Max	1040 W. Michigan Indianapolis, Indiana
42. Cechanowicz, Walter	409 Griswald Detroit, Michigan
43. Chaplin, R. C.	5 No. Sleight Street Naperville, Illinois
44. Chord, Edward K.	10400 So. Christiana Chicago 43, Illinois
45. Clarke, William	2541 Prospect Avenue Evanston, Illinois
46. Clauss, Walter L.	1049 Millman Street Peoria, Illinois
47. Cleary, William A.	w. A. Cleary Corp. New Brunswick, New Jersey
48. Cleary, J. Leo	W. A. Cleary Corp. New Brunswick, New Jersey
49. Cler, W. F.	3026 Lower Huntington Rd. Ft. Wayne, Indiana
50. Coble, Clem	New Augusta, Indiana
51. Cohee, B. K.	5605 Montgomery Road Cincinnati, Ohio
52. Cornwell, Ward	1358 Anita Grosse Point 30, Michigan

53. Coval, Pete	R.R. 6 Miller Road Ft. Wayne, Indiana
54. Coyne, Mike	Glenwoodie Country Club Glenwood, Illinois
55. Crumrine, Ralph	-702 Bristol Avenue Lima, Ohio
56. Curran, Leo	5018 E. 11th Street Indianapolis, Indiana
57. Daniel, William H.	Purdue University Lafayette, Indiana
58. Davies, George	West Washington Street Indianapolis, Indiana
59. Davis, Raymond C.	Medinah Country Club Medinah, Illinois
60. Davisson, Herman T.	606 So. Grand Indianapolis 19, Indiana
61. Dettling, T. J.	43 E. Market Street Akron, Ohio
62. Dieckgraefe, Harold E.	6418 Marquette Avenue St. Louis 9, Missouri
63. Dienhart, A. P.	1913 Rosemont Street Lafayette, Indiana
64. Dietrich, Carl B.	706 N. 69th Street East St. Louis, Illinois
65. Dinelli, Frank J.	Northmoor Country Club Highland Park, Illinois
66. Doolen, Darrel	313 Blackhawk Road Riverside, Illinois
67. Dowell, Earl	615 Potomac Lafayette, Indiana
68. Drachman, P. E.	908 Lombard Evansville, Indiana
69. Drobunski, Zigmond	The Country Club Chagrin Falls, Ohio
70. Dryfoos, Sidney L.	3108 Mayfield Road Cleveland 1, Ohio
71. DuBois, Joseph H.	2418 Sampson South Bend, Indiana
72. Duehr, Edward J.	131 St. & Ridgeland Ave. Worth, Illinois
73. Dunlap, Frank	902 Caledonia Cleveland 12, Ohio
74. Dunn, Andrew C.	389 N. Delaplaine Riverside, Illinois
75. Dunn, Robert J.	Youche Country Club Box 327 Crown Point, Indiana
76. Easter, Jim	410 S.Main Street Monticello, Indiana
77. Ehlert, Kurt F.	Kenney Machinery Corp. Indianapolis, Indiana
78. Ahrich, Alfred	167th & Crawford Avenue Tinley Park, Illinois

79. Elder, Bill	1296 Conner Street Noblesville, Indiana
80. Engelhardt, Peter	Box 273 Worth, Illinois
81. Esterline, Walter	Delaware Country Club R.R. 3 Muncie, Indiana
82. Fifield, E.	1236 Rutledge Street Gary, Indiana
83. Fink, Ollie E.	1379 North High Street Columbus, Ohio
84. Forste, Clifford	Losantiville Country Club Cincinnati, Ohio
85. Gabriel, Sam J.	Cook County Forest Preserve River Forest, Illinois
86. Galiher, O. M.	-3445 N. Parker Indianapolis, Indiana
87. Gammill, H. E.	Bureau ValleyCountry Club Princeton, Illinois
88. Gilley, Angus,	R.R. 2 Connersville, Indiana
89. Goodrich, Ford	Flint Golf Club Flint 3, Michigan
90. Grant, Gilmore	Audubon Country Club 3265 Robin Road Louisville 13, Kentucky
91. Glissman, Harold	84th & West Dodge Omaha 5, Nebraska
92. Graffis Joe	407 S. Dearborn Street Chicago 5, Illinois
93. Graves, Stan	22625 Detroit Road Rocky River, Ohio
94. Grau, Fred V.	4604 Amherst Road College Park, Maryland
95. Gridley, Owen	Chikaming Country Club Lakeside, Michigan
96. Gries, George	Purdue University Lafayette, Indiana
97. Griesenauer, Gregory J.	3938 Potomac Street St. Louis 44, Missouri
98. Groezinger, F. Herman	Minerva Lake Golf Club Box 150 Westerv ille, Ohio
99. Grotti, Dominic	Sunset Ridge Road Northbrook, Illinois
100. Gruber, Calvin	Hamilton County Park Dist. Cincinnati, Ohio
101. Guyer, Ralph	631 S. Berry Road Webster Groves 19, Missouri
102. Habenicht, Carl B.	Box 258 Tinley Park, Illinois
103. Haines, Paul P.	208 Highwood Highwood, Illinois
104. Hallowell, Charles K.	303 Drexel Building Philadelphia 6, Penna.

105. Holzimiller, W. Roy	Reedsburg Country Club Reedsburg, Wisconsin
106. Hammerschmidt, T. F.	Box 103 Lisle, Illinois
107. Hannemann, H. R.	Box 164, R. R. 1 Menesha, Wisconsin
108. Harasty, Louis	Canterbury Golf Club Cleveland 22, Ohio
109. Hardy, Percy	Indian Boundry Golf Club River Grove, Illinois
110. Hart, Jack	P. O. Box 470 Zanesville, Ohio
111. Harvey, Charles W.	3920 West 71st Street New Augusta, Indiana
112. Harvey, George M.	209 S.Main Street South Bend, Indiana
113. Hayes, Thomas V.	8224 Washington Street St. Louis, Missouri
114. Haywood, Freeman Jr.	2427 Cherokee Pkwy. Louisville, Kentucky
115. Heiermann, John	401 Cecil Avenue Buchanan, Michigan
116. Helmbold, George	R. R. 11 Box 613M Dayton, Ohio
117. Heseman, Marvin E.	2301 Division Street Evansville, Indiana
118. Hibbitts, William S.	323 W. Plymouth Bremen, Indiana
119. Hinz, Alvin	White Pines, Church Rd. Bensenville, Illinois
120. Hjort, Carl H.	2224 Oriole Trial Long Beach Michigan City, Indiana
121. Hocker, Orville L.	1825 Coventry Road Dayton 10, Ohio
122. Hoffer, G. N.	American Potash Institute Lafayette Life Bldg. Lafayette, Indiana
123. Hoover, Joseph F.	R.R. 4 Urbana, Ohio
124. Hosfeld, A.	1140 Sixth Avenue Rockford, Illinois
125. Howe, Robert	8231 W. Honey Creek Pkwy. Milwaukee, Wisconsin

126. Hoyt, Walter	1611 Plainfield Rd. La Grange, Illinois
127. Huber, Lawrence	1985 Zollinger Road Columbus, Ohio
128. Hughes, Clarence C.	Rt. 4 Carmi, Illinois
129. Hull, R. B.	Purdue University Lafayette, Indiana
130. Jackiewicz, Joseph	6665 Harts Road Niles, Illinois
131. Jackson, Wallace	302 Garver Avenue Rockford, Illinois
132. Janssen, Elmer	300 Fourth Avenue Rock Falls, Illinois
133. Jelu, Robert O.	15547 Myrtle Avenue Harvey, Illinois
134. Johnson, E. F.	2049 Lake Avenue Wilmette, Illinois
135. Jones, LeRoy	1904 W. Mt. Hope Lansing, michigan
136. Jury, Ira W.	5215 Forest Hills Road Rockford, Illinois
137. Katrenics, Joe	Gary Country Club Gary, Indiana
138. Keeley, C. R.	University of Notre Dame Notre Dame, Indiana
139. Keen, Ray A.	#5 Manhattan, Kansas
140. Kelling, Henry W.	939 County Line Rd. Highland Park, Illinois
141. Kelly, Joseph B.	2205 Schuyler Avenue Lafayette, Indiana
142. Kennedy, Richard	991 N. Bolton Avenue Indianapolis, Indiana
143. Killmer, Walter	2143 Maple Road Homewood, Illinois
144. Kincaid, Samuel C. Jr.	Apt. B-3 2640 Monreo St. Toledo, Ohio
145. Kirchdorfer, Joe Jr.	1841 Gresham Road Louisville 5, Kentucky
146. Kirchner, M.	2737 N. 74th Street Elmwood Park, Illinois
147. Klomparens, Wm.	Michigan State College East Lansing, Michigan
148. Knobloch, Lawrence	Indiana Dunes State Park Chesterton, Indiana
149. Kramer, Francis J.	1008 Sherman Evanston, Illinois
150. Kramer, John F.	1008 Sherman Evanston, Illinois
151. Kramer, Michael J.	1008 Sherman Avenue Evanston, Illinois

152. Kramer, Norman W.	147 St. & 82nd Ave. Orland Park, Illinois
153. Kress, Frank G.	3200 W. Grange Avenue Milwaukee, Wisconsin
154. Kueltzo, Harry	Oak Lawn, Illinois
155. Kurek, William E.	Northmoor Golf Club Peoria, Illinois
156. Kahn, Franklin J.	1755 E. 55th Street Chicago, Illinois
157. Lambert, Robert	2802 Kenmore Avenue Dayton, Ohio
158. Lammert, Joseph F.	7650 Lammert Lane Normandy 21, Missouri
159. Lange, Henry	Glen View Club Golf, Illinois
160. Lapp, Amos	468 Locust Street West Chicago, Illinois
161. Lawson, Charles C.	526½ N. Arthur Rushville, Indiana
162. Leaming, Stewart	472 Park Valparaiso, Indiana
163. Lee, O. C.	Purdue University Lafayette, Indiana
164. Lee, Owen	1105 Oakland Avenue Muncie, Indiana
165. Leishman, Gordon	332 Elm Street Reading 15, Ohio
166. Leitch, George E.	Burroughs A/M Co. Brighton, Michigan
167. Leonard, Charles E.	R.R. #2 Marshall, Michigan
168. Leonard, C. R.	Carmi Country Club Carmi, Illinois
169. Likes, Don	3659 Brotherton Road Cincinnati 9, Ohio
170. Lindenschmidt, Robert	Hartwell Golf Club Cincinnati, Ohio
171. Linkogel, Albert	R. 1 Conway Road Clayton 5, Missouri
172. List, Marcus E.	70495 Convent Blvd. Sylvania, Ohio
173. Long, Paul J.	Emerald Hill CountryClub Sterling, Illinois
174. Longheinrich, Alfred	Rt. 23 Affton 23, Missouri
175. Loughlin, Wm. J.	Clearcrest Country Club Evansville, Indiana
176. Lundblad, Nels	814 N. Summit Wheaton, Illinois
177. Lyle, Samuel	101 Robert Avenue Ferguson 21, Missouri

178. Lyons, William E.	1843 Glenmount Akron 19, Ohio
179. MacGregor, John	660 Euclid Avenue Glen Ellyn, Illinois
180. McCarty, James A.	526 N. W. 4th Street Evansville, Indiana
181. McCoy, John S.	2501 Bedford Avenue Cincinnati 9, Ohio
182. McDermott, Joseph	1933 Brownsboro Road Louisville, Kentucky
183. McElroy, Nathan E.	220 S. Perry Lima, Ohio
184. McIntosh, Jack	Oak Hills Golf Course Palos Park, Illinois
185. McIntosh, Dave	131st & 80th Avenue Palos Park, Illjnois
186. McLaren, Malcolm	1518 Warrensville Center Rd. Cleveland 21, Ohio
187. McMullen, Malcolm H.	1042 Cottage Avenue Columbus, Indiana
188. Malikowski, Joseph	W. A. Cleary Corp. New Brunswick, New Jersey
189. Maloney, H. J.	The Upjohn Company Kalamazoo, Michigan
190. Manka, James	Purdue University Lafayette, Indiana
191. Mascaro, Tom	West Point Products Corp. West Point, Penns ylvania
192. Maschmidt, Fred W.	Normandie Golf Course St. Louis 14, Missouri
193. Mashie, Emil	Onwentsia Club Lake Lake Forest, Illinois
194. Mathews, Homer	241 Court Street Sullivan, Indiana
195. Maxwell, Joseph H.	9222 Clifton Park Avenue Evergreen Park, Illinois
196. Meetz, Ted	Michigan City Mun. Golf Course Michigan City, Indiana
197. Meisel, Lawrence J.	444 Sol Brentwood Blvd. Clayton, Missouri
198. Mendenhall, Chester	5301 State Line Kansas City 2, Missouri
199. Mendenhall, Floyd	R.R. 7 Box 267 Decatur, Illinois
200. Mendenhall, Marion	Kenwood Country Club Cincinnati 27, Ohio
201. Mesloh, Harry W.	1557 Springdale Rd. Mt. Heathy 31, Ohio
202. Michel, Avon L.	Mallinckrodt Chem. Works St. Louis, Missouri
203. Midlosko, Joseph	Curtice, Ohio
204. Mikulski, Martin	Riverside Golf Club Clintonville, Wisconsin

205. Miller, A. J.	831 Second Royal Oak, Michigan
206. Milne, William W.	7560 Oakley Park Road Walled Lake, Michigan
207. Mitchell, Vertus	212 S. Pankhill West Frankfort, Illinois
208. Modlin, Frank J.	451 Third Street Toledo, Ohio
209. Moltz , Fred	Valparaiso Golf Club Valparaiso, Indiana
210. Monical, Nelson	Portage Country Club Akron, Ohio
211. Morrer, Francis P.	865 Grove Glencoe, Illinois
212. Mossler, L. I.	Broadmoor Country Club Indianapolis, Indiana
213. Mott, G. O.	Purdue University Lafayette, Indiana
214. Mowry, David T.	2272 W. Big Bend Rd. Kirkwood 22, Missouri
215. Mueller, Adolph	Woodlawn Cemetery Forest Park, Illinois
216. Mulvenna, Alex J.	145 N. Stone LaGrange, Illinois
217. Musser, H. B.	Pennsylvania StateCollege State College, Pennsylvania
218. Myers, Wilke E.	Ohio Nat'l Life Ins. Co. Cincinnati, Ohio
219. Naughton, Dick	Lake of the Woods Golf Course Mohamet, Illinois
220. Nelson, Roy W.	2621 Jersey Avenue St. Louis Park, Minnesota
221. Niemann, Freddie	3030 W. 61st St. Indianapolis, Indiana
222. Noer, O. J.	Milwaukee Sewerage Com. Milwaukee, Wisconsin
223. Nuessle, Fred	Flossmoor Country Club Clossmoor, Illinois
224. Nugent, W. C.	Hazelden Country Club Brook, Indiana
225. Osbun, Lee	Hartley Hills Country Club Hagerstown, Indiana
226. Partyka, Edward P.	3310 Gustave Street Franklin Park, Illinois
227. Peck, Harold	Country Club Drive Battle Creek, Michigan
228. Peck, Roy	1609 Whites Road Kalamazoo, Michigan
229. Petersen, C. A.	South Shore C.C. Chicago, Illinois
230. Peterson, J. B.	Purdue University Lafayette, Indiana

231. Phillips, Raymond — Louisville Country Club, Louisville 6, Kentucky

232. Pieper, Walter — -Matteson, Illinois

233. Pion, Argel L. — R.R. 1 Leo Road, Ft. Wayne, Indiana

234. Plahm, Fred — 8201 W. 95th Street, Palos Park, Illinois

235. Plein, Clarence — 1139 Hilltrop Drive, St. Louis 14, Missouri

236. Plent, Richard A. — 5041 Lee Road, Maple Heights, Ohio

237. Polillo, George — 495 West Tompkins, Galesburg, Illinois

238. Porter, Arnold — R. 9 Box 77, Indianapolis, Indiana

239. Prieskorn, Harold C. — 4535 Brighton Road, Brighton, Michigan

240. Prieskorn, Robert — 721 Venoy Road, Wayne, Michigan

241. Quarandillo, Louie — Benton Country Club, Fowler, Indiana

242. Radko, Al — U.S.G.A. Green Section, Beltsville, Maryland

243. Ragan, Walter — 703 Kirk Avenue, Kirkwood, Missouri

244. Randby, Chester H. — Knollwood Club, Lake Forest, Illinois

245. Reynolds, A. J. — Miami Valley Golf Club, Dayton, Ohio

246. Reynolds, Dick — 3300 Wheibanther, Dayton, Ohio

247. Reynolds, George H. — 727 David, Dayton, Ohio

248. Riddell, Homer P. — 3760 Broadway, Indianapolis, Indiana

249. Riley, William F. — 2121 Madison Avenue, Indianapolis, Indiana

250. Rinaldi, Anthony — 1623 Sunview Road, Cleveland 24, Ohio

251. Roach, W. J. — Wyoming Golf Club, Cincinnati 15, Ohio

252. Rolfs, Raymond — 308 Hilcrest Avenue, Menomonee Falls, Wisconsin

253. Roseman, Warren J. — 2610 Ridge Road, Evanston, Illinois

254. Rost, Bert — Park Ridge Country Club, Park Ridge, Illinois

255. Runyan, C. R. — 4709 Winton Road, Cincinnati 32, Ohio

256. Ruthven, W. H. C. — Box 118 Alliston, Ontario, Canada

257. Salisbury, A. M.	445 So. Court Street Crown Point, Indiana
258. Savage, Phil	817 Symes Street Royal Oak, Michigan
259. Schacht, Robert	Country Club of Terre Haute Terre Haute, Indiana
260. Schery, Robert W.	515 Dougherty Ferry Kirkwood 22, Missouri
261. Schmatzmeyer, August H.	217 Shirley Ferguson 21, Missouri
262. Schneider, E.	3325 Bexley Court Evansville, Indiana
263. Schramm, Melvin	R.R. 3, 201st & Ash Chicago Heights, Illinois
264. Schultz, W. J.	New Albany Country club New Albany, Indiana
265. Schurtz, Joseph O.	914 Old Main Street Miamisburg, Ohio
266. Scobee, Marvin K.	Highland Golf Club 5555 Grandview Drive Indianapolis, Indiana
267. Seabury, R. F.	813 W. Douglas Street Jacksonville, Illinois
268. Seaney, Wm. L.	809 Fairview Avenue Crawfordsville, Indiana
269. Sehrt, Ralph W.	Manchester, Missouri
270. Sellers, Everett	North Shore Country Club Glenview, Illinois
271. Shafer, George	Hartley Hills Country Club Hagerstown, Indiana
272. Shields, Willie	636 Cherokee Station Louisville, Kentucky
273. Shock, Earl	2560 Berkley Drive Dayton 9, Ohio
274. Shryack, Lawson G.	1241 E. Wheeler Macomb, Illinois
275. Simmons, Howard E.	Highland Park Golf Course Cleveland 22, Ohio
276. Simon, E. J.	R. R. # 1 Rockford, Illinois
277. Slocum, Gerald W.	1015 Market Street St. Jospeh, Michigan
278. Smith, colin	19512 Kings Highway Warrensville Heights, Ohio
279. Smith, William R.	1127 Miller Avenue Oak Park, Illinois
280. Sopko, Mike	37501 Jordan Drive Willoughby, Ohio
281. Soutar, Jim	Bloomington Country Club Bloomington, Indiana
282. Sprenger, Fred C.	709 Bigelow Street Peoria, Illinois

309. Updegreff, W. E. — Wichita Country Club, Wichita, Kansas

310. Urzywski, Frank — 706 Evesham, Toledo, Ohio

311. Van Scoik, Wm. S. — 1018 Maxine Street, Ft. Wayne, Indiana

312. Vaughan, Ed. — P. O. Box 128, Park Ridge, Illinois

313. Vaughn, J. H. — 1016 Parker Avenue, Indianapolis, Indiana

314. Vaughn, J. R. — Michigan State College, East Lansing, michigan

315. Vaughn, Thomas L. — Hillcrest Country Club, Indianapolis, Indiana

316. Volk, N. J. — Purdue University, Lafayette, Indiana

317. Wakely, Ted — Chippwea Country Club, Curtice, Ohio

318. Wareham, James A. — 347 First Street, Batavia, Illinois

319. Warren, B. O. — Warren Turf Nursery, Palos Park, Illinois

320. Warren, R. M. — 8400 W. 111th Street, Palos Park, Illinois

321. Watson, J. R. — Toro mfg. Company, Minneapolis 6, Minnesota

322. Weidenfeller, Ted A. — St. Charles, Illinois

323. Whitaker, Lyman B. — 4525 Marcy Lane, Indianapolis, Indiana

324. White, Maurice — 1906 Indiana Avenue, Peoria, Illinois

325. Whitfield, J. Sidney — R.R. 14, Box 191, Indianapolis, Indiana

326. Whittle, J. D. — Fox Valley Cout. Club, Batavia, Illinois

327. Willard, Geo. N. — West Frankfort, Illinois

328. Willcox, Ward W. — 807½ South Street, Piqua, Ohio

329. Williams, Robert M. — 87th & Southwestern Avenue, Chicago, Illinois

330. Wilson, Floyd D. — Anderson Country Club, Anderson, Indiana

331. Woehrle, Herman — Kankakee Valley Country Club, St. Anne, Illinois

332. Woehrle, Theordore — Purdue University, Lafayette, Indiana

333. Wolfe, Larry — Rosemont Country Club, -Akron, Ohio

334. Wolfrom, Clarence — 11341 Chicago Road, Warren, Michigan

335. Wollenberg, Edwin	21707 Locust Street Matteson, Illinois
336. Wright, Leland	1125 Lincoln Avenue New Castle, Indiana
337. Wyman, Allan	509 Lafayette Avenue Danville, Illinois
338. Wysong, Al	R.R.#1 Monticello, Indiana
339. Yaw, Lowell D.	1219 Prospect Mishawaka, Indiana
340. Young, Eben P.	4521 No. Colorado Indianapolis, Indiana
341. Young, O. W.	1130 Stroop Road Dayton 9, Ohio
342. Zanzig, Kenneth R.	8935 So. May Street Chicago 20, Illinois
343. Zellner, Charles F.	Avon Fields Golf Course Cincinnati 25, Ohio
344. Zimmerman, W. E.	150 Overlook Terrace Bloomfield, New Jersey

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PRINCIPLES OF TURF RENOVATION

A. M. Radko
USGA Green Section

When we think of the principles involved in overseeding turf areas in need of renovation, we think a great deal of the principles involved in seeding into a newly prepared seedbed. The primary difference is that in overseeding turf areas, we think in terms of keeping the area in constant usage. Therefore, we attempt to limit the disturbance of the soil to a minimum to save the good grasses which have survived and also to provide some sort of a playing surface until the new seeding comes through.

Before we consider the necessary steps in the overseeding of turfed areas, it would be wise to analyze the problem and find the reasons why the turf is in need of renovation. What caused the poor stand of turf in the first place? Was it due to poor drainage, compacted physical condition of the soil, insects, disease, poor fertility level, water management, unadapted grasses, poor management and maintenance practices? If poor turf cover was due to any one or several of these reasons, corrective measures should be taken before any attempt is made to improve the area by overseeding.

Plan the renovation problem well in advance so that all the necessary steps may be done properly and in proper season. The fall of the year is the best time to renovate a turf area with cool-season grasses. Consult with turf specialists from the State Experiment Station and the College or Universities in order that you may have the best possible advice to begin with. Usually a turf area in need of renovation is weedy; therefore, proper treatment with herbicides to eliminate or to check these weeds is the first logical step toward renovation. It is often the best procedure to plan to apply the weed killers in two or three applications 7 to 10 days apart. In this way the desirable turf grasses may be saved and the weeds should be severely set back or eliminated.

Prior to this time it would be wise to take soil samples to determine the pH, phosphorus and potash levels of the soil. Based on the results we should apply the necessary nutrients for optimum root growth. If the lime could be applied well in advance of the seeding, it should be so done.

The next step in renovation is to use some device to loosen the soil, to bring as much soil to the surface without disturbing the top layer of soil or the existing turf to any great extent. How much or how this is accomplished is a matter open to discussion, but we have found that the more loose soil with which the seed comes in contact, the better the results, There are many aerating devices on the market today which are being used for this purpose. Many of you may have some special equipment that you may prefer to use. Following the aerating devices, it is possible to drag with a chain link fence to crumble the cores of soil brought to the surface. In this way we create a firm but not a compacted seed-bed.

The next step is to choose the proper seed mixtures--grasses that are adapted for the particular conditions under which they are to grow and for the specific use to which they are put. Seed mixtures for area which are watered will differ from seed mixtures recommended for unwatered areas. Height of cut also is a determining factor in selection of seed mixtures - it is useless to try to establish a good stand of common bluegrass and fescue on areas which are to be cut close. Therfore, not only do we have to select the right grasses, but we also have to have the proper quantities of each to provide the type of turf desired. There are wide differences in the number of seeds per pound between grass species, which is an important consideration in determining percentages of each grass in mixture. Table I taken from the USGA'S book of "Turf Management" by H. B. Musser, shows the important turf grasses. When you consider grasses that make the growth that bermudagrass, the zoysia grasses, and Merion bluegrass make in one growing season, it appears that we are wasting a lot of good seed.

TABLE I

Quality Characteristics of Good Turf Grass Seeds

	Min.% Purity	Min.% Germin.	Approx. No. seeds per Lb.	Viable seeds per sq.ft. when sown at rate of 1 lb. 1000 sq. ft.
Kentucky Bluegrass	95	85	2,250,000	1,800
Merion bluegrass	98	80	2,500,000	1,950
Colonial bentgrass	95	90	7,000,000	5,950
Chewings and red fescue	95	85	600,000	480
Kentucky 31 fescue	95	90	500,000	430
Zoysia (Z-73) japonica	95	95	1,000,000	900
Bermudagrass	95	85	1,750,000	1,400
Ryegrass	98	95	275,000	260
Redtop	95	90	5,750,000	4,890

Table II shows how the number of seeds vary per pound when different percentages of the same grasses are considered. These figures are representative of the way these proportions work on paper; under practical conditions we know that there is a certain percentage of each grass which will not survive. Therefore, the figures shown may be decreased further, by as much as one-third, under practical conditions. The approximate ratios shown tell an interesting story when compared with the percentages of each grass in mixture.

Table II

Number of Viable Seeds per square foot of grasses, indicated in mixture sown at the rate of one pound per 1,000 square feet.

Mixtures by Percent Weight	Number of viable seeds per sq. ft. Kentucky Bluegrass	Creeping Red Fescue	Colonial Bentgrass	Totals	Total seeds per Sq. In.
30% Ken. Blue 60% Crep. Fes. 10% Col. Bent	545	291	599	1435	9.9
Approx. Ratio	2	1	2		
60% Ken. Blue 30% Crep. Fes. 10% Col. Bent	1089	145	599	1833	12.7
Approx. Ratio	8	1	4		
10% Ken. Blue 30% Crep. Fes. 60% Col. Bent	181	145	3591	3917	27.2
Approx. Ratio	1	1	23		

These figures are based on the following number of seeds per lb.

Kentucky Bluegrass	2,250,000	(purity 95%-germination 85%)
Creeping Red fescue	600,000	(purity 95%-germination 85%)
Colonial Bentgrass	7,000,000	(Purity 95%-germination 90%)

The normal rate of seeding recommended is 2 lbs. per 1000 sq. ft. When the improved grasses are used by experienced turf men reduced rates of seeding are advisable.

The normal rate of seeding recommended is 2 lbs. per 1000 sq. ft. When the improved grasses are used by experienced turf men reduced rates of seeding are advisable. For fairway or other large scale plantings the rate of 2 lbs. per 1000 sq.ft. normally is excessive, 50 to 75 lbs. per acre should suffice.

Fertility level is closely tied in with the establishment of new turf. In general, a heavy rate of fertilizer with a low rate of seeding is more effective in producing a good turf than a heavy seeding rate with or without a heavy rate of fertilizer. Ike Rabbitt's work, back in 1939, was a striking example of the role of fertilizer with various seeding rates. These trials under Beltsville conditions showed that best results were obtained where seeding rates of one, two, and three pounds of Kentucky bluegrass seed to 1,000 square feet and fertilizer at the rate of 4 pounds of nitrogen was applied. The plots seeded more heavily were very badly diseased during the following summer and a serious infestation of weeds resulted. Too, the competition between plants for water, air, and nutrients on the heavily seeded plots resulted, in higher mortality rates and poorer turf.

Time of seeding is another important consideration. It is generally agreed that fall seedings give best results with cool season grasses. Seedings made early enough to allow the seedling plants to germinate and become established before cold weather arrives, are best. At this time competition from weeds is slight. On golf courses and athletic fields fall seedings are not always possible. Often times spring seedings must be made as necessity or playing, schedules dictate. Spring seedings usually become heavily infested with weeds - the seedling plants hardly become established when they become dormant, and weeds take over. Spring seedings are especially difficult throughout the so-called crabgrass zone.

In summary all the factors contribute to the degree of success attained in overseeding or renovating an area. Each factor is in itself an important one; when considered as a group the chances for failure are multiplied unless each individual factor is carefully planned and executed.

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NITROGEN FERTILIZERS FOR TURF

H. B. Musser
Pennsylvania State College

The problems of turf fertilization differ materially from those encountered with most other crops. This is because in the case of turf we must have a program that will provide adequate quantities of available nutrient materials straight through the entire growing season. There is no resting period nor time when utilization slows down as maturity of the crop approaches.

Nitrogen is the element of greatest concern in this connection because it usually gives the important growth producing results.

The proper use of nitrogen fertilizers first requires an ability to recognize the need for it. The most common evidences are:

1. Lack of good color in the turf.
2. Encroachment of clover and weeds.
3. Increase in disease incidence (dollar spot).
4. Reduced growth rate.
5. Results of plant tissue tests.

The proper use of nitrogen fertilizers also requires a recognition of differences in its character in different fertilizers and the difference in response we get from the various kinds. The nitrogen we use may be in a number of chemical forms. The practical difference between these is in the availability of the nitrogen how fast the grass roots can get it.

On this basis the various kinds are classified into:

(1) Quickly available, and
(2) Slowly available

This is an important distinction because it determines the way in which any particular material must be used.

The quickly available types are those that release all their nitrogen for use by the grass immediately or very soon after (a week to 10 days) they are applied. Ammonium sulfate, ammonium nitrates, urea, and the various liquid fertilizers belong to this group. The period of time during which they will supply adequate quantities of nitrogen to the grass depends primarily

upon how fast the grass is growing and so makes use of them and whether there is sufficient water going down through the soil to carry them away in the drainage water.

The slowly available forms include the natural organic and such other materials as must be decomposed by decay organisms in the soil before the nitrogen which they contain becomes usable by the grass. Since decay is usually a gradual process such materials yield smaller quantities of usable nitrogen at any one time, but supply these amounts over a much longer period than is ordinarily experienced with the quickly available forms. Commonly used slowly available forms include, the conditioned sewage sludges such as Milorganite, prepared tankages like Agrinite, the seed meals as soybeans and linseed, and synthetic products such as urea-formaldehyde formulations.

The important practical question is whether there is enough actual difference in the effect of these two classes of materials to justify taking it into account in making nitrogen applications.

In field trials where the two classes have been compared by the Pennsylvania Agricultural Experiment Station over the 6 year period 1947-1952, very marked and consistent differences in their effects have been secured.

In these tests total annual rates of from 2 to 6 pounds of nitrogen per 1,000 square feet have been used. Their effects have been measured by the quantity of clippings each produced at each mowing throughout the growing season and by the periods in which the greatest quantity was produced. The overwhelming weight of evidence shows that the quickly available kinds of nitrogen produced practically all of the growth increase during the six to eight week period immediately after their application. The slowly available forms produced less growth at any one period but extended the improvement over a much longer time.

This is a tip off on the way these different forms must be handled. Where quickly available kinds are used they must be applied in lesser quantities and at more frequent intervals.

Other items also must be considered in nitrogen use. Rates of application are important, but they depend entirely on the needs of the individual turf area. Since needs depend so much on weather, kind of grass

and similar things it is never safe to set up an arbitrary figure in a nitrogen fertilizer program. About as far as we can go is to recognize that it always will be wise to use much less at any one application if we are using a quickly available type when we are depending upon a slow form. Probably a safe ratio would be from 1/4 to 1/5 as much.

This immediately raises the question of how far we can go in the direction of maximum quantities. Here again, good judgment is needed, because of soil, grass and weather differences. Certainly we can and should use more on intensive areas such as putting greens than on slower growing turf areas such as fairways and lawns. But we should recognize that too much is just as dangerous as too little. This is particularly true if we get an overdose during unfavorable weather conditions. Excesses may, and usually do, result in such things as increased damage from hot weather due to soft grass, increased injury from diseases such as brown patch and pythium, and, in many cases, large losses of the nitrogen itself.

Some attention should be given in the use of nitrogen for new seedings. In this case it does not seem to make so much difference what form is used, although it would seem wise to balance the application so that at least equal quantities of slow and quick acting, materials are applied. One of the most important considerations is to be sure that the seedlings have enough in the shallow soil zone so that they are not checked by deficiencies where seedings are made at the optimum times, early fall or early spring. Tests at the Pennsylvania Experiment Station have shown that the more nitrogen that has been used, up to a rate of 12 pounds per 1,000 square feet, the quicker and better turf establishment there has been. While this is no indication that the same quantities could be used to advantage under other conditions, it does point up the fact that it will pay dividends not to starve turf at the start.

These then are some of the things that must be taken into account in the use of nitrogen on turf. It can be dynamite. Because of its tremendous effects it must be handled cautiously and properly to get the desired results with it.

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INDUSTRY AND TODAY'S TURF

W. H. Daniel
Dept. of Agronomy, Purdue University

Many of you recall the prerequisite of a laborer on a turf area was that he be able to push a hand mower. We admit that several changes have been made and the complications of maintaining turf areas becomes increasingly complex. Nor do we expect this trend to change back to the time when a man just pushed a hand mower.

Behold the turf superintendent of today. He has so many materials, chemicals, gadgets, fertilizers, fungicides, and planting materials available that it appears somewhat like a mirage in a desert. He is now an executive, he should be informed, he is many things as Frank Dunlap so ably described for you two years ago. Who are his helpers?

Industry - in this word I include the manufacturers, the seed growers, the nurserymen, the distributors and their salesmen - has and is expending a great amount of effort toward the production of new materials and their incorporation into your turf management programs. Look at 2,4-D for a moment. The testing, widespread use and common acceptance of it since 1946 is an example of how industrial production affects you. Look at the development, increased use and acceptance of the various turf cultivating equipment. It isn't a haphazard development anymore. It is industry, experiment stations and turf superintendents cooperating.

There is one very important trend in today's turf activities. Today the distributor and his salesmen are an integral part of the local organization for turf improvement. He no longer is interested in turf just because he has a mower to sell. As his variety of merchandise widens and as his clientele enlarges, he becomes a technical man just as the superintendent and it behooves him to be better informed than his customers.

The distributor has a wonderful opportunity to observe and serve. Through the day to day contacts, often on the turf area, the superintendent shares his problems and successes. As the observation grows and the information gained from repeated observations increase the salesman has increased value to his organization and his customers.

Let's list some materials available today for turf use. How much are you able to help your customers on them?

New labor saving equipment - aerifiers, sprayers, sod cutters.

Fertilizers developed for safety, ease and results in application.

Dry - How much more economical? What limitations?

Pelleted - as ammonium nitrate, ammonium nitrate and lime.

Soluble - To be used in liquid applications.

Liquid - What are the comparative price and advantages?

New varities of grasses -What will they do and not do? 2,4,5-T alone or combinations for brush or clover control.

Cyanamid for seed bed weed seed removal.

Methyl bromide for quick(48 hours)seedbed sterilization

P.M.A., Potassium Cyanate, for crabgrass control.

Sodium arsenite at low rates for weedy grass inhibition Polycross bentgrass for over seeding, for new putting greens

Merion bluegrass for new lawns, for special uses.

The attendance of so many of you from industry here today is an indication of your recognition of the responsible helpful service you are rendering to turf supervisors. More and more our turf research program is planned to work with industry and their products toward developing better turf. It only follows that when all interests are learning, sharing ideas and working together that turf improvement is the final result.

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A QUARTER CENTURY OF SOIL TESTING

O. J. Noer
Milwaukee Sewerage Commission

Soil testing is a useful tool in turf management, but its purpose is misunderstood by many laymen. Whenever anything happens to the turf, or when it is poor, the layman clamors for a soil test first. Although fertilization is the most important single factor in the production and maintenance of turf, other factors are involved and are vital also. After they have been made favorable, fertilizers will do the job expected of them.

The factors upon which growth depends are listed below. Only when all are favorable is optimum growth obtained. They are:

1. Selection of grasses suited to local climate weather.
2. Sufficient light - or use shade grasses or other cover.
3. Favorable air temperatures.
4. Protection from injury - mechanical, insects, diseases.
5. Follow sound maintenance practices.
6. Good soil environment.
7. Favorable soil reaction.
8. A fertile soil with ample nutrients.

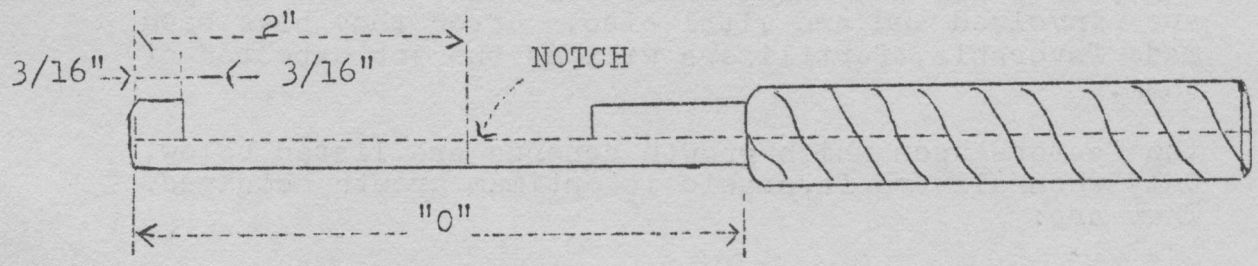
Frequently one and often several may be unfavorable. Eliminating one may effect a noticeable improvement, but best results are secured when all are made favorable. It may be likened to the capacity of a barrel, as depicted in Table I. The amount of water it can hold is governed by the shortest stave. As each short stave is lengthened the next shortest determines the capacity. The same thing is true of plants.

When one plant food element is in very short supply growth is necessarily meager, and other needed elements may be plentiful. But when the extreme deficiency is corrected by an application of fertilizer, plant growth is accelerated and the demand for other plant nutrient elements is increased. This may create a new deficiency in one or more elements; a fact which should never be overlooked.

Collecting Samples is Important: Proper sampling is very important. Tests may give misleading information

unless the samples are truly representative. Each sample must be a composite of eight to ten plugs. All plugs should be uniform in diameter and taken to an exact depth. We have standardized on EXACTLY two (2) INCHES for reasons which will be explained later. Moderate size samples cut mailing cost and simplify laboratory preparation for testing. The sampler illustrated below is a good one.

SOIL SAMPLER - made from a golf club shaft



Select a shaft with a heavy sidewall and grind out the slot on an emery wheel. Have the slot extend slightly below the center line - lengthwise of the shaft O to facilitate removal of the soil plug. Make the cutting edge 3/16". File a mark exactly two inches from the lower end so soil plugs will be exactly two inches.

Use a CLEAN, New container for each sample. Small paper bags (1/2 or 1-pound size) can be obtained at any grocery store. Label the outside PLAINLY with a soft lead pencil. Ink or hard lead are unsuitable. Besides name of club or owner, state whether from tee, green, fairway, lawn, etc., and give the number and designate the spot sampled (landing area, approach, northeast corner of lawn, etc.)

Samples must be reasonably dry for mailing, otherwise containers break in transit, or labels become unreadable. Never use ARTIFICAL HEAT for drying.

GREENS AND TEES: One composite sample from each is ample. Only four or five from the entire course will suffice when the soil and turf are uniform.

FAIRWAYS AND LAWN AREAS: Variations in soil, topography, and turf determine the number of composite samples to collect. On level areas of uniform soil and turf from four to six samples are enough. They should be from widely separated spots on the course or lawn. Otherwise collect two to four composite samples for each variation of soil, topography, or turf. The soil in each composite should be from the same elevation, and should be uniform in color and texture.

When sampling a localized area of poor turf, collect another sample from a nearby spot of good grass.

Include information about drainage, kind of grass, maintenance, watering and fertilizer practice.

Test for Soil Reaction and Plant Food Elements: Soil tests are designed to determine possible need for lime, and to estimate the amount of water soluble and immediately available nutrient elements in the soil. Phosphorus, potassium, calcium, and magnesium are customarily determined. The results serve as an inventory of soil fertility levels. When used that way, soil tests are a useful guide in devising an effective--fertilizer program.

Organic Matter and Nitrogen: Some laboratories test for organic matter and nitrogen. Plant tissue tests are more promising than soil tests for nitrogen because none of the existing soil methods are satisfactory for grassland areas. Need for nitrogen can be judged by the behavior of the grass. Poor color, thin turf, slow, rate of growth, and the presence of weeds and clover, are the customary signs.

TESTING SOIL REACTION AND LIME USAGE

Quick tests are good Enough for Soil Reaction: Field testing with any one of several inexpensive test kits which are quite accurate is satisfactory for the purpose of judging lime requirements. The solutions should be resonably fresh, or the results may be inaccurate due to the effect of the glass on the reagent. The pH will be too high unless the glass bottle used for the solution has been "weathered" by the manufacturer of the set. The indicator solution should remain in contact with the soil for a sufficient time to develop maximum color before it is matched with the color chart.

The tests express soil reaction in terms of pH, (potential of hydrogen). The scale is from 0 to 14,

with 7 as the dividing point or neutrality. Figures below 7 represent increasing acidity, and higher ones increasing alkalinity. Each figure differs by a multiple of 10, so pH 6 is ten times, pH 5 is one hundred times, and pH 4 is one thousand times more acid than neutral.

Soils fall in the range of pH 4.0 to pH 8.5, but more commonly within the narrower limit pH 5.0 to 7.5. Most grasses grow best in the range pH 6 to 7.5.

Soils which are more than moderately acid, that is below pH 5.7 definitely need lime and its use is justified without regard to any other factor.

Lime may be beneficial when the soil is slightly acid, in the range of PH 5.7 to 6.2, particularly when Kentucky blue grass predominates. But the large scale use of lime can await the outcome of trial applications on test strips, particularly when the soil is not more than slightly acid. Strips across a fairway or lawn measuring 10 x 100 feet are a convenient size and contain 1,000 square feet. Rates of 25, 50, and 100 pounds are equivalent to 1/2, 1, and 2 tons per acre. For similar tests on greens the first two rates can be used on areas of 1,000 square feet, or 2-1/2 and 5 pounds on 10 x10 foot plots, or 100 square feet.

Determinations of Calcium and Magnesium on Acid Soils: When soils are sufficiently acid to need lime, it is desirable to determine the quantities of available calcium and magnesium. If calcium is very low, heavier liming is justified and would otherwise seem necessary. The determination of magnesium is more important. Some acid soils are so deficient in magnesium that plant growth is depressed as a consequence. Then a dolomitic type of limestone should be applied. Besides correcting acidity, dolomite provides magnesium. One containing not less than 20 to 30 per cent magnesium, reported as the oxide should be used.

When magnesium is less than 1,000 pounds per acre by the Truog Method, a soil deficiency is likely and probable. Calcium is less important, but the range, should be 4,000 to 6,000 pounds or more.

Soil Texture and Kind of Grass Affect Rate of Application on Fairways and Lawns: The rate of applying lime is affected by the kind of soil and grass. Less lime is needed on sandy soils than on a loam or clay to produce the same change in pH. Kentucky blue grass requires more lime than fescue or bent grass. These

factors, beside pH, are taken into account in Table II.

Lime on Greens: The use of lime on greens should be based upon the soil pH. A finely ground limestone is the safest and easiest form to apply. A dolomite of high magnesium content should be used when soil tests show a low content of available magnesium (1,000 pounds or less by the Hellige-Truog method). Suggested rates are given in Table II.

Kind of Lime: The figures in Table II are for fine to medium ground limestone, and should be increased 25 to 50 per cent for coarser material. The rate for hydrated lime should be reduced by 25 to 30 per cent, because 74 pounds of hydrated lime are equivalent to 100 pounds of pure ground limestone in neutralizing, value. Hydrate is apt to burn and is not safe to use on greens at rates above 5 to 10 pound per 1,000 square feet. Even then it should be applied in late afternoon and watered-in early the following morning.

Mention has benn made of the wisdom for using a dolomitic lime of high magnesium content on soils which are low in available magnesium.

TESTING FOR PLANT NUTRIENTS

Much of the criticism about soil testing is justified because of poor sampling, or the use of a method which is not suited to specialized turf areas. The interpretation of the results is important also. What may be an adequate level of phosphorus and potassium for fairways may not be enough for greens.

Basis of Different Methods: The commonly used tests, such as Purdue, Truog, Morgan, Spurway, or Edwards, etc., differ essentially in the strength of the solvent used to extract the soil nutrients. A small amount of soil is extracted for a definite period of time. The solution dissolves all the water-soluble nutrients, and the easily soluble ones which are readily available to plants. Some of the solvents are too weak for grassland areas. Then the tests may not show any difference and fail to distinguish between soils with a high and low level of phosphorus and potash. The test may shown an acute need which isnot borne out in the field.

Results Obtained on Same Soils with Three Methods: Soil samples were collected to a uniform depth of 3 inches from three fairways at Pickwick and Evanston Golf Club in Chicago. Phosphorus was determined by the Truog, Purdue, and original Spurway method. Purdue and Spurway use designations very low, high, etc.,and Truog

reports pounds per acre with 75 pounds being enough for fairways and lawns. The soils are dark colored silt loams in each instance. The results are as follows:

		Truog	Purdue	Spurway
Pickwick	A	10 lbs.	V.L.	L.
	B	10 lbs.	V.L.	V.L.
	C	25 lbs.		L.
Evanston Golf Club	A	90 lbs.	H-	None
	B	90 lbs.	H-	None
	C	100 lbs.	H-	None

Phosphorus was low with all methods at Pickwick and grass responded to its use. At Evanston the Truog and Purdue methods showed an adequate supply - which was borne out in practice. Spurway method showed an acute deficiency. Similar results were obtained with potassium tests.

These results show the necessity for using a good method, one which distinguishes between a soil of low, and one of high content of phosphorus.

As a result of these and other results which were submitted to Dr. Spurway by us, he prepared a stronger solvent and suggested using it on soils showing low results with the original solvent, which is essentially water. Duplication requires extra work when many samples are tested during the course of a year.

Methods of Reporting Results: For simplicity and convenience, most laboratories report results as Very High, High, Medium, Low or Very Low. Although these terms appeared to the layman, they are misleading as ordinarily applied. Fertility levels should be higher in greens than fairways because clippings are removed and growth is maintained by more frequent and more generous watering.

By reporting the amounts as pounds per acre, it is possible to establish different levels for fairways, and greens. Our laboratory uses this method for that reason. With the Truog method fairway samples should contain 75 pounds phosphorus and 175 pounds potash per acre. The corresponding figures for greens are 200 to 300 pounds for phosphorus, and 300 to 400 pounds for potash.

When available magnesium is below 1,000 pounds per acre

there may be a soil deficiency in this element, as pointed out elsewhere.

Depth of Sampling Very Important: Two samples tkaen at the same spot but to different depths will contain different amounts of available phosphorus and potash. The deeper sample contains the least. To obtain consistent results and to show and follow trends, it is necessary to take samples to exactly the same depth at all times. It is why we standardized on 2 2 inches.

The amounts of phosphorus and potash decrease sharply with depth on grassland areas because the soil is not disturbed after turf coverage is obtained. Both are fixed near the surface. Failure to appreciate this fact has been responsible for misleading results even with the better soil testing methods.

Variation in Phosphorus With Depth: Samples were taken on a fertilizer plot at Blue Mound Country Club in Milwaukee to depths of 1-1/2, 3, and 4 inches. Available phosphorus was determined by the Truog method. The results were as follows:

1-1/2 inches - 65 pounds
3 inches - 35 pounds
4 inches - 25 pounds

Phosphorus is reasonably good in the 1-1/2 inch sample (75 is considered adequate), but it would be considered low in the 4-inch sample. Yet samples were collected from the same spot.

Fixation of Applied Phosphate: Superphosphate was applied in spring and again in the fall on plots at Tuckaway Country Club in Milwaukee. Our plot received 600 pounds, and the other 1,200 pounds in total amounts of 20 per cent grade superphosphate per acre.

The original turf was exceedingly poor, but no noticeable improvement occurred as a result of phosphate or potash applications. However, heavy nitrogen feeding, produced tremendous improvement.

Samples were taken from each plot representing depths of 0" to 1", 1" to 2", 2" to 3", and were tested by the Truog method. Results show that most of the phosphate was fixed in the top two inches of soil.

Depth	Check	600 lbs. S.P.	1200 lbs. S. P.
0" - 1"	70 lbs.	100 lbs.	140 lbs.
1" - 2"	40 lbs.	65 lbs.	80 lbs.
2" - 3"	25 lbs.	45 lbs.	55 lbs.
0" - 2"	55 lbs.	82½lbs.	110 lbs.

By sampling to a two-inch depth results correspond to the phosphate usage. It is the basis for our decision to take 2" samples.

Accumulation of Phosphate in Bent Greens: Attention has been called to the fact that many greens are becoming low-grade phosphate mines. Ordinarily our laboratory does not show amounts above 800 pounds per acre because it necessitates considerable extra work. In some instances the exact amount has been determined. They are exemplified by the following results from greens at Joe Allen's two courses. Available phosphorus is given as pound per acre in samples taken to a 2-inch depth and tested with the Truog method.

Green No.	California Golf Course	Avon Fields Golf Course
1	1,875lbs.	3,300 lbs.
5	2,700 lbs.	1,250 lbs.
9	2,800 lbs.	3,900 lbs.
13	2,875 lbs.	3,775 lbs.
17	2,000 lbs.	4,050 lbs.

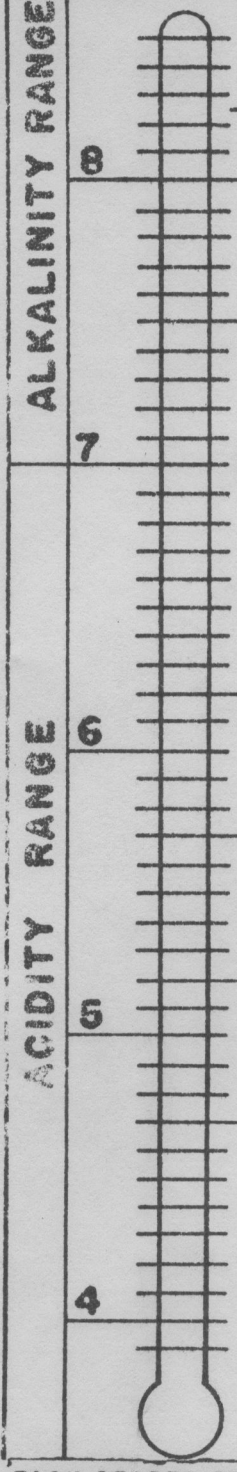
Avon Fields is the older of the two courses.

Soluble Salts: Damages may result from a high concentration of soluble salts, usually chlorides and sulphates, but carbonates as well in the semi-arid regions. Troubles are most common in spots where underground or other sources of water have a high content of chlorides and sulphates. Grasses have trouble absorbing water and nutrients, especially in hot weather when soluble salts are high. Failure of seed to germinate is one of the first signs.

At Southern Hills in Tulsa, Oklahoma, tests showed the soil in the greens to be high in soluble salts, especially chlorides. The backwash from the water softener was blamed in part. It was discharged into the pond from which water was used for the greens. The backwash was diverted elsewhere. The difference in salt content after two years is shown in the following tests for chlorides:

THE pH. SCALE

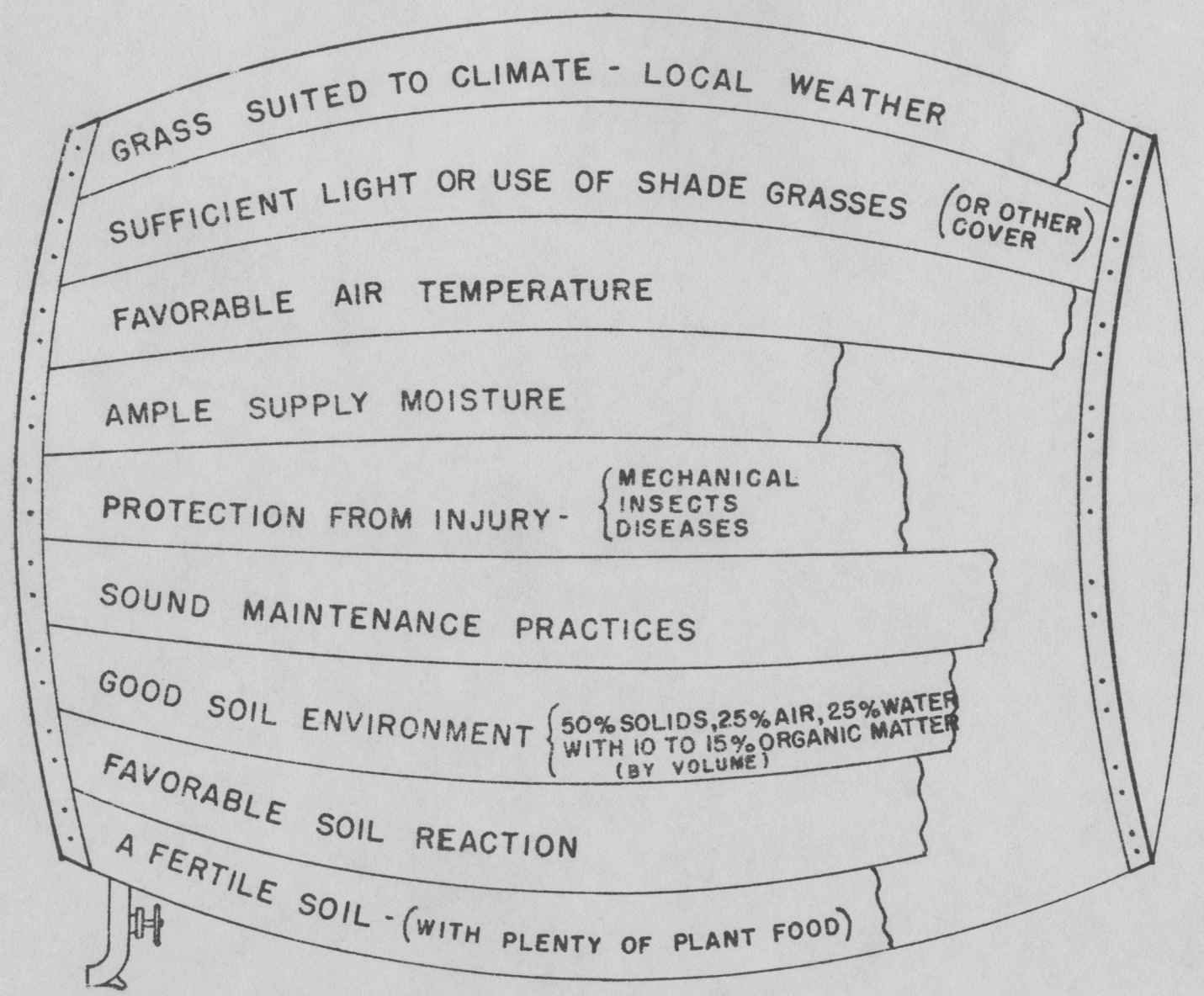
IS THE THERMOMETER USED TO EXPRESS THE ACIDITY OR ALKALINITY OF SOILS



EACH DEGREE REPRESENTS 0.1 pH.

SUGGESTED RATES FOR APPLYING LIME.

pH. VALUE	DEGREE	FAIRWAYS AND LAWNS — GROUND LIMESTONE — POUNDS PER ACRE				GOLF GREENS — GROUND LIMESTONE — LBS. PER 1000 SQ. FT.	
		BLUE GRASS RYE GRASSES BERMUDA		FESCUES BENT GRASSES		BENT	BERMUDA
		SANDS AND SANDY LOAMS	LOAMS AND CLAYS	SANDS AND SANDY LOAMS	LOAMS AND CLAYS		
8	VERY STRONG						
	STRONG						
	MEDIUM						
	SLIGHT						
7	NEUTRAL						
	VERY SLIGHT	0	0 (pH. 6.2-7.0)	0	0	0 (pH. 6.5-7.0)	0
6						0-10 (pH. 6.0-6.5)	0
	SLIGHT	1000	1500 (pH. 5.7-6.2)	0	0	10-20 (pH. 5.5-6.0)	0-10
	MEDIUM	2000	3000 (pH. 5.2-5.7)	1000	1500	20-40 (pH. 5.0-5.5)	10-20
5	STRONG	3000	4000 (pH. 4.7-5.2)	2000	3000	40-60 (pH. 4.5-5.0)	20-40
	VERY STRONG	4000	6000 (pH. BELOW 4.7)	3000	4000	60-80 (pH. 4.0-4.5)	40-60
4							


GRASS SUITED TO CLIMATE - LOCAL WEATHER
SUFFICIENT LIGHT OR USE OF SHADE GRASSES (OR OTHER COVER)
FAVORABLE AIR TEMPERATURE
AMPLE SUPPLY MOISTURE
PROTECTION FROM INJURY - MECHANICAL INSECTS DISEASES
SOUND MAINTENANCE PRACTICES
GOOD SOIL ENVIRONMENT 50% SOLIDS, 25% AIR, 25% WATER WITH 10 TO 15% ORGANIC MATTER (BY VOLUME)
FAVORABLE SOIL REACTION
A FERTILE SOIL - (WITH PLENTY OF PLANT FOOD)

	Soluble Chlorides Pounds Per Acre	
	1949	1951
Green No. 2	4,000	1,500
7	4,000	2,000
9	4,500	1,500
12	4,500	1,500

Summary: Soil testing when properly done is a useful tool in turf productions. Unfortunately, some methods are not satisfactory, and at times even the best ones are not entirely trustworthy. Much progress has been made, and in the not too distant future even better methods will be evolved. The new tissue test methods are promising also, and may be the answer to problems which develop during the growing season.

During the past quarter century our laboratory has tested several thousand samples each year. Many clubs send samples periodically. Examples of results to show the usefulness of soil testing are given separately in the following pages.

A P P E N D I X

Examples of Typical Soil Tests

GUYON COUNTRY CLUB
Huntington, W. Va.

The first tests were made in 1938, the second in 1939, and the last ones in 1949. By that time phosphorus exceeded 800 pounds and potash was 500 to 700 pounds per acre.

Originally the greens were strongly acid, low in magnesium and also in phosphorus and potash. This was changed with dolomitic limestone and the increased use of phosphorus and potash.

	pH		Phosphorus		Potash		Calcium		Magnesium	
	1938	1939	1938	1939	1938	1939	1938	1939	1938	1939
2	4.3	6.3	140	250	275	375	600	6000	150	1200
5	4.8	6.2	150	300	250	375	750	5800	100	1200
10	4.3	5.9	150	300	300	375	600	4000	100	1200
16	4.3	6.4	135	300	250	375	750	5800	150	1200

A dolomitic type of lime was used generously in 1938 and 1939 twice each year. Its use improved soil reaction and increased soil content of magnesium and of calcium.

Superphosphate and muriate of potash were used in spring and fall at 10 to 15 pounds for superphosphate and 5 to 7 pounds for 60 per cent grade muriate of potash.

EASTWARD-HO COUNTRY CLUB
Chatham, Massachusetts

The first batch of samples were collected from the greens and tested in November, 1951. The second lot was collected in September, 1952. The soils were strongly acid and low in magnesium. Dolomitic limestone was used with the following result. Phosphorus and potash levels were high in part because nitrogen was used sparingly. The differences are shown below on several typical samples.

	pH		Phosphorus		Potash		Calcium		Magnesium	
	1951	1952	1951	1952	1951	1952	1951	1952	1951	1952
2	5.2	5.5	800+	800+	800	600*	2500	3000	200	1000
5	5.3	5.4	800+	800+	750	600	3500	3500	350	900
9	5.4	5.6	800+	750	750	575	5000	5000	700	1300
13	5.4	5.5	800+	700	800	625	5500	4500	600	1300
17	5.3	5.5	800+	700	750	600	5500	7500	700	1400

*The lower levels of potash, although still adequate, may be due to the increased use of nitrogen in 1951 without adequate amounts of potash.

WINGED FOOT COUNTRY CLUB
Mamaroneck, New York

Samples were collected from the fairways in 1938. Dolomitic limestone has been used along with ample phosphate and enough nitrogen. Some potash has been used also. The tests made in November, 1951, show marked difference and as a result of the lime and fertilizer. The four below picked at random are typical.

East Course	pH		Phosphorus		Potash		Calcium		Magnesium	
	1939	1951	1939	1951	1939	1951	1939	1951	1939	1951
2	5.0	5.4	40	150	200	375	900	3000	250	900
9	4.6	5.2	40	110	190	300	700	2000	250	800
12	4.8	5.3	25	175	200	450	800	3000	250	950
16	4.9	5.4	25	160	190	300	800	5000	250	900

EDGEWOOD COUNTRY CLUB
Anderson, Indiana

The first samples from the greens at this club were submitted for testing in 1949. The results below show phosphorus and potash levels to be very, very low.

Green	pH	Available in lbs. per acre Phosphorus	Potash	Calcium	Magnesium
1	7.7	90	150	14,000	1,500
5	7.8	Trace	125	14,000	2,000
7	7.8	25	125	14,000	2,000
9	7.8	40	150	14,000	2,000

It was suggested that greens receive phosphate and potash in the spring and fall of each year. Rates equivalent to 15 pounds of superphosphate (20 per cent grade) and 5 pounds muriate of potash (60 per cent grade) per 1,000 square feet were recommended.

Samples collected in December, 1951, were tested with the following results:

Green	pH	Available in lbs. per acre Phosphorus	Potash	Calcium	Magnesium
1	7.6	325	600	12,000	1,700
5	7.6	300	600	12,500	1,700
7	7.6	300	500	13,000	1,800
9	7.7	300	525	12,500	1,800

The club reported better turf as a result of changing the fertilizer program to provide enough phosphorus and potash besides plenty of nitrogen.

CAMARGO CLUB
Madeira, Ohio

The first tests made in 1950 showed available potash to be low. Typical results at that time were as follows:

Green	pH	Phosphorus	Potash	Calcium	Magnesium
1	7.2	700	200	12,500	1,800
7	7.3	500	175	13,000	2,000
11	7.3	800+	250	12,500	1,800
15	7.2	600	175	12,000	2,000+
18	.2	650	200	12,000	2,000+

As a result, Taylor Boyd used more potash than before. Tests in December, 1951 showed everything else about the same, but more potash, as indicated below:

Green	pH	Phosphorus	Potash	Calcium	Magnesium
1	7.2	700	600	12,500	1,800
7	7.3	500	525	13,000	2,000
11	7.3	800+	500	12,500	1,800
15	7.2	600	550	12,000	2,000+
18	7.2	650	525	12,000	2,000+

To quote from Mr. Tayler's letter: "Re muriate of potash, I don't know what to say because on greens - even the bastard bents on 5 and 6 - had no large patch after the muriate was applied".

MUNICIPAL GOLF COURSES
Cincinnati, Ohio

Samples submitted in 1950 were low in potash. By 1952 the amount doubled as a result of the increased use of potash. Available phosphorus is extremely high. Avon Fields is the older course and has more as a result.

CALIFORNIA GOLF COURSE:

Greens	pH		Phosphorus		Potash		Calcium		Magnesium	
	1950	1952	1950	1952	1950	1952	1950	1952	1950	1952
1	7.1	7.2	800	1875	250	675	13000	13500	2000	1500
5	7.0	7.1	800/	2700	275	675	13000	13000	1700	1500
9	-	7.0	-	2800	-	700	-	14500	-	1500
13	-	6.0	-	2875	-	700	-	15500	-	1500
17	7.1	7.1	800/	2000	250	725	12000	15500	2000	1500

AVON FIELDS GOLF COURSE:

Greens	pH		Phosphorus		Potash		Calcium		Magnesium	
	1950	1952	1950	1952	1950	1952	1950	1952	1950	1952
1	6.7	6.7	800/	3300	325	650	12000	11500	1300	1600
5	7.7	7.5	800/	1250	275	600	12500	12500	1400	1800
9	6.7	6.5	800/	3900	275	675	12000	11500	1200	1400
13	6.9	6.5	800/	3775	350	675	12000	11500	1500	1500
17	6.7	6.6	800/	4050	350	700	11000	12000	1500	1300

SANKATY HEAD GOLF CLUB
Nantucket, Massachusetts

Samples from the fairways were submitted for testing in December, 1951. The following are typical examples of the results:

		Available - in pounds per acre			
Fairway No.	pH	Phosphorus	Potash	Calcium	Magnesium
1	4.8	75	325	200	Trace
4	4.8	Trace	300	200	Trace
9	5.0	30	325	200	200
15	4.8	40	325	200	250
17	4.8	Trace	300	200	Trace

Improvement of these fairways is a matter of providing lime, phosphate, and plenty of nitrogen. The lime rates should be heavy -- two tons or more per acre - because of the low calcium content, and a dolomite of high magnesium content should be applied to eliminate any possibility of a soil deficiency in magnesium. The rate for phosphate should furnish 80 to 100 pounds of actual phosphoric acid, and the nitrogen fertilizer should furnish no less than 125 to 150 pounds per acre of actual nitrogen.

EAGLE WATERS GOLF AND COUNTRY CLUB
Eagle River, Wisconsin

In September, 1952, this club reported poor turf and sought help as a result. The soil tests were as follows:

Greens	pH	Phosphorus	Potash	Calcium	Magnesium
1	5.7	800+	160	1,000	Trace
6	5.7	800+	150	1,500	Trace
7	6.3	700	150	1,500	Trace
8	5.6	800+	140	1,000	Trace
9	6.3	800+	225	1,500	Trace

Without question greens have been fertilized in the past with a high phosphate, low nitrogen and potash fertilizer.

Improvement is a matter of liming with a dolomitic type of lime to increase soil content of magnesium. More potash is essential and the summertime level of nitrogen should be increased.

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PUTTING GRASS ROOTS TO WORK

George A. Gries
Purdue University

Every parent knows that no two children can be treated identically and that the bit of pyschology that worked with Junior yesterday will probably backfire tomorrow. So it is with the roots of grasses. There is no single magic formula or set procedure which can be recommended to get the most efficient work from grass roots. Each species is distinct, with its own likes and dislikes, and even one strain cannot be treated the same under all of the situations in which we would like to grow it. Everything we do to grasses - from seeding to clipping - influences the growth and functioning of their roots. We can not generalize as to their care.

Ever since man started cultivating plants he has treated them so as to produce maximum fiber, ornament, or food. As our rich native soils lost their fertility or as man has attempted to grow species in other than their native habitats, he has had to fertilize, irrigate or otherwise treat the plant to increase its beauty or utility. Except for the few crops which he may have grown for the roots he has always judged their well-being or vigor by the top growth. Nearly always any improvement in top growth was the result of improved root growth for the top is a sensitive barometer that quickly reflects the welfare of the root system.

This close association between top and root growth has not always been fully appreciated. As it was learned that the leaves lost quantities of water and that they needed certain elements to allow the production of food by photosynthesis, there developed the belief that all that was necessary was to add ample of these materials to the soil and the roots would do the rest. Roots were regarded as mere pumps or mouths that would pull from the soil solution anything that the top needed and at its will. It was even thought that the forces that enabled the root to absorb water and minerals was entirely resident within the tops. We now know, however that much of the absorption by roots- both of water and nutrients -is the result of the action of the roots themselves. The root cells must do work to affect this absorption, and to do this work they must expend energy. The source of this energy is the "burning" or oxidation within the root cells of the foods supplied by the green portion of the plant. This burning is similar to that which occurs in a furnace or a gasoline engine although the rate is much slower. Just as gasoline and

air must be mixed in a carburetor or as the furnace needs a draft to supply oxygen so do the plant roots need a supply of oxygen for maximum efficiency. The soil is normally porous and within the pores is held the oxygen as well as the water and nutrients which the cells of the living root requires. Naturally there is an optimum balance between these three factors for the growth of each species and under each environment.

Let us examine then how some of the practices to which we subject our grasses in parks, lawns, fairways, golf greens, or highway berms effect the conditions which we have established as being necessary for the efficient functioning of grass roots.

Irrigation. Water is vital for plants and an ample supply must be present for the roots. With too little, a drought condition exists and while the leaves for a while will go merrily on losing water to the atmosphere the roots soon can not absorb enough. The plant wilts and may ultimately die. Often the greatest problem is too much water. As the air spaces in the soil become filled with water, air is forced out. Though ample water and perhaps minerals are present, the root cells can not function efficiently and absorption is impaired. If such a condition persists, the root cells may die. The familiar yellow color of plants following flooding is evidence that insufficient air has been present for normal root functioning.

Some grasses, like the marsh grasses, are more tolerant of water soaked soils than most species. It has been shown that rice and presumably other grasses which grow with "wet feet" have the ability to actually supply oxygen to the root cells through the aerial portions of the plant.

It is common knowledge that occasional soaking is better for the average lawn than is daily light sprinkling. Let us look below the soil level to see if we can explain this. With the daily sprinkling only the top layers have sufficient moisture to allow root growth and hence a shallow root system is developed. However, the occasional soaking supplies ample moisture and allows air penetration to such a depth as to encourage a deep root system. Now visualize what would happen should watering be stopped for a week. The grass with the shallow root system would suffer far more than the one with the deep system.

Fertilization. Most of our soils once had ample fertility for the luxurious growth of our native plants, but as man exploited them by the constant removal of plant or animal products and by failure to repay the soil the minerals borrowed, they gradually became impoverished of one or more of the elements essential for plant growth. We now accept fertilization as a standard practice, but let us see just how our methods influence root growth and functioning. Just like a human, the grass root is going to take the easiest course. Wherever the fertility is optimum, there will the roots grow and multiply. If we fertilize in bands, the roots will develop in bands; if the fertilizer stays on top, the roots will be shallow. Growth will be slow in areas or zones of low fertility and will be inhibited in regions of excessive fertility. Under this latter condition, the root may absorb too much fertilizer. The root cells themselves may be damaged by the very high concentration of soluble salts or they may absorb so much fertilizer, that it will concentrate in the leaf cells to the degree that it will cause a burn.

Often faulty fertilization practices and overwatering go hand in hand and may start off a vicious cycle that is difficult to stop. We have seen that over-irrigation frequently leads to yellowish plants. The man who is not alert may immediately assume nitrogen deficiency. He piles on the nitrogen but knows that it must be watered in to prevent burning. So he pours on more water but the grass gets worse -- perhaps that calls for more nitrate and more water. In this case the doctor is treating the right symptom - but the wrong cause, and so the patient gets sicker.

Clipping is not without its effects on root growth. The leaves make the food which is used in the growth and functioning of both the tops and the roots. Any excess is stored in the roots, rhizomes, or stolons. Following clipping or grazing, this excess of reserve is drawn upon to start new growth of the stems and leaves. The more frequent the clipping the more are the reserves depleted with the possibility of root starvation with excessive clipping. Naturally erect grasses are more severely injured by repeated top removal than are the creeping or prostrate grasses.

Compacting the soil is the surest way of excluding the vital oxygen from the soil. The packing of the soil reduces the air spaces necessary to hold both air and water. The differences between the conditions which may develop in a lawn or on the highway berm are only matters of degree.

Now let us examine what has been done and what can still be done to help plant roots work more efficiently. One approach is through the breeding of varieties better adapted to some of the extreme conditions under which we should like to grow grasses. No one grass will ever be adapted to every situation nor can it have the growth habit which we would want on both the golf green and football field. The job of the plant breeders then is to tailor-make varieties in one case more tolerant of drought and in another better adapted to growing with "wet feet". They are altering the growth habit to fit particular needs and to withstand more or less clipping. Soil conditioning agents and aerating devices are used to prevent the development of conditions unfavorable for root growth.

The proper use of soil and plant tissue tests to allow uniform and proper fertilization, and means of determining proper regulation of irrigation all contribute to the well-being and efficient functioning of the grass roots.

The most important practice in the proper management of grasses, however, is the liberal application of abundant common sense. We must remember that our grasses are just like children. Each one is different and will respond differently under various circumstances. By applying this common sense, in getting acquainted with our grasses, and in the use of the tests and materials available to us we can all do a better job in keeping our grass roots healthy and vigorous as they perform their daily task of supplying the necessities for good turf.

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SOIL MOISTURE RELATIONS UNDER TURF

Jim Watson, Agronomist
Toro Manufacturing Corporation

In a discussion of soil moisture one must include other very closely related topics namely: physical properties of soil and soil air. These three subjects are inter-related and actually cannot be discussed, independently. We also must consider the utilization of water by the plant and the role of water in the soil. It is not generally realized that a very large proportion of the water absorbed from the soil is lost

by the plant into the atmosphere and plays no permanent part in the development or in its metabolic processes. Water is supplied to and absorbed by the plant in a liquid form while the greater part of the water lost by plants is in the invisible form of water-vapor. This probably accounts for the failure to recognize the tremendous quantities of water needed for plant growth. The loss of water-vapor from any part of a plant exposed to air is known as transpiration.

TRANSPIRATION

The importance of transpiration and its effect on soil moisture is apparent when we consider that the 60 to 90 percent of the plant body which is water actually represents only a very small proportion of the water used by the plant. There is a constant stream of water passing in through the roots and being transpired by the leaves. From 300 to 500 pounds of water are required by every one pound of dry matter produced by the plant. Many plants transpire an amount of water equal to their weight every twenty-four hours The amount of water transpired by a given plant is governed by several factors such as: Temperature, Air Movement, Humidity, Soil Fertility, Light Intensity and Soil Moisture.

Watering practices that are based directly on transpiration phenomena are "syringing" of golf greens during hot, windy summer days, and the watering of turf areas during winter on early spring when atmospheric temperatures are considerably higher than soil temperatures. In both cases transpiration is likely, to exceed water absorption. This results in wilting, or dessication. On high areas not covered by snow and exposed to drying winds during winter and spring months winter killing is often observed. The plant roots are relatively inactive and cannot take up sufficient water to offset transpiration.

SOIL WATER

Water, in addition to its direct usage by plants, also acts as a solvent for the various minerals within the soil and is a means by which nutrients are made available to the plant. Water serves as a regulator of certain physical phenomena and is utilized by soil micro-organisms.

SOIL AND MOISTURE RELATIONSHIPS

The nature of the soil is intimately associated with water and air relationships. The capacity of the soil to hold water and air as well as the movement of water and air are primarily functions of soil structure (the arrangement of soil particles).

In the true sense the structural unit known as an aggregate -- this does not include individual soil particles such as grains of sand, silt or clay. Nevertheless, these individual particles play an important role in our discussion of soil moisture under turf because of their influence on the porosity of the soil.

POROSITY

Porosity may be defined as that percentage of the soil volume not occupied by solid particles. In a soil containing no moisture the pore space will be filled with air. In a moist soil the pores are filled with both air and water. The relative amounts of water and present will depend largely upon the size of the pores. Two types of pores are recognized, the capillary and the non-capillary. For convenience we shall call the small (capillary) and the large (non-capillary) pores. The small pores hold water by capillary and are responsible for the water-holding capacity of soils. The sum of the volumes of the small pores is called "capillary porosity". The large pores will not hold water tightly by capillarity. They are normally filled with air and are responsible for aeration and drainage. The sum of the volumes of the large pores is called "non-capillary porosity".

The total porosity of a soil is not as important as the relative distribution of the pore sizes. Total, porosity is inversely related to the size of the particles and increases with their irregularity of form. Porosity also varies directly with the amount of organic matter present in the soil. Clays, for example have a higher total porosity than sands. Clays have a large number of small pores which contribute to a high water-holding capacity and slow drainage. Sands, on the other hand, have a small number of large pores which are responsible for a low water-holding capacity and rapid drainage. Under field conditions the total pore space is seldom less than 30 percent (coarse, clean sand has about this amount of total pore space). In silt loams the total pore space amounts to about 50 percent or one-half the volume of the soil. The ideal

soil for plant growth should have about 50 percent total porosity, equally divided between small and large pores, or in other words contain 25 percent water space and 25 percent air space.

CLASSIFICATION OF SOIL WATER

Soil particles are wetted by water and have considerable attraction for water, consequently, soils exhibit a capacity to take up and retain water. This water is distributed through the small pore system of the soil and over the surface of the soil aggregates and soil particles.

The capacity of soils to absorb water and retain moisture provides a reserve which enables plants to grow during periods when soil moisture is not frequently replenished. Various soil moisture constants have been defined and used as an index of moisture retention by soils. Most of the terms are concerned with hypothetical concepts or measurement made in accordance with standardized laboratory procedures.

Soil water was classified as early as 1897 by Briggs, and defined as follows:

(1) Hygroscopic water - the very thin non-liquid film surrounding the micro-aggregate (individual soil particle)

(2) Capillary water - the liquid stage which is held in the small pores and as a continuous film around the soil particles and the microorganisms. It is held by the molecular forces of cohesion. Sometimes this water is divided into the inner and outer capillary water.

(3) Gravational water - that water which exists in the large pores and is free to respond to the pull of gravity. It drains, or percolates through the soil column.

From the standpoint of utilization by plants water may be classified as (1) unavailable (2) available and (3) excess (superfluous). These forms correspond closely to the three forms of water classified by Briggs. From a practical standpoint we are primarily concerned with, the available water in a soil. It should be pointed out, however, that many of our turf problems can be

traced to the excess or superfluous water which is not removed from the soil.

Soil moisture constants associated with the upper and lower limits of available water in the field take on a special and practical significance. For our purposes we may use the terms "field capacity" and "wilting point" to indicate the upper and lower limits, respectively, of available water. These terms may be defined as:

(1) Field Capacity - that percentage of moisture that remains after the gravational or excess water has drained from the soil. It should be noted that field capacity can be attained only in a well-drained soil. Field capacity, represents a level of moisture quite close to the moisture equivalent" -- a level of moisture readily determined in a laboratory.

(2) Wilting Point - that percentage of moisture found in a soil after plants wilt permanently. Contrary to popular belief it has been established that all plants will wilt at about the same level of soil moisture. In other words,in spite of inherent differences between plants they are unable to extract water beyond a given level from the same soil.

INFILTRATION

The process of the downward entry of water into soil is referred to as infiltration. For any given soil or soil condition there exists a maximum entry, or infiltration rate. When application rates, whether from rainfall or irrigation, exceed the infiltration rate, runoff or ponding occurs. In other words, when water is applied to soil at a rate faster than it can be taken in, the excess water is lost for all practical purposes.

MOVEMENT

The downward movement of water through the soil is spoken of as percolation. When rainfall or irrigation stops, the moisture moves gradually out of the larger pores in a downward direction. This movement takes place primarily under the influence of gravity. According to Baver the downward movment of water by gravational forces in natural soils is related to (1) the amount and continuity of the large pores as determined by soil structure, texture, volume changes and

biological channels, (2) the hydration of the pores and (3) the resistance of entrapped air. Concomitant with the recession of water in the large pores, air is drawn into these pores. The large pores are seldom, if ever, entirely voided of water because of the molecular attraction of the soil particles for water. As the soil approaches field capacity, there is a reasonably continuous gaseous phase throughout the soil but the moisture films covering the soil particles become so thin that additional moisture movement in these films is considerably restricted. Movement of this water (capillary) takes place very slowly as a liquid from the thicker to thinner films. Such movement is spoken of as capillary or film adjustment and plays a vital part in supplying water to plants.

WATER AND NUTRIENT ABSORPTION BY ROOTS

One of the characteristics of an actively growing root system that is performing its function of absorbing water and nutrients is that it has a relatively extensive area of growing tissue permeating the soil. Only a small part of this extensive system is actually engaged in absorbing water and nutrients from the soil. Absorption of water and nutrients taken place in the root hairs found near the top of the actively growing root. Roots must have water and air as well as nutrients to grow and develop, hence, the growing tip of the root follows or grows through voids where these materials are found.

We have mentioned earlier that water moves into soils through the large pores and that as the excess water, is drained away these pores are filled with air. It is within the large pores that the capillary water absorbs oxygen so that the moisture which the plants use contains a sufficient amount of this essential element. We might also assume that this water, charged with oxygen, contains the necessary nutrients required by the plant for growth. As a result we will find plant root growing around and within the large pores and utilizing the capillary water charged with oxygen and nutrients within a restricted area. Until quite recently it was thought that capillary movement or film adjustment would cause available water in adjacent areas to move into the root absorption zone and replenish the supply. Thus, it was felt that the plant roots could more or less remain within a given area and extract practically all of the available water. It has now been established, however, that such is not the case and that although capillary or film adjustment does occur that it is not rapid enough to provide plants with the required amount of water and nutrients.

We now know that most of the water and nutrients which plant roots are able to take up are made available to those plant roots by the growth or extension of the roots into parts of the soil which have a sufficient amount of available moisture and a new supply of nutrient elements. In other words, the plant root usually grows to new supplies of moisture and nutrients instead of these materials seeking the root, otherwise it would soon utilize all the nutrients and water in a given area. This is one very good reason for developing and maintaining as desirable physical soil condition as possible under turf.

It goes without saying that the soil which permits extensive and deep root development is one that displays good tilth, has good structure, has desirable pore space distribution, is abundantly supplied with available nutrients, is periodically replenished with, water and is sufficiently permeable to permit good drainage. In such a media which obviously would be well-aerated the roots, in general, are long, light colored and well-supplied with root hairs. In the absence of adequate amounts of oxygen the roots are thickened, shorter, darker and have less than a normal number of root hairs.

Inadequate soil aeration, or in line with the terminology we have been using -- insufficient large pores, decreases the intake of water by plants directly through its effect on absorption and indirectly by reducing root growth. In waterlogged soils or where sufficient anaerobic biological activity occurs, the accumulation of such products as methane, carbon monoxide, and hydrogen sulfide may result. Also, reduced forms such as nitrates, ammonia, ferrous compounds and manganous compounds will build up in soils. These products are quite toxic to plant roots and if the situation is prolonged, death of the plant occurs.

AERATION AND DISEASE

In addition to the more or less direct influence of soil aeration on plant growth, soil aeration exerts an important indirect effect as a factor in the occurrence and severity of certain plant diseases. Such effects are of two kinds (1) the lack of oxygen and/or excess of carbon dioxide on the growth and longevity of the pathogen and (2) the increased susceptibility of the host plant when grown in poorly aerated soils. Pathogens that attack plant roots are the ones that are most influenced by soil conditions. The importance of temperature, pH and moisture content are widely recog-

nized as factors affecting root-attacking organisms. It is assumed by some that the principal effect of high moisture content arises from the attendant poor aeration.

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A KODACHROME STORY OF TURF RESEARCH IN THE UNITED STATES

Tom Mascaro
West Point Products Corporation

Growing good turf is a problem everywhere. As you travel about the country, you realize that the major problems are basically the same. However, each area has its own particular problem, which in the mind of the local superintendent is more important than anything else. Suppose we take a quick trip around the United States to see what some of these problems are.

If we visited a course in New England or Southeastern Canada, and asked the superintendent what made grass grow, he would say warmth. Their winters are long and their summers are short so they believe that a longer period of warm weather would make it easier to grow good grass. If we travelled to Florida and asked a superintendent what was needed to make grass grow, he would say fertilizer. There is plenty of warm weather in Florida, so the superintendents know that warmth alone is not enough to produce good grass. In the St. Louis-Kansas City area and the mid-western states, the superintendents believe an improved grass is the answer to their problems. They have heat and their soils are good,but their main problem is finding a grass hardy enough to stand up under their extremely cold winters and extremely hot summers. As we move farther West and come to Salt Lake City, the superintendent there would tell you that good soil is most important. Out on the west coast, in the Palm Springs area, golf courses are built on the desert.The superintendent there would tell you that water is the most important factor in growing good turf. If we move north along the west coast, we see Cyprus Point and feel the constant winds that blow from the Pacific Ocean. The superintendent there would tell you that

less wind would eliminate some of his problem. Moving up into the Pacific Northwest, where the golf courses were cut out of the forest, the superintendent might say that the grass grows well, but they ought to know more about management.

Actually, good grass depends on many factors. Every one is important. The one that presents the greatest problem varies in the different localities. We in the United States are fortunate because of the great strides made in turf research in recent years. Great advances have been made in bringing together many people interested in turf work, to discuss their mutual problems.

Let's look at the turf research picture as it stand today. Much of the turf work has centered around the U.S.G.A. Green Section Headquarters at the Plant Industry Station at Beltsville, Maryland. We are all familiar with the work started by Piper and Oakley and the work done by Dr. John Monteith, while the turf gardens were at Arlington, Virginia. During the war, the Pentagon was constructed on the site of the old turf plots and many of the grasses were moved to Beltsville. Much of the turf work at that time was done in Washington and the information was then sent out to various parts of the country.

In 1946,Dr. Fred V. Grau took the position of Director of the Green Section. Through his experience in turf work, as Extension Agronomist for the State of Pennsylvania, he recognized the need for a decentralized turf program in the United States. During the years he was with the Green Section, he did much to stimulate this movement. Dr. Grau also recognized the need for more young people to get into turf work. He began with a handful of students but by now there are over a hundred.

Many of these men have become leaders in their own areas. To name a few--Robinson now is Turf Specialist for the southern turf program. Neil Wright is agronomist for H. L. Wagner, seed producer in Oregon. Jim Watson did much to stimulate the turf work in Texas, and now is employed as agronomist for the Toro Manufacturing Company. Jack Harper is in charge of the turf work with the U. S. Department of Agriculture. Scotty Forbes is now doing breeding work at Tifton, Georgia. Bill Daniels heads up the Midwestern Regional Turf Foundation. Charlie Wilson is Western Regional Director for the U.S.G.A. Marvin Ferguson did much travelling on turf problems with the Air Forces Air Materials Command, and has recently taken over the Texas Turf program.

Much of the work done at Beltsville was pilot work in the way of selections and sending out plant material to the various Experiment Stations. When Grau took over the position with the Green Section, there were only four Experiment Stations actively engaged in turf work. Today, there are approximately thirty.

Zoysia breeding and studies of its seed production have been done at Beltsville. Bermudas were developed and sent out to the various Experiment Stations. They were in turn supplied to turf growers in that area.

Merion bluegrass, having been removed from the old Arlington plots, was re-evaluated, recognized for its superiority and sent out for trials all over the country. Interest in seed production was stimulated. It hardly seems necessary to mention the popularity that Merion bluegrass enjoys today.

Another thing developed at Beltsville, under Dr. Grau, was the combination of the warm season -- cool season grasses; namely, Zoysia and Merion bluegrass. Combination plots at Beltsville have demonstrated the practicability in that area, and it is being tested in many other parts of the country. These are only a few of the things developed at Beltsville.

Perhaps the greatest single contribution made by Dr. Grau was stimulation of interest at the many Experiment Stations to carry on turf work at a local level. That has done more than anything else to stimulate interest and assist local men in solving turf problems under their own conditions.

That program of decentralization has extended even into Canada. The turf program being conducted at Guelph, Ontario, under Dr. James Boyce, is spreading rapidly into other stations in the Dominion of Canada.

In the New England states, Dr. Jesse DeFrance heads up the turf work at Rhode Island. Rhode Island has the distinction of having the record for the longest continued and uninterrupted work in the turf field.

We move on down to Rutgers where the turf program is under the direction of Dr. Ralph Engel. Extensive turf plots have done much to assist the superintendent of the State of New Jersey.

The New York turf program is under the direction of Dr. John Cornman at Ithaca. Under a fellowship from the U.S.G.A. Green Section, Gene Nutter got his

doctor's degree here, and is now heading up the turf work in Florida.

We move along to Pennsylvania, and here we find the largest installation of turf plots, operated with state funds. Information is taken to the turf people of the state through the State Extension Service. The turf program in Pennsylvania is a model set-up for all states to follow or from which to build their own program.

Professor Musser, in charge of turf work at Penn State, has made a great contribution in the development of many new varieties of grasses. Prof. Musser is the author of the book "Turf Management", written under a grant from the U.S.G.A. Green Section. It is the first practical publication for turf men since 1923.

The plots at Penn State cover an area of approximately seven acres. There are between twelve and fifteen thousand individual plots. To name a few, there are pilot tests of many new selections; moisture requirements of creeping bents; nitrogen-potash ratio experiments; strain tests of the polycross creeping bents; strain tests of vegetative selections of creeping bents; fairway, lawn and airfield grasses; crabgrass control studies; seed treatment tests; and lawn seed mixtures.

Much work has been done at Penn State, in cooperation with Dr. Alderfer of the Agronomy Department, on compaction studies and water runoff. A fellowship established by West Point Products Corporation to study effects of aerification on water runoff covers a large area consisting of 72 replicated plots.

Some results of these experiments are available already. Penn State is also carrying out projects under fellowships established by American Cyanamid Company and H. L. Wagner.

From Penn State we move on to Tifton, Georgia. In 1946, Dr. Glenn Burton, with the help of Dr. Grau, established a turf program for the southeastern states. Dr. Burton's work on breeding better pasture grasses paved the way for some of the improved turf strains of bermuda that we have in the south today.

The turf plots in Tifton are quite expensive and have grown each year. Some of the work is being supported by the Georgia Highway Department. Much support is given to this program through the Southern Turf Association. Many problems peculiar to southern turf

are being studied at Tifton -- fertilization of southern grasses, weed control and so forth.

Dan Hall, student at Tifton in 1946-1947, did much of the work in getting the plots established. He is now superintendent at the Peachtree Golf Course in Atlanta. B. P. Robinson is now full time Turf Specialist for the turf program in the south. Much work has been done on the use of sawdust as a source of organic matter for topdressing materials.

Next we move out to the midwest. The Midwest Regional Turf Foundation, established at Purude University--Lafayette, Indiana, has grown to cover about five states. Many men have contributed to the success of this program for the midwest. Dr. Herbert Albrecht, Dr. G. N. Hoffer, Dr. G. O. Mott and many others helped to establish a sound program.

Dr. William Daniel was taken on a few years ago as full time Turf Specialits and he has done an outstanding job in getting the information out to the people who need it. His work with the Midwest Regional Turf Foundation is an inspiring example of what can be done to stimulate general interest in turf grass.

The experimental gardens at Purdue include studies of many of the common problems that exist in the midwest-new strains of grasses, soil sterilization, clover control, disease control and prevention, etc.

In nearby Michigan, turf work is under the direction of Dr. James Tyson. Turf plots are maintained to provide information on the local level. The college is host to a turf conference each year. Incidentally, Bill Daniel was a Michigan product before he moved to Purdue.

Moving down to Ohio, we find a turf program in its infancy. Richard Davis, former Purdue man, is the organizer here. Turf plots are being established at Wooster. There is still much work to be done, but the program is off to a good start.

Next, we go onto Kansas State. The turf grass program here is also new. It is only a few years old, but already much progress has been made. The Central, Plains Turf Association was established and has given its support to the College in establishing an excellent series of turf plots. The College conducts the annual turf conference for this group. Under the direction of Dr. William Pickett and Dr. Ray Keen, there is no doubt that the turf grass program in the Central Plains area will make much progress in the future.

We move north from there to Ames, Iowa, where Dr. Harvey Lantz conducts a turf program for the state of Iowa and surrounding areas. They have a series of turf plots established at the College to provide the answers to local problems.

Now we move on to the state of Texas. The turf grass program there is being spear-headed by the Texas Turf Association. Frank Goldthwaite and the entire Goldthwaite organization deserve much credit for contributing much time and funds to roll this into one of the outstanding turf grass programs in the nation. Men like Dr. R. Potts, Dr. A. Crain, Dr. Jim Watson and Dr. Marvin Ferguson have done much to give the state of Texas a program that is benefiting all people interested in turf culture. Plots are established on the experimental farm of the Texas A & M College at College Station. Turf conferences held each year, along with regional meetings, do much to get the information out to those who need it.

Next door, in Oklahoma, turf work is being carried out at Oklahoma A & M, under the direction of Dr. Sarthou. A Turf Conference is held each year, and answers to the local problems are being provided. Bob Dunning deserves recognition for the great amount of time he put into the organizational work for the turf program. The Oklahoma PGA is cooperating in the job, too.

Moving out to Southern California, we find a turf program at U.C.L.A. Dr. Verne Stoutemyer organized this program with the assistance of Dr. Grau. His first job was to bring the already available information to the people on the west coast. Now they have a turf grass program of their own. C. C. Simpson, Chairman of the Los Angeles C. C., was among the first to get in and pitch for the new turf program. Active in the turf grass program are men like William Beresford Supt. of the Los Angeles C. C.; Harold Dawson, Secretary of the Southern California Golf Ass'n; John Gallagher, who did much of the original work on the turf plots; Zaki Mahdi, an outstanding Egyptian, student who contributed much with his experiments in vegetative planting. There are many others, too. Gordon Wycoff, now in charge of the turf plots, along with Dr. Stoutemyer will keep the program moving and the future looks bright.

California is stretched out over such a long distance, that it has considerable variation in climate. So a separate turf program is carried out in Northern, California. There the work is under the direction of Dr. Robert Hagan. He is promoting both research and

extension. Work in Northern California is contributing information not only for local use, but also of national value. Much of their information on the irrigation of turf can be applied where turf grasses are grown. Outstanding irrigation plots are located at Davis, California, in the San Joaquin Valley. Trials are being conducted on some of the improved grasses, such as U-3 bermuda and Merion bluegrass.

From here we move up to the Pacific Northwest. At Pullman, Washington, the turf program is headed up by Alvin Law. This turf program includes a series of demonstration plots and yearly turf conferences. At the Turf Conference at Pullman, you cannot help but be impressed by the tremendous distances men travel in order to attend.

Here, in a general way, we have the turf grass program as it exists on a national scale. Certainly what I have said is not complete nor does it include the many men behind the scenes -- the men who have done and are doing so much to establish turf culture as an important phase of agriculture. Much of the information that comes out of these various experiment stations is published in the Turf Conference Proceedings; in magazines such as Golfdom and The Golf Course Reporter. Extension teaching both by college personnel and agronomists employed by industry helps to spread new information. The Superintendents themselves become a part of extension, through their local meetings. Many of these men have their own experimental nurseries where extensive trials are conducted to find out if new developments can be applied to their particular situation.

Individual turf men themselves deserve the credit helping to establish all these turf grass programs. Their demand for accurate information pointed out the necessity for research and extension in turf. Many new grasses have come from the men on the job. Joseph Valentine discovered Merion bluegrass behind a tee at Merion Golf Course. He recognized it as an exceptional grass twenty years ago. He provided the original plants from which our B-27 has been developed. Les Hall, Supt. at Savannah Country Club, selected a vigorous bermuda from his course, which is now very well known as U-3 bermuda. Eberhard Steiniger, Supt. of Pine Valley GC in New Jersey, contributed Cohansey bentgrass.

We are not working alone with our problems and discoveries. Fortunately, we are united on a national scale, so the work done by each man is available to help the others. Work will become easier and turf become better because of the efforts of everyone.

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VISIT TO ATHLETIC FIELDS IN 1951 and 1952

Charles K. Hallowell
Agricultural Extension Service

The fields visited in 1951 were - the Clothier Field and Alumni Field at Swarthmore College, Franklin Field at the University of Pennsylvania, the Municipal Stadium in Philadelphia, Palmer Stadium at Princeton, Rutgers Stadium at New Brunswick, Yankee Stadium, the Polo Grounds and Baker Field, (Columbia University) in New York City, and Michie Stadium at West Point and the High School Field at Bronxville were also inspected.

Following the inspection of all the fields, the group discussed and summarized what they had seen at the different fields.

The soils were inclined to be heavy but showed no evidence of poor drainage. The most ideal soil, from a texture standpoint, was described as a grayish brown, sandy loam with a considerable portion of the sand fraction consisting of medium size particles. The organic matter content was often low and compaction was a problem. Fields aerified showed a reduction of compaction. With the one exception, sufficient lime had been used.

Varying amounts of fertilizer had been used and at only one field was there any evidence of the fertilizer being too light to produce a good cover, Considerable study is needed to determine the amount of and the time to apply nitrogen. There have been facts collected showing the importance of having a slow acting nitrogen fertilizer for golf course turf. It seems that the same information would be pertinent for athletic field turf. Annual applications in either early spring or later fall of phosphorus and potash are likely to supply sufficient amounts of these two elements.

Seed mixtures used had included most all the basic, turf grasses and the ryegrasses, with red top being added on a few of the fields. The turf population showed that the bluegrass and ryegrass produced the most satisfactory turf. From observation it would seem that when renovating or reseeding existing turf, that it would be advisable to use only bluegrass and perennial ryegrasses. All were agreed that bent grass was of now value in athletic field turf. Alta fescue when renovating. How to get merion bluegrass into an existing turf is still unknown. There was some indication that the plugging method of transfering good turf such as Merion to the fields would be helpful.

There were many expressions that a sod nursery is a must for all heavily used athletic fields and the ideal method of moving in new sod is by transferring 2 inch plugs.

Cultivation - The Aerifier has been used a number of times on several of the fields. This tool is a great aid in reducing compaction and simplifying any renovation program.

Use of chemicals - Broad leaf weeds were scarce in the turf, this resulting from the use of 2,4-D. Knotweed, clover, crabgrass, poa annua and chickweed may be checked by using sodium arsenite or potassium cyanate. Fields having an unsatisfactory turf need a long range improvement program which includes proper chemicals to check the undesirable plant materials.

The group was well agreed that many of the fields could be greatly improved if the man on the job had a better understanding of turf management. There is need for trained men who can apply the present findings about good turf management. It appeared that those in charge of some of the fields had failed to secure facts about soils and grasses available from the Agricultural Extension Service of each State College.

Kentucky bluegrass was highly predominant on the more satisfactory fields. The group recognized many of its weaknesses, such as susceptibility to leaf spot and intolerance of close cutting. However, its vigor, persistence, and sod-forming qualities clearly establish it as the most desired grass for this area until some other species can be developed.

The bluegrass strain known as Merion (B-27) was observed on several fields. Continued performance of the type observed will make it most desirable for athletic fields. Careful study of its performance in athletic fields is important.

An experimental planting of F-74 fescue was observed at one location. It was suggested that this strain or other improved strains are worthy of experimental use on athletic fields.

Perennial ryegrass is desirable for providing quick cover in emergency situations. Its tough leaf characteristic and deep-rooting habit was pointed out. It is recommended over common or domestic ryegrass.

The bentgrasses are completely ruled out for athletic fields.

Although a considerable amount of Alta fescue had been seeded in a number of fields, no example was observed where Alta fescue was dominant or serving in other than a minor role in established turf.

There was evidence that water is beneficial if it is used correctly. If knowledge or guidance on watering is not available, it is better that its use be curtailed or ommitted. Frequent light watering seemed to be a factor in producing the poorest turf observed. It was agreed when water is applied that the soil be wet thoroughly one inch in depth then no water be used again until the soil becomes dry.

More frequent cutting was to be desired on most of the fields observed. The less grass leaf clipped off at each mowing lessons the shock to the plant. Such mowing should lead to a denser type of turf. A cutting height of 1 1/4 inches was recommended for playing season height on the typical football field of Kentucky bluegrass. Height of 3 inches were commonly observed. This practice was considered tolerable by some as a means of bringing such weeds as crabgrass, under control. Otherwise the practice of such high mowing was recognized as creating a problem of carefully lowering the height prior to the start of play to avoid a "stemmy" and thin turf during the season. It was agreed that it is desirable to maintain constant cutting height if a good, dense stand of turf can be established and maintained without raising the height during the summer.

The horizontal, rotary blade type of mower was recognized as a valuable type for higher cutting. It was pointed out that it should be set higher than the reel type as it tends to give a closer cut.

The use of a nursery was recommended for fields that received heavy use. This technique offers the only

hope of maintaining turf on some of the areas that receive excessive and frequent wear. In addition, it is very useful for emergency sodding or plugging on any field where a turf cover is considered valuable. Facts are needed about how and when to bring in the sod. Some fields were handicapped because of the lack of adjacent practice fields.

Use of good cultural practices is considered most valuable and fundamentally important for weed control in athletic field turf. Among these factos, height, of cut, adequate fertilizatib n, correct watering, and the use of the better grasses are the most important.

The chemical, 2,4-D was considered the standard treatment for control of broad-leaved weeds such as dandelion, buckhorn and plantain. Sodium arsenite, phenyl mercury compounds, and potassium cyanate may be useful for controlling crabgrass. However, it was recommended that careful consideration be given before use of chemicals for this purpose. The individual performance of each of the chemicals to be used should be determined and the utmost care should be used in application. Cases were reported where it was considered that phenyl mercury compounds had severly injured the root system of Kentucky bluegrass turf. Yet, it was also reported that many Kentucky bluegrass plots have been observed to appear healthier after treatment with normal rates of phenyl mercury acetate for crabgrass control. Thus, additional work on ehemicals appears necessary to learn all the facts.

One of the fields was badly in need of renovation. The program should start in the spring with periodic spray to eliminate the poa annua and should be followed with aerification and reseeding with permanent grasses.

The opinion was expressed that the Aerifier should receive more general use on athletic fields. This was interpreted by some to mean that it would be an exceptional case that would not benefit from the use of the Aerifier. Study is needed to determine the degree to which tools such as the Aerifier should be used on athletic fields.

It was pointed out that the use of the Aerifier and proper soil amendment might be easier than bringing in new soil. There was general agreement that the Aerifier was a good tool for use prior to renovation seeding.

There is experimental work at Penn State College to determine the effect aerification has on reducing run-

off of rainfall or water applied, and the assistance given in getting fertilizers at a lower depth in the soil.

There was complete agreement that there was a need for more facts about the necessary fundamentals for producing turf on athletic fields. This means more research work. Also, it is important that there are a number of facts that should be made available to those in charge of growing turf on athletic fields. This is a responsibility of the Agricultural Extension Service.

In 1952 the athletic fields visited were- Griffith Stadium, Boys Club, Washington, Baltimore Stadium, United States Naval Academy, #1 Stadium Field, #2 Farragut Field, #3 Upper Lawrence Field, #4 Holland Field, #5 Varsity Practice Field and #6Hospital Point Field.

The following was the discussion at the conclusion of the visits to the fields--

It was the unanimous recommendation of the group that the basic athletic field turf in this region should be a good strain of a warm-season perennial grass. U-3 bermudagrass, Meyer (Z-52) Zoysia japonica, and seedlings of the Z-73 strain of Zoysia japonica were prominently mentioned. These grasses provide a dense, traffic-hardy, weed-free turf when properly managed.

The loss of color during the late fall and winter months is the principal objection to the sole use of warm-season perennial grasses. For aesthetic value,it is desirable to overseed with a cool season grass which also will meet the requirements of heavy traffic.It would be difficult to overseed successfully if the field was in constant use. Merion(B-27) bluegrass and Kentucky 31 fescue received primary consideration as these strains would provide a more permanent turf than would inferior strains. There still remain many problems in the necessary techniques for the establishment of combination turfs.

Poa annua also was mentioned as a natural companion to the warm-season grasses as Poa generally volunteers in great abundance in this region. If the Poa annua could be encouraged to invade the field to provide the necessary cool-season color, the necessity for re-seed each year would be eliminated, or at least minimized.

By and large it was agreed that a turf nursery is needed to replace sod in the center 30 yards of fields as this area is subject to most wear. When a field is in constant use, the chances for a successful catch from seeding is slight. A good turf nursery is an insurance plan through which a field can be kept in turf at all times. Plugs and sods can be used as trouble areas arise. Many fields are being reseeded annually with little or no success. This money could be used for the establishment of a sod nursery. One question that arose was, "Can they afford not to sod?" The best time of the year to sod would be in the spring of the year. Sod cut at 3/4 inch thickness will root quicker than sod cut at 2 inches. A quick-soluble phosphorus application under the sod will cause it to root faster.

Aerification is an important management practice in turf management. It has become a regular practice of most fields, however, it is of utmost important that it be used in connection with other good management practices such as fertilization, water usage, etc. for best results.

Most of the fields visited had received sufficient quantities of fertilizer yet there is need for additional information. Timing of fertilizer applications is a very important factory - if warm-season grasses alone are to make up the bulk of the field when timing of fertilizer applications should favor these grasses. If, however, a cool-season-warm-season turf is desired, the fertilizer applications should favor and cool-season grasses. The bulk of the fertilizer should be applied in spring and fall.

It appears also that the bulk of the nitrogen should be 50% - 75% in organic form, the reaminder in inorganic nitrogen. It is best to provide conditions for an even growth for grasses; not to grow it in bursts.

Over-stimulated turf is in a succulent state therefore it is in a weakened condition and is more susceptible to injury from traffic and diseases.

A good fertilization program will, to a large extent, reduce the need for water applications.

The fields which received most artificial water were the wortst looking fields. More good turf was ruined and weed infestation was almost 100% on the saturated fields. Fields that were managed properly, and had no available artificial watering systems looked best.

Good turf, well managed, will provide the soft, cushiony playing surface that athletes desire, excessive water will not do the job. It is advisable to water only under unusual conditions.

The soil at Annapolis were good except for the Holland Street Field Soil. The large quantities of sand used for topdressing these fields presents a disturbing, factor because of the possibility of layering. It is almost impossible to work a surface layer into the soil without bad results. There are perhaps more troubles ahead due to pockets and layering. Too, it is difficult to stabilize a sand surface layer for play.

There is need for more research regarding management practices as related to specific problems encountered in growing athletic field turf. While some progress is being made in education, there still remains much to be done. There is a big Educational job ahead!

At Beltsville the "Turf of the Day" was zoysia with Merion bluegrass. Named "best" was zoysia turf developed from Z-73 seedlings. There are four different zoysia turfs established at Beltsville which were inspected by the group. They are: Common Zoysia Japonica, Parent Meyer (Z-52) zoysia - Seeded Meyer (Z-52) zoysia - and Seedling Zoysia (Z-73) japonica.

The first three listed were in combination with Merion (B-27) bluegrass, the fourth (Z-73 seedlings) had been aerified and overseeded with Merion bluegrass this fall. Several members of the group offered the opinion that the turf provided by Z-73 seedlings was open enough to allow for good possibilities with success with overseeding and maintaining a good balance with Merion bluegrass. Being more open that the common and Meyer strains it appeared also that footing on Z-73 seedling turf was more stable.

The biggest question, largely unanswered, was, "What do the coaches want?" "Do they know what they want?" Colonel Blaik of West Point is once coach who knows what he wants - "Something smooth, firm, and green", says Colonel Blaik. While other coaches have not expressed themselves as the West Point mentor has,we feel sure that this description would suit most standards. Several coaches for some reason feel that the production of good turf is correlated to the amount of water applied. They feel that the more you water the better the turf. More education is needed through extension, articles, and teaching with refer-

ence to the available information. More research is needed to further our own information on specific problems.

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INTRODUCTION TO THE QUESTIONS SECTION

In order to reduce duplication and to give a range of information, all questions presented in the divisions are divided by subject matter as follows: --

1. Grasses and Their Adaptation
2. Fertilizers, Soils & Amendments
3. Renovating, Aerifying & Irrigating
4. Weeds and Weedy Grasses
5. Disease and Insects
6. Labor Incentives

Considerable editing has been done to make the answer brief which may give only a partial answer to the problem presented.

The Editor wishes to again express thanks to the chairmen and secretaries of each division for their assistance and leadership during the divisional meetings.

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QUESTIONS ON GRASSES AND THEIR USE

1. When will Merion blue seed be plentiful? A late frost reduced 1952 production of Merion to only 200,000 pounds. Seed yields in 1953 will be greater but demand and price will continue high. Superintendents should place order for seed early and plant it only under favorable conditions.

2. What are the results of Merion bluegrass throughout the U. S.? Merion due to its leafspot resistance has given excellent turf. It is slow growing as a seedling unless adequate nitrogen is applied.

3. What is the proper height of cut for Merion bluegrass on tees? Suggest 5/8 inch cut often, aerified at least 3 times per year and don't overwater.

4. Can Merion bluegrass be planted successfully with Ky. bluegrass already well established as turf for tees? If Ky. blue is well established it would be hard to do because of competition to seedings. When Ky. blue gets out, seed Merion in aerifier holes.

5. What grasses mix well with Merion bluegrass? U.S.G.A. recommends Merion be sown alone or seeded into Meyer Zoysia. Area first established to zoysia and then overseeded with Merion. At State College, Pennsylvania, Merion in combination with selected, fescues has given excellent results. Mixtures, should not be planted at heavy rates or Merion will be restricted.

6. What grasses, other than bent, will give best results on tees? U-3 bermuda in Southern part of Midwest. Poa trivialis on wet, sandy tees in northern areas. Zoysias may do well when available. Merion placed as sod from nursery has done extremely well.

7. Which turf is best for tees in central Michigan? Mixtures of bents and bluegrasses may give good results. Poa trivialis looks very good in cool spring.

8. How can bentgrasses be kept green when mixed with blue in the fairway? Bentgrass and bluegrass mixed are difficult to mow to favor. Using the flexicombs on mowers, aerifying at least twice per year and grub control with Chlorodane may reduce thatch and keep turf open and growing.

9. What is the best bent seed to reseed around greens to fill in bare ground (aprons)? Possibly use Merion bluegrass after extensive aerifying. Stolon bent may be placed in disk marks by hand or aerifier holes. Astoria or colonial should be better than seaside.

10. Which in your opinion is the best bent for greens in Cleveland District? Some possibilities are C-15 alone, good in cool weather; C-1 and C-19 combined; vigorous Washington selection; C-1, C-19, and C-15 in equal volume of stolons has been used.

11. Where in Midwest section is C-52 bent best? C-52 greens up rather early in the spring and in the pie green tests has been one of the better selections. It is adapted to most of the Midwest.

12. Is C-15 a good grass? C-15, Toronto by name, is a vigorous cool season grass. It greens up first in spring, and if planted in late fall as mixed stolons will dominate the mixture. Should be cut close and thatch kept to a minimum. Recommended for Chicago, Detroit, and Cleveland areas.

13. What would be the best type bent to start in a new nursery in southern Indiana and how much per 100 square feet, and who has the stolons for sale? For a private course nursery C-7 proved good in 1952, C-1 and C-19 mixed are widely used, and C-52 is medium in quality. Suggest you check other local courses. An experimental selection, 10 (37) 4, is available from W. H. Daniel, Purdue University.

14. Are some strains of bent more tolerant of iron chlorosis? Velvet bents are more susceptible than Creeping. Excess soil moisture, high phosphorus and limited root systems favor iron chlorosis.

15. How can a good turf be established on a playfield under two years time? On athletic fields 100 lbs. Alta or Ky. 31 fescue and 50 lbs. Ky. or 30 lbs. Merion bluegrass are recommended for Midwest. Usually apply 1,000 lbs. of 8-8-8 or equivalent mixed in soil and at least 20 bales of straw mulch to give uniform cover. Two months should be long enough.

16. What type of grass seed mixture would you advise for a very sandy soil and Northern climate? Watered and unwatered? For watered fairways use bent. If unwatered use Chewings Fescue and Ky. or Merion mixed. For southern Indiana, Bermuda and Zoysia,

sprigged in spring and overseeded with Merion in early fall.

17. How late in fall can you sow seed in Ohio and, expect to get it established before winter so it doesn't freeze out? If a small area with a light straw mulch, anytime should be possible. If unmulched, use heavy fertilization and hope to have one month before severe winter weather for plants to establish ground cover. Also light rolling in open weather in February may help save young seedlings from heaving and drying out.

18. What is the best type grass for fairways that are flooded for short periods each year (Ohio Valley)? Redtop and bentgrass will tolerate flooding. Bluegrass or fescue will when dormant but may die if growing and flooded long time. Look to see what has survived so far and plant more of it.

19. What is the best way to get good fairways on clay soils in northern Indiana? Renovate by Labor Day by 4 aerifications, spread 500 lbs., of 8-8-8. Spread seed and go over with rotary hoe or spike disk followed by rolling. Water as needed carefully for 3 weeks. Fertilize next spring with 400 lbs. of 10-6-4 or equivalent. Control weeds in late spring.

20. What seeds and in what ratio should be used in cemeteries in the Chicago area in spring when quick, results are a must, that is, in areas as small as 3' x 9'? Use bluegrass with a little rye or good commercial mixtures in open. In dry shade, fescues and in damp shade or wet areas Poa trivialis can be used. Possible mixtures, 4 lbs. rye, 3 lbs. Ky. bluegrass, 2lbs. Poa trivialis, 1 lb. Redtop.

21. What seeds would you recommend for overseeding tees predominating Poa annua? On tees with Poa annua a late fall planting has little chance as Poa annua comes in very thick. A nursery area planted to Merion bluegrass or C-115 bentgrass or Creeping bentgrass may be developed, then the tee resodded to give a good tee cover. Poa trivialis planted in mid-August after spike disking may get ahead of Poa.

22. What kind of grass do you recommend for tees on private courses in Chicago District? Bentgrass cut at 1/4" to 5/16" for tees has given good results. Spot seed in divots with Ryegrass 5 parts and Bentgrass 1 part.

23. What grasses can be grown on a tee that is shaded

and surrounded by trees? Possible cutting tree roots will help. Poa trivialis and Poa annua with repeated aerification may do as well as any.

24. What is the best mixture of grasses to be used on sandy loam? In cemeteries or lawns mixtures carrying three parts fescues and one part Merion when planted in the early fall and repeatedly fertilized, have given good turf.

25. Which grass or grasses can give us (So. Illinois) good turf all year on fairways with no water? Only small amounts of Meyer Zoysia (Z-52) are available from W. H. Daniel, Purdue University. You could get this to begin nursery and gradually expand it into fairways. U-3 bermuda will be more available but less satisfactory. Merion bluegrass should be planted only with careful renovation and favored by adequate fertilization after germination.

26. How difficult will it be to keep Meyer Zoysia runners out of lower beds? In getting zoysia started if it is well fed, it may grow into beds somewhat but not to extent of Bermuda. When established cut down on fertilizer and runners should not cause trouble. Once a year pruning should be adequate. Winter kill will reduce loose runners.

27. What would be the most economical way to establish a Zoysia tee? Plant plugs or spriggs on one foot centers in nursery. Fertilize as heavily as putting green and mow at 1/2 inch. Sod tee with sod.

28. Is Zoysia practical for Detroit or Chicago areas and what are its good points? How should it be used with other grasses? Zoysia may be hardy in Detroit and Chicago but it would be off color in winter and grow much less due to cooler summers. For same, effort and expense, Merion bluegrass may make better turf.

29. Will Meyer Zoysia (Z-52) seedlings winter as well as established turf? There will be some loss of runners if sod is not formed because of freezing and thawing action. A light straw mulch in winter will reduce runner loss and give quicker ground cover.

30. What is difference between Z-73 and Zoysia Japonica? There are three zoysias: japonica - coarse, leaf hardy; matrella - medium leaf, slightly hardy; tenufolia - fine leaf, not hardy. Meyer (Z-52) is a selection of japonica. Z-73 is a vigorous seedling

selection from Meyer of intermediate leaf width and good seed production.

31. What have been the results of U-3 bermuda for tees in areas of southern Indiana? There are U-3 tees in Cincinnati, Evansville, St. Louis and Terre Haute. Plant as soon as possible in summer. Use sodium arsenite on crabgrass and mulch first winter after planting.

32. We have a 9-acre plot seeded last fall on which the stand of turf is very thin, especially in certain areas. Would it be preferable to aerate and seed or disc lightly and seed this spring? Fertilizing will probably give best results for the money expended. Shallow aeration would be beneficial. Use regular seeding rates if not enough grasses to bother about.

33. What is the best and most practical method of removing Poa annua from greens when it is in very small patches, i.e., 2" in diameter?Try to promote a a deep rooted bent, lessen compaction, and time fertilizer applications to favor bent. Plugging out in early spring may be partial answer.

34. How can we keep grass on tees for public golf? Have a limit on what grass can stand. Use large enough tees, rotation and policing to enforce rotation, and grass selection -- For area to be used-bent in north bermuda in south, zoysia when available.

35. In changing type of grass in established grass, is there an easy way of just topdressing and reseeding or does old area have to be recultivated for best results? Spray with 3 lbs. of sodium arsenite at least twice aerify, fertilize and seed in fall.

36. How can 45° creek banks be kept from washing away? Planting willow may be of value. A hay mulch in early August may give protection and get turf started. Mow often at 2-4" height. Fertilize to get vigorous initial cover of turf.

37. If you have a Poa problem on your green aprons, how can you convert to bent? Aerifying in late summer and seeding Merion or other grasses may get them started ahead of Poa. Cyanamid or methyl bromide may be used to kill Poa seeded before planting desired grasses.

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QUESTIONS ON RENOVATING, AERIFYING AND IRRIGATIONS

1. Outline spring renovation on the putting green? Start with a severe raking and repeated mowing to remove accumulated thatch and old grass. Follow with heavy fertilizing to encourage new growth. Be sure you have water turned on so grass can be dampened to rinse off fertilizer and prevent leaf burn if needed.

2. Should newly seeded fairways be rolled; if so, with how heavy a roller this spring? Roll only heavy enough to bring grass plants in contact with the soil to prevent their drying out.

3. Should clippings be left on lawns? One rule of thumb is to cut grass often enough that the leaf blade cut off is no longer than the leaf blade left. Only when making "Hay" should clipping be removed.

4. What was Dr. Grau's procedure for rehabitating his lawn shown on his slides? Dr. Grau used light-sodium arsenite followed by sprigging and plugging of zoysia and bermudas.

5. When is a lawn properly watered? When sufficient water is applied to wet the soil to a depth of at least 6 inches.

6. On a golf course where watering must be done after dark. What is the best time? Experience shows that early morning watering may be better than early evening, as disease is favored less in morning.

7. Give seed mixture, fast growing, for commercial, lawn seeding in northern Indiana? On housing projects where lots of wear and low maintenance, is the rule, 50% bluegrass, 30% fescue, 10% rye and 10% redtop was recommended. Fescue increased on lighter soils, bluegrass on heavier soils. Ky. 31 recommended for tough soils and hard wear. Use alone or add bluegrass.

8. What grass would you suggest using for a spring-renovation in regions where seeding bluegrass is a waste of time and money? Ryegrass may give quick cover and be a temporary lawn until fall.

9. What has the reaction been to the new thatch machine made by West Point? The machine is based

on previous tools made by several superintendents. Demonstrations of machine are showing very promising results.

10. What machines and procedure for mass sprigging or stolonizing of large areas are being used? So far the use of 1-inch spoons on aerifiers followed by hand sprigging every 2 feet has been main procedure. Need of a machine or adaptation is great for this work.

11. What observation do you have with regard to soil conditioners under turf? Soil conditioners are mainly two types. They are most efficient when thoroughly mixed with the soil and produce a water stable aggregation. The soil may be compacted again so aerification is expected on wear areas. For erosion control it may last one growing season.

12. Has anyone used or tried Vermiculite in new green construction and if so, what results? Vermiculite was tested in Oklahoma where it showed a tendency to break apart within 3 years to a more compacted form. Greenhouse users find it deteriorates in some two or three seasons when used for cuttings Opinion was that peat would be more satisfactory.

13. Is the theory that topdressing of greens is not necessary sound? Topdressing very often used to be a constant practice in putting green management. Today with aerifying, thatch removal, disease protection, and less topsoil available many superintendents topdress only when the putting surface needs leveling. Topdressing is very expensive, today and many greens are not topdressed.

14. What is your opinion about using sawdust in topdressing? Sawdust is all right if hardwood and well decomposed. Pine has too much rosin, should be amorphous. Sawdust waterholding capacity is 150% as compared to 400% for most other materials as peat. Corn cobs and hulls can be used also.

15. How would you advise softening a green that was built with a rototiller? Try aerifying the putting green four times in one day to completely loosen the surface then roll lightly, topdress and fertilize to get grass recovery. Then aerify once over at least twice a year.

16. If sand is composed of large pores, why will it prevent water from going through it as in case of

"sand layer"? Water movement in soil is by suction or capillary action. A sand layer below soil interrupts the continuous action, so water hangs in soil above, then rushes freely through the sand. Water movement upward in soil is also limited.

17. Is it practical to drain level fairways by me.ns of sump pumps if natural drainage lacks sufficient pitch? Better to use French Channels,backfill with sand or back fill with pea gravel of graded sizes.

18. Do you recommend immediate topdressing and fertilizing after aerification? In spring it may be done. In fall fertilize after aerification. No point in topdressing if in good physical condition. Topdress before and after aerification if change of structure is desired. Fertilization prior to aerification to have turf actively growing. Light watering after aerification. Shallow aerification in summer half of green at one time.

19. What frequence and timing of aerification is best for turf areas that have not been aerified before? Spring and fall combination good. Aerifying too early may encourage Poa annua if bent is still dormant. Fertilize permanent grass in fall six weeks prior to dormancy.

20. If grass starts to wilt, how soon must you water? Must apply as soon as wilting is evident or possible loss of leaves.

21. How are Bouyoucos blocks used to determine irrigation needs? They are used on fairway or tee as indicators. Install blocks in root zone below aerifier depth.

22. Is aerification the answer to fair ring? No control known. Use enough nitrogen to keep rest of the green the same color. Fungus causes dryness. Aerification helps overcome the effect but not the cause.

23. How can you determine when to water? Sufficient if soil is wet to 4-5 inches.

24. Is there a possibility of too much aerification? Yes. Surface too loose. Some greens have been aerified once a week for entire season.

25. Should first year greens planted to bent stolons be aerated extensively? The purpose of aerifying is to loosen the soil and get adequate water and

air infiltration. In establishing the green and, watering there may be surface compaction. Could aerify twice over lightly as soon as green is well covered with turf.

26. New greens planted in the fall had a tendency to bunch? What is the quickest procedure to an even coverage? Fertilize and mow, and plug into bigger openings.

27. Has aerifying increased weed population in greens? Some increase has been noticed in the weaker strains of bent. Anytime an opening occurs in turf, whether, caused by disease, ball marks, spikes, cupchange or any cultivation, weedy grass seed has a chance of survival.

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QUESTIONS ON FERTILIZER USE AND SOILS

1. How much and how often should Merion bluegrass be fertilized on tees? Since Merion has leafspot, resistance, it can respond to high nitrogen levels. Use half as much as on bent putting greens. For example, fertilize once per month, aerify but don't overwater.

2. What is the objection in using a complete fertilizer through the growing season on lawns or fairways? Spring and fall applications of complete fertilizers (as 10-6-4) usually give adequate phosphorus and potash for the season. Vigorous turf growth may be encouraged by either nitrogen or complete fertilizer applied in summer also. For example, one superintendent applies 200 lbs. of 10-6-4 on dry turf in summer and pulls a link drag behind spreader.

3. How much fertilizer should be used per acre to grow good fairway turf? First, fertilize to get uniform coverage. For adequate nitrogen apply between 2 and 4 lbs. of actual nitrogen per 1,000 sq. ft., per year in from 2 to 4 applications depending on material and management.

4. At what rate would you recommend fertilizing fairway in June, July and August? Suggest 400 lbs. inorganic

in April, then 400 lbs. organic fertilizer per acre in early June, then up to 400 lbs. inorganic in mid-September.

5. What type of ofertilizer would you use on a very sandy soil? Sandy soils usually hold in reserve a limited moisture or nutrients. Light (300 lbs./A or less) rates of inorganic fertilizers in spring and organics in late spring and fall should give adequate growth.

6. With what and at what rates should grass seedlings planted last fall be fertilized this spring? Anaylsis such as 10-10-10 or 10-8-6 at 400 lbs. per acre in early spring should encourage good coverage. An early summer application of up to 20 lbs. of actual, nitrogen per acre should help maintain growth, then fall fertilization should help fill in bare areas.

7. Where phosphates are low under established turf can this be applied on forzen ground? Apply as 20% superphosphate. Some aerification to aid in penetration desirable. Can be applied on frozen ground.

8. Is there a general recommendation of fertilizer per 1,000 sq. ft. to be worked in a new turf area. If the soil to be planted was hauled or moved, plan to apply 2 lbs. of each N - P - K per 1,000 sq. ft. Example: 1,000 lbs. of 8-8-8 per acre.

9. Why do some fertilizers of the very same anaylsis differ in cost? Because organic nitrogen costs more than inorganic nitrogen per pound of nitrogen-supplies.

10. To grow grass on sandy loam what should be (a) the amount of seed? (b) the amount of fertilizer?(c)the amount of sprinkling? (a) 1 to 5 lbs. depending on seed. No need to seed heavy. (b) not over 500 lbs. of 10-10-10 per acre. (c) Use straw mulch if possible. Water lightly in mid-afternoon if possible to keep seed damp until roots established.

11. How much 5-10-5 or 8-8-8 should be used for spring treatment of greens per 1,000 sq. ft? Up to 20 lbs. per 1,000 sq. ft. See directions on bag.

12. Is using the amount of nutrients removed by clipping on a green a basis for establishing the amount of plant food to return? Only to the extent one realizes that clippings show only part of the fertilizer

applied. Nitrogen leaches readily, phosphates are reverted to unavailable forms and potash is leached. A minimum safe growth supply of nutrients may be 8 lbs. N, 2 lbs. P_2O_5 and 4 lbs. K_2O per 1,000 sq. ft. per season in the Midwest.

13. Discuss timely fertilization, aerification and the other maintenance operations in the spring to hold down unwanted Poa annua on putting greens and aprons. Poa annua seed are usually present in soils and become established in the thin turf. Aerification and heavy fertilization in the early fall may encourage bent grass more than Poa.

14. Explain the procedure for the use of Nugreen fertilizer. Use complete fertilizer in spring. Every 3 weeks apply 44% nitrogen; at 5 lbs. of urea per green add 2 lbs. potash (soluble). Cost is 44¢ per green per treatment.

15. Does Anhydrous Ammonia have a place in turf fertilization? No. Difficult to apply gas, without loss on considerable N, but other forms of soluble nitrogen as solution 32 can be used.

16. What is the advantage of liquid fertilizers over dry applications if any? Liquids may be easier to apply uniformly and reduce risk of burning. Many fertilizers are soluble and the cost should be considered as well as convenience.

17. Has soluble fertilizer a place in the green maintenance? Yes if cost is reasonable. Most of the phosphorus and potash needed can be supplied in spring and fall.

18. Do liquid fertilizers offer a cheap source of plant nutriments? No. But safety and convenience may be very worthwhile.

19. Will liquid fertilizers furnish an adequate source plant nutrient during warm weather feeding? Most liquid fertilizers were developed for horticultural crops. Turf needs most nitrogen, little phosphorus, some potash.

20. Can we justify the promotion of "plant food" fertilizers in preference to "farm" fertilizers on lawns? One of the big problems of the home owner is to get fertilizer on turf without burning and streaks. Liquid, pelleted and organic fertilizers may reduce these problems and often result in more use of fertilizer. Actually the available nutrient is all that counts to the plant root.

21. Is soil testing accurate enough to tell when an acid needs limestone added? Every state has soil testing service which determines pH and lime requirements. The latter allows for buffering effect of clay and organic matter content of soil. Sample under turf should be from surface to 2 inches deep from several spots in one location. No turf area should be limed without being tested to determine need first.

22. Is the tissue test kit available? Not in unlimited quantities. A small kit is available from Jim Bray, Washington Street, Urbana, Illinois.

23. When should lime be applied to greens, spring or fall? Only when soil test shows need. Best applied in fall after aerifying to get best possible penetration in soil.

24. How late can lime be used on greens before fertilizing first time in spring? Apply lime if soil test shows pH low at any time of year. Not over 60 lbs. per 1,000 sq. ft. any one time.

25. What is dolomitic lime and why is it better than regular ground agricultural lime? Some soils are low in available magnesium. Dolomitic limestone may be approximately 1/3 magnesium oxides and the nutrient should be beneficial if needed.

26. Should a compost made from manure be supplemented with chemical fertilizers? Use of supplemental fertilizing materials will reduce amount of manure needed to obtain same amount of nutrients. The manure may act as a diluent to get good spreading, may get some decomposition in storage.

27. Does a compost having a 2-2-2 analysis made from manure supply sufficient plant food for a lawn? If same amount of nitrogen is used as with high analysis carriers, results should be as good or better.

28. Compare chicken manure, sheep manure and cow manure for use on a lawn? The analysis of dried manures are poultry, 2-1-1; sheep, 1-4-1; cow, .6-2-.5. The amount to

$$\frac{80\text{\# nitrogen per acre wanted}}{20 \times \% \text{ - Nitrogen per ton of manure}} = \text{Tons required}$$

or:

$$\frac{80 \text{ wanted}}{20 \times 2\%N} = \frac{80\#}{40\# \text{ per ton}}$$

- 2 tons/A Chicken manure
- 4 tons/A Sheep manure
- 6 tons/A Cow Manure

29. Is raw sewage sludge a valuable source of plant nutrients? If applied as manure is ordinarily applied and plowed or mixed with soil. Odor and grease may be objectionable if applied on surface.

30. What value is raw sludge treated with chloride and lime? May be used in making new lawns by mixing with soil. May be composted for 1 year then used.

31. How should iron sulphate be applied for iron deficiency? Use 1/2 lb. to 1 lb. of iron sulphate per green in 20 gallons water and don't water in.

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QUESTIONS ON DISEASE AND INSECTS

1. Is there any difference in high or low pressure sprays for fungicides and herbicides on greens and fairways, PMAS - 2,4-D? Lower pressures for fungicides. A good coverage is desired. With 2,4-D avoid drift so use lower pressure, i. e., 100 lbs. or under. The 400 lbs. plus in fungicide sprays may give more actually knocked off leaf blades.

2. Why is it that dollarspot usually hits on the back of the green first? Because the conditions and soil temperature at that time are just right in that area. Available nitrogen may be leached there.

3. In treating a green with PMAS for weed crabgrass control, will it be effected by chemicals for disease control? Do not recommend mixing with

various other materials since PMA is a fungicide. PMAS has been mixed with Tersan.

4. Is PMAS good for dollarspot? Yes, 3/4 to 1 fluid ounce per 1,000 sq. ft. weekly.

5. Can PMAS be used on Merion bluegrass? Several cases of discoloration of Merion have been observed. On Merion KOCNgives a little discoloration so it may preferred. Applying PMA in later afternoon may give less discoloration than morning spraying.

6. What have been the results of PMAS in controlling crabgrass? PMA as 3-5 weekly sprays on young crabgrass has been successful. Do not delay treatments. Do not use excess material.

7. When I see blue spots on a green is it brownpatch Bluish grass usually means wilting either caused by a low root absorption (sprinkle), lack of soil moisture (irrigate), or beginning of disease attack (spray). Brownpatch, pythium and melting out can show some blueish cast in early stages.

8. Can melting out be spread by watering? Yes, as it produces spores.

9. Does Pythium follow melting out? Not necessarily. Pythium has to have higher temperatureand more moisture.

10. Can melting out be carried by mower? Yes, usually not an important factor though. May be present and inactive until conditions favor an outbreak.

11. What is thelife cycle of a brownpatch pathogen? Do sclerotia harbor in the crown of the plant? The brownpatch pathogen (pellicularia filamentosa) inactive stage is sclerotia which are on vegetation, and in the soil. Under high humidity and temperature of 80-90° F. a fast growing mycelium is produced.

12. Would like a description and suggested control for pythium. There are many pythium diseases. The one most common on turf are reddish spots, size of dollarspot, may join to form figures following surface drainage. Control doubtful. Hope for change in weather. See Howard's "Fungus Diseases of Turf Grasses", Rhode Island Bulletin No.

13. What about angleworms on greens? Use Chlordane at 1/4 pound per 5,000 sq. ft. or Arsenate of Lead at 1 lb. per green to reduce worm activity.

14. What is the best and most economical control of common angle worm on fairways? Lead Arsenate used at 10 lbs. per acre. Chlordane, 10 lbs. actual per acre, are common rates.

15. How do you control nematodes? No control except complete soil sterilization.

16. What is the most economical method for control of moles in turf? Kill food, grubs and worms with chlordane or lead. Moles will then not find food in area.

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QUESTIONS ON WEEDS AND WEEDY GRASS

1. What relation has the height of cut on the length of roots? For Ky. bluegrass or fescues a cut less than 1.25 inches is considered to reduce the effective leaf surface and thus the extent of roots. Frequent uniform mowing allows a lower cut. For bent, whose leaf surface at low cut is sufficient, the height of cut may not influence root depth.

2. What results have been found in using Chlordane to control crabgrass? Best results reported have been using twice normal rate, 20 lbs. of actual Chlordane in emulsion formulation carried in 60 - 80 gallons oil per acre. Results have been very eraditic and difficult to interpret. No control found with wettable powder.

3. Has there been work done with PMAS to control Poa annua? PMAS does not prevent seed formation and no control has been noted on Poa annua.

4. Outline crabgrass control for putting greens. About May 1 or at the time crabgrass first germinates, begin weekly sprays with PMA solution, 10% at 1 fluid ounce per 1,000 sq. ft. Expect to use from 3 to 5 applications. During this time PMA should be satisfactory fungicide. Use other fungicides if needed to control severe brownpatch.

5. What is the best control for crabgrass and cost per acre?

Material	Rate/A	Applications	Total Cost/1,000 sq. ft.
10% PMA	5 pts.	3 or more	app. .65
91% KOCN	8 lbs.	3 or more	app. .85
91% $NaAsO_3$	1-2 lbs.	4 or more	app. .02

The above are only guides. The cheapness of sodium arsenite is largely offset by its extensive burning to desired grasses. Each material has best uses and time of year. In dry formulation expect to use twice as much material as in spray applications. In order to get uniform coverage with these use 50 gals per acre or more. Spray tests from 25-200 gallons per acre show 25 gallons not uniform and anything over 100 extra.

6. What is burning effect of KOCN? Merion and Ky. bluegrass are least injured. Fescue and bent are medium in ease of burning but bent should recover faster. Crabgrass, clover and chickweed will be burned back but new shoots from dormant nodes will need retreatment until entire plant is dead. KOCN costs more but does safer selective weedy grass control than sodium arsenite.

7. What should be done if PMA treatment turns grass yellow? This indicates excess treatment. It probably turned yellow about three days after treatment and should become green again in two weeks. Watch grass closely, continue spraying at one-half regular rate. Do not dealy treatment much or crabgrass also recovers.

8. Why are we so concerned with crabgrass today? Crabgrass is an old weed but now that chemicals are available for its control, information is available for you. Also close cutting of Ky. bluegrass and fescue continues to offer more chance for crabgrass infestation. Always consider first why the weeds, came in and correct cause as well as remove crabgrass.

9. Is there a control for goose grass? Yes, hand weeding. No chemical proven satisfactory as yet. Reported by Ernie Schneider that 1 oz. 2,4-D per 1,000 sq. ft. gave control of goose grass. Daniel pointed out damage from 2,4-D had occurred in other areas. Suggested not to use 2,4-D on bent at heavy rates any any time.

10. How can clover be eliminated in established greens? Establish proper fertilizer balance on greens to favor grasses (more nitrogen). In late fall,-- 2,4,5-T 3 oz. to 3 gals. of water per green in spray application. Standard rate is 1 qt. 2,4,5-T solution per acre. Use 3/4 fluid ounce (32 per qt.) per 1,000 sq. ft. in 1 gal.

11. What is rate of 2,4-D per gal. of water? Standard solution carries 1 lb. of acid per quart of solution. One use would be 1 fluid ounce per gallon per 1,300 sq. ft.

12. How can clover and chickweed be controlled on fairways? For chickweed continual defoliation by sodium arsenite, KOCN, etc., helps but a good stand of grass is effective. For clover, an equal mix of 2,4,5-T and 2,4-D. One quart each per acreas late fall spray has given complete control.

13. How can a clean seedbed be prepared? Menthol Bromide (gas), cost 80¢ per 1,000 sq. ft. (plus cost of cover), can be reseeded 48 hours after starting. Cyanamide, 75 lbs. per 1,000 sq. ft. (get bulletin), on and disked in or aerified seedbed. Wait 1 - 4 weeks depending on temperature and rainfall to reseed.

14. A light green, fast growing, coarse-leaved grass was brought in with top soil. How can it be controlled? It is a swamp grass-sedge with bulb at base. It usually dies if mowed close one season. 2,4-D in early spring may kill it.

15. List the weed killers that will kill everything.

    a. Ammate is an immediate contact killer. Does not kill perennials.

    b. Arsenic Acid effective is used in excessive rates to burn vegetation.

    c. Sodium arsenite will kill everything at rates of 10 lbs. per acre, but it gives no residual effect.

    d. CMU will kill all vegetation. Keep pedestrians and animals off area until the chemical has penetrated into the ground.

    e. Brush, use 2,4,5-T in oil. Can be used in winter when most plants are dormant.

f. TCA at heavy rates can kill Johnson or quack grass, etc. Will sterilize soil from 1 - 4 months

g. Some fuel oils may be satisfactory.

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QUESTIONS ON SHRUBS AND EVERGREENS

1. How much fertilizer should be used on Hedge Rugosa? Small amounts of any good turf fertilizer are sufficient.

2, Which Yew is the hardiest? Taxus cuspidata.

3. a. What sort of deciduous trees should be planted at Cleveland, Ohio? b. Where are blight-proof chestnut trees available from? a. Consult Ed Scanlon of Shade Tree Division of Cleveland. b.Nut Nursery at Rockport, Indiana.

4. What are the best low growing shrubs? Rhus aromatia (procumbent variety); Ceanothus, Ribes alpinum, Vib opulus nana, cotoneaster apiculata, cotoneaster herozantalis, spireas (dwf.) ninebark, Euonymous alatus compaeta, Ilex crenata convexa, Green Island, Mahonia aquifolium, Ilex glalra, abelia grandeflora, Euonymous patens, Euonymous fortusa carrieri.

5. What are the requirements of fertilizer for evergreens? Less than turf.

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QUESTIONS AND COMMENTS ON LABOR INCENTIVES

Mr. Clarence Wolfrom prepared the following excellent suggestions which are given in outline below:

A. Major Labor Incentives:

1. Security for themselves and family. Year around work.

2. Wages comparative with industry.

3. Prompt increases at end of probation period.

4. Paid vacation, summer or winter.

5. Seniority and job priority.

6. Full time pay; not loss for weather.

B. Added Incentives to make Work More Pleasant:

1. Properly informed on what is expected of them.

2. Appromixate time each job takes after they are properly trained.

3. Not reprimanded in front of other men.

4. What you don't say often helps more than what you do say.

5. Always use the cooling off period.

6. Get all the facts before saying anything.

7. Study each man individually.

8. Be interested in his and his family's health.

9. Always be a good listener.

10. A good word for a job well done.

11. In solving a problem always ask, "What does he think is the best way".

12. Keep him interested. Tell him why this has to be done and why you do it this way.

13. If he has a better way, try it out. Do not be too set on your ways.

14. Have periodic golf matches with neighboring course men.

15. Dinner in the club once a year paid for by the Superintendent if necessary.

C. Winter Jobs at Maple Lane

1. Rebuild tees and greens.

2. Plant trees, trim and remove old cnes.

3. Clean, repair, paint all course equipment, pumps, filter screens and tanks.

4. Repair old and build new fences.

5. Clean and paint club house inside.

6. Sand, refinish floors.

7. Clean and repair fans.

8. Repair water valves.

9. Clean drains.

10. Clean heating system.

11. Repair and refinish chairs and tables.

12. Rebuild precooler.

13. Remodel kitchen.

14. Repair screen doors and screens.

15. Repair and paint signs.

16. Build new signs.

17. Build new tee benches.

18. Treat greens for snow mold.

19. Clean house in work shop, stock bins, tool cabinet.

20. Repaint and build Maple Lane Spikers.

21. Take inventory of parts.

22. Remove all snow from roads and walks and parking lot.

23. Sand when icy.

24. Attend as many turf conferences as possible.

Better course gives bigger income from increased green fees and thus higher salaries for superintendent.

1. Do any clubs have pension funds? Several clubs are studying pension plans. Most are paid by club.

2. Do any clubs have hospitalization plans? Several have Blue Cross and Blue Shield.

3. What retirement plans are available? The American Association of Nurserymen have a business plan with John Hancock Company of Hartford, Conn. Suggest you write them for retirement programs giving data on number of men, etc.

4. How many men work year around? Number of men in winter decreases number of men needed in summer. Two experienced men are better than three inexperienced men. One course has 5 in winter and 8 or 9 in summer. On an irrigated course more are needed.

5. What are average wages by districts? Detroit, $1.25 to $1.75; Akron, $1.53; Chicago, $1.25 to $1.65; Indianapolis, $1.25 to $1.55.

6. How many clubs have a set number of hours they work each week? Answer by show of hands: 40 hr. week, 80%, 1½ time Saturday and Sunday, 12% Double time Saturday and Sunday, 20%; 9 hours per day, 40%; 8 hours per day, 50%.

7. Do you think superintendents and members would be better off if labor was unionized? No. Unions are not able to supply qualified men for work nor to provide training.

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