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deep-rooted perennial plants would also be of importance in killing plants.

LITERATURE CITED

1. Basler, E. 1977. Effects of growth regulators and gibberellic acid on 2,4,5-T translocation. Weed Sci. 25:36–40.
2. Basler, E. and R. McBride. 1977. Effects of coumarin, juglone and abscisic acid on the translocation of auxin. Proc. Plant Growth Regulator Working Group. 4:295–300.
3. Binning, L. K., D. Penner, and W. F. Meggitt. 1971. The effect of 2-chloroethylphosphonic acid on dicamba translocation in wild garlic. Weed Sci. 19:73–75.
4. Chykaliuk, P. B., E. Basler, and T. F. Peeper. 1980. Effects of the growth regulator GAF 141 on the downward translocation of herbicides. Proc. Plant Growth Regulator Working Group. 7:23–28.
5. Hay, J. R. 1976. Herbicide transport in plants. Pages 363–376 in L. J. Audus, ed. Herbicides: Physiology, Biochemistry, Ecology. Vol. 1. Academic Press, New York.
6. Ogg, A. J., Jr. 1975. Control of Canada thistle and field bindweed in asparagus. Weed Sci. 23:458–461.
7. Sandberg, C. L. 1978. Herbicidal efficacy and physiological aspects of glyphosate [N-(phosphonomethyl)glycine on field bindweed (*Convolvulus arvensis* L.). Diss. Abst. Int. 39(3): 1074–1075.
8. Weed Science Society of America. 1979. Pages 1–3 in Herbicide Handbook. Weed Sci. Soc. Am. Champaign, IL.

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Common Waterplantain (*Alisma triviale*) Interference with Wild Rice (*Zizania palustris*)[1]

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Abstract. Three cultivars of wild rice (*Zizania palustris* L.) were grown with various densities of common waterplantain (*Alisma triviale* Pursh) established from seeds and from rootstocks during 1979 and 1980. Wild rice cultivars did not differ in their response to common waterplantain interference. Common waterplantain grown from seeds at densities up to 82/m^2 did not significantly reduce wild rice yield. Common waterplantain established from rootstocks significantly reduced wild rice yield at densities as low as 3/m^2. A density of 43/m^2 reduced wild rice yield by 91%. The yield component most susceptible to interference from common waterplantain was panicles per plant. The number of seeds per panicle was reduced by densities as low as 11/m^2 and seed weight was reduced by densities of 22/m^2 or greater. Only a density of 43/m^2 reduced the stand of wild rice. Common waterplantain established from rootstocks at a density of 17 plants/m^2 did not reduce wild rice yield if removed by 7 weeks after planting. Interference from common waterplantain for 9 weeks or longer reduced wild rice yield by approximately 50%.

Additional index words. Competition, yield.

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INTRODUCTION

Wild rice (*Zizania palustris* L.) (previously classed by Hitchcock as *Z. aquatica* var. *angustifolia*) is an annual aquatic cereal native to the Great Lakes Region. It grows naturally in lakes and rivers in Minnesota, Wisconsin, and Canada and was once a major source of food for the Sioux and Chippewa Indians of this region (9). Wild rice is undergoing domestication and is presently cultivated on approximately 11 000 ha in Minnesota. Most of the land used for wild rice production is situated in low-lying areas not previously used as farmland. Because of the high capital investment associated with dike construction and irrigation equipment, and because land cultivated with wild rice is poorly suited for alternate crops wild rice is commonly grown in the same field year after year. This continuous monoculture has permitted the establishment of common waterplantain at competitive levels in many fields.

Common waterplantain is an emersed, erect aquatic perennial that may grow to a height of 1 m. It reproduces by rootstocks and by seeds (Figure 1). Common waterplantain seeds remain dormant after maturation until subjected to a period of cold temperature (below 2 C) for 1 or 2 months (4). They can remain viable in the soil for many years (8). Rootstock buds also become dormant in the fall. This dormancy is broken by a cold period similar to that required by the seeds. In California, common waterplantain is troublesome on the banks and edges of irrigation and drainage canals and in fields of rice (*Oryza sativa* L.) where crop stands are thin (8).

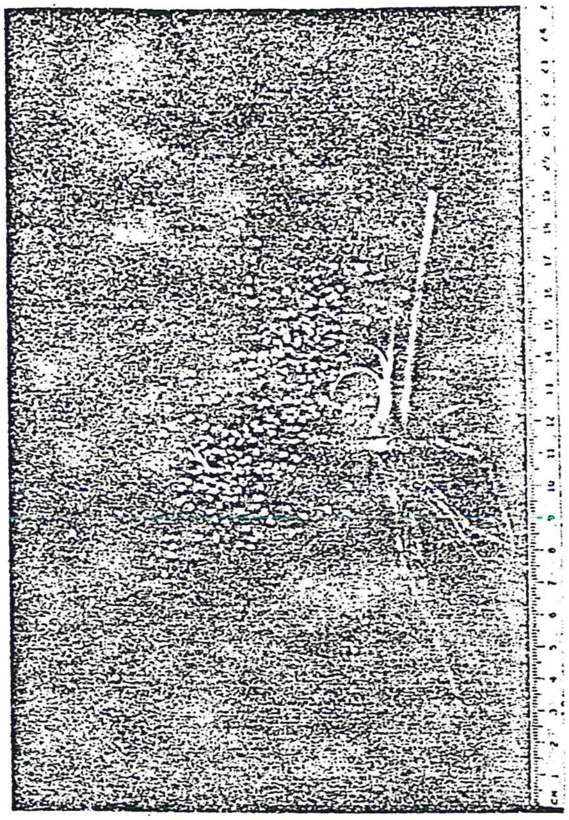

Figure 1. Common waterplantain seeds and rootstock.

Cultivars within a crop species can vary in their ability to mpete with weeds. Rice cultivars that required a longer riod of time to mature competed better with barnyard-ass [*Echinochloa crus-galli* (L.) Beauv.] than did earlier-turing cultivars (7). Burnside et al. (1) found that tall, e-maturing soybean [*Glycine max* (L.) Merr.] cultivars re generally better able to compete with weeds than were ort, early-maturing cultivars. Competitive ability of grain rghum [*Sorghum bicolor* (L.) Moench] cultivars was sociated with plant vigor during early growth stages).

The objectives of this study were to investigate the effect common waterplantain densities on the growth and yield wild rice cultivars and to determine the maximum length time that common waterplantain may interfere with wild e cultivars before yields are reduced.

MATERIALS AND METHODS

General — Experiments were conducted in 1979 and 1980 the University of Minnesota's North Central Agricultural periment Station at Grand Rapids, Minnesota. The soil s an Indus clay loam (*Typic Ochraqualf*) with a pH of 5.8. e experimental area was fallowed and fumigated the year ore cropping. The fumigant, methyl bromide, was applied the rate of 360 kg/ha to eliminate residual wild rice and weed seeds. Prior to planting, 25 kg/ha of N was applied as urea. The soil had high levels of extractable phosphorous (160 ppmw) and exchangeable potassium (300 ppmw).

On May 21, 1979, and April 30, 1980, wild rice was hand broadcast at a rate of 50 kg/ha of viable seeds. The seeds were incorporated into the soil by a shallow rototilling. A randomized complete block design with a split-plot arrangement was used for both experiments conducted. Wild rice cultivars ('Netum', 'K2', and 'Johnson') were whole plots. Subplots were 2 by 2 m.

Common waterplantain was established by hand-planting small individual rootstocks, which had one viable bud, or by lightly raking the seeds into the soil after seeds of wild rice had been incorporated. Rootstocks and seeds were collected from growers' fields the previous fall and stored at 2 C.

Immediately after planting, the field was flooded to a depth of 20 cm. This depth was maintained until 1 week before harvesting, when the water was drained. Malathion (0,0-dimethyl phosphorodithioate of diethyl mercaptosuccinate) was applied at 1.1 kg/ha when wild rice had reached the floating-leaf stage to control a midge (*Cricotopus* spp.) and during grain filling to control the wild rice worm (*Apamca apamiformis* Guenee). Zinc ion-maneb complex (zinc ion + manganese ethyl-bisdithiocarbamate) at 1.8 kg/ha was applied early in August for prevention of leaf spot caused by *Helminthosporium* spp.

Wild rice was harvested from the center 2.25 m^2 of each plot when approximately 30% of the kernels were dark. Plants and panicles were counted from each harvested area before threshing the grain with a plot thresher. The threshed grain was weighed immediately. Netum, K2, and Johnson were harvested on August 28, September 4, and September 11, respectively, in 1979. All cultivars were harvested on August 25 in 1980. Seed weights were determined by weighing 200 kernels, which had been oven-dried at 50 C for 48 h. The dried grain was heated at 100 C for 1 hr, dehulled, and weighed to determine processed yield. Percent recovery was calculated by dividing the processed grain weight by the harvested grain weight.

Plant density. In 1979, common waterplantain densities were: 0, 5, 11, 22, and 43 rootstocks/m^2 and 54, 108, and 215 seedlings/m^2. The highest rootstock density and the two lowest seedling densities were omitted in 1980. The appropriate 2-by 2-m plots were seeded with 6, 12, and 24 g of common waterplantain seed in 1979 to establish 54, 108, and 215 seedlings/m^2, respectively. These weights represented the amount of seed needed to establish the three seedling densities in glasshouse experiments. Because of poor establishment in 1979, 218 g/plot of common waterplantain seed were planted in 1980 in order to establish 215 seedlings/m^2.

At harvest, five waterplantain plants were pulled from each plot and weighed (combined above ground portions and rootstocks) after drying at 50 C for 96 h. The treatments were replicated three times in 1979 and twice in 1980.

Duration of interference. Subplots were uniformly planted with common waterplantain rootstocks at a rate of 17/m^2

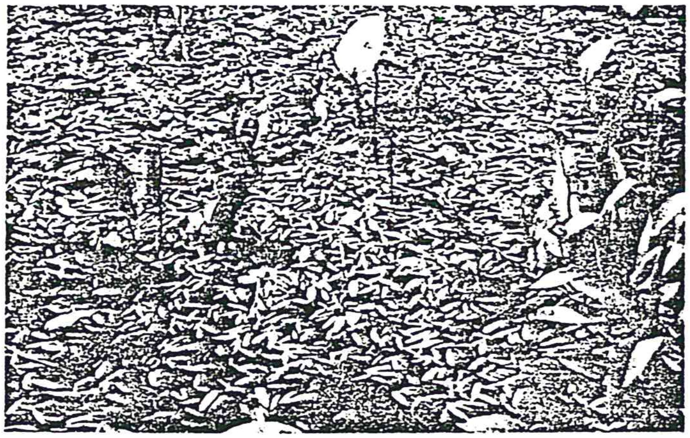

Figure 2. Leaf development of common waterplantain 36 days after seeding (floating leaves) or planting rootstocks (upright leaves).

with the exception of the weed-free control. After planting, common waterplantain was allowed to grow with wild rice for 0, 3, 5, 7, 9 weeks, and all season (an average of 15 weeks) in 1979 and for 0, 5, 7, 9, 11 weeks, and all season (approximately 17 weeks) in 1980. At the end of each interference period, common waterplantain plants were removed by hand, and in 1980 dry weights were obtained on five random plants/plot. All plots were free from other weed specie throughout the growing season. All treatments were repli cated twice each year.

RESULTS AND DISCUSSION

Plant density. The three wild rice cultivars responde similary to common waterplantain interference averaged ove all densities of waterplantain grown from rootstocks or seed yields did not differ significantly (data not shown). Moreove cultivars did not interact with weed densities.

The densities of common waterplantain established fro seeds ranged between 7 and 82/m^2 in 1979 and betwee 0 and 40/m^2 in 1980, and did not correlate with the numb seeded. A regression analysis indicated that densities of com mon waterplantain grown from seeds did not affect wild ric growth or yield (r^2 = 0.01 for yield both years). The lac of harmful interference to wild rice from relatively hig densities of common waterplantain seedlings may be due t the slow rate of seedling growth. Wild rice was over 40 c tall and in the late tillering stage before most of the commo waterplantain seedlings had reached the surface of the wate Even though seedlings do not affect wild rice yield the produce perennial rootstocks that have the potential f rapid regrowth the following spring (Figure 2).

All densities of common waterplantain grown from roo stocks significantly reduced wild rice yield (Table 1). R

Table 1. Common waterplantain dry weight and wild rice yield and yield components averaged over three wild rice cultivars as influenced by den ties of common waterplantain grown from rootstocks in 1979 and 1980.

Common waterplantain[a]		Wild rice[a]								
		Grain					Vegetation			
		Yield								
Density	Dry wt[b]	Harvested	Processed	Recovery	Seeds/ panicle	Weight/ 100 seeds	Plant height	Shoot dry wt	Plant density	Panicles/ plan
(plants/m^2)	(kg/ha)	(kg/ha)	(kg/ha)	(%)	(no.)	(g)	(cm)	(kg/ha)	(1000's/ha)	(no.)
					1979					
0	...	1391a	501a	36a	59ab	1.9a	182a	4300a	367a	2.0a
5	2030d	1083b	389b	36a	68a	1.8ab	183a	3500a	349a	1.5b
11	3420c	741c	265c	36a	57bc	1.8ab	165b	2000b	378a	1.2c
22	4980b	579c	206c	35a	50bc	1.6b	159b	1100b	312ab	1.2c
43	9500a	163d	47d	29b	47c	1.4c	149b	400c	254b	0.8d
					1980					
0	...	1382a	547a	39a	79a	2.3a	182a	4200a	172a	3.3a
3	1350c	1026b	401b	38a	71ab	2.2ab	172a	3200ab	166a	2.5b
5	1360c	591c	219c	37a	57abc	2.2ab	170a	1900b	152a	2.2b
11	3030b	466c	193c	41a	45bc	2.1ab	169a	1500c	142a	2.0c
22	4260a	434c	164c	38a	43c	2.0b	151b	1300c	142a	1.6d

[a]Values within a column and year followed by the same letter do not differ at the 5% level according to Duncan's multiple range test.
[b]Includes both shoot and rootstock dry weights.

ıction in harvested yield varied between 22% and 91% with :nsities between 5 and 43/m^2 in 1979 and between 26% and)% with densities between 3 and 22/m^2 in 1980. Harvested and 'ocessed wild rice yield responded similarly to interference :cept at the highest common waterplantain density, which duced the percent recovery significantly from all other :nsities in 1979. Yield reductions attributable to common aterplantain interference at comparable densities were rger in 1980 than 1979, probably because of the warmer ıring in 1980, which favored rapid common waterplantain :tablishment and growth. Water and air temperatures aver- ;ed 3 C and 2 C higher, respectively, in 1980 during the rst 6 weeks of growth.

In 1980, maximum wild rice plant density was only half ıe density established in 1979 because of poor germination. ommon waterplantain interference did not, however, alter ild rice plants per hectare except at the highest density :tablished from rootstocks in 1979. Panicles per plant de- 'eased linearly with increased densities of common water- .antain established from rootstocks and was the component : yield reduced most by interference. Moreover, panicles :r plant was the only yield component significantly affected / the lowest levels of weed competition. Smith et al. (6) ıund that panicles per plant and seeds per panicle were the ›mponents most influenced by intraspecific competition spring oats (*Avena sativa* L.). In contrast, Vesecky et al. .0) found that competition from wild cane [*Sorghum bicolor* ..) Moench] reduced the number of seeds per panicle grain sorghum more than it reduced other yield compo- :nts.

The number of wild rice seeds per panicle was reduced only by the highest densities of common waterplantain from rootstocks in 1979 and by 11 and 22/m^2 in 1980. Seeds per panicle were consistently higher in 1980 than in 1979, possibly because of the lower wild rice population. Common waterplantain densities of 22/m^2 were required to decrease seed weight. The kernels on individual panicles ripened unevenly and some were shed before all were ripe. Consequently, wild rice had to be harvested before all kernels were mature (5). Therefore, the reduction in seed weight by high levels of competition is largely due to a reduction in the number of fully mature kernels, because high densities of common waterplantain from rootstocks tended to delay maturity (data not given).

Wild rice shoot dry matter declined sharply as densities of common waterplantain from rootstocks increased (Table 1). The greatest reduction exceeded 90% in 1979. Plant height was reduced by common waterplantain densities of 11/m^2 or more in 1979 and 22/m^2 in 1980.

Common waterplantain dry matter increased as its plant density increased. Common waterplantain grown from rootstocks at a density of 11/m^2 or more in competition with wild rice produced more dry matter than did wild rice; a density of 22/m^2 of common waterplantain produced as much dry matter as wild rice grown weed free.

Duration of interference. Wild rice cultivars did not differ in their response to the length of interference from common waterplantain grown from rootstocks. The effect of duration of competition, therefore, was averaged across cultivars (Table 2).

Common waterplantain densities used in this study did

ıble 2. Wild rice yield and yield components averaged over three cultivars as influenced by duration of interference with common waterplantain own from rootstocks at a density of 17/m^2 in 1979 and 1980.

ommon waterplantain[a]		Wild rice[a]									
		Grain					Vegetation				
		Yield									
uration of ıterference	Dry wt[b]	Harvested	Processed	Recovery	Seeds/ panicle	Weight/ 100 seeds	Plant height	Shoot dry wt	Plant density	Panicles/ plant
(wks)	(kg/ha)	(kg/ha)	(kg/ha)	(%)	(no.)	(g)	(cm)	(kg/ha)	(1000's/ha)	(no.)
					1979					
0	...	1447a	501ab	35a	42ab	2.29a	163a	3700a	382a	2.5a
3	...	1542a	544a	35a	50a	2.21a	162a	3600a	362a	2.3a
5	...	1356a	427b	32ab	48ab	2.17a	164a	3300a	331a	2.4a
7	...	1357a	487ab	36a	60a	2.18a	153ab	3300a	351a	1.9ab
9	...	780b	287c	36a	40ab	2.28a	136c	1500b	265a	2.0ab
ıll season	...	584b	186c	32ab	38b	1.93b	140bc	1200b	329a	1.3b
					1980					
0	...	1324a	558a	42a	80a	2.13a	183a	2800a	156a	2.9a
5	204a	994a	420b	41a	84a	2.08a	175a	2200a	164a	2.4ab
7	398a	1107a	400b	35b	62ab	2.17a	181a	2300a	187a	2.5ab
9	1804b	636b	229c	35b	69ab	2.12a	165ab	1100b	116a	2.4ab
11	3441c	636b	236c	37ab	65ab	2.17a	170ab	1100b	156a	1.8b
ıll season	3799c	407b	134c	32b	56b	2.26a	147b	700b	124a	1.5b

[a]Values within a column for each year followed by the same letter do not differ at the 5% level according to Duncan's multiple range test.

[b]Includes both shoot and rootstock dry weights.

not reduce harvested yield if removed by 7 weeks in both years. Nine weeks of interference, however, reduced harvested yield by 46% and 52% in 1979 and 1980, respectively. Interference beyond 9 weeks did not reduce yields further. Processed yield responded similary to harvested yield except in 1980 when only 5 weeks of interference reduced processed yield significantly. Interference for 9 weeks reduced wild rice dry matter by half. Both vegetative and reproductive growth were sensitive to this period of interference.

The number of panicles per plant was the first yield component influenced by competition, with reductions noted after 7 weeks in 1979 and 5 weeks in 1980. Seeds per panicle varied greatly from treatment to treatment and were significantly reduced only by season-long competition in 1980. Seed weight was reduced by season-long competition in 1979 by 16%.

These data indicate that, between 7 and 9 weeks after seeding, wild rice is extremely sensitive to competition from common waterplantain. This sensitivity might be due in part to the rapid growth of common waterplantain during this period. Between week 7 and week 9, common waterplantain increased more than 4-fold in dry weight in 1980. Common waterplantain also maintained a height advantage over wild rice until after about 9 weeks of growth and shaded it during this period. Fisher (2) found that shading during the 30-day period just before anthesis in spring wheat (*Triticum aestivum* L. em Thell.) reduced yield more than shading in any othe growth stage. Information from this study indicates tha yield losses can be avoided if common waterplantain fror rootstocks is controlled within 7 weeks after planting.

LITERATURE CITED

1. Burnside, O. C. 1972. Tolerance of soybean cultivars to wee competition and herbicides. Weed Sci. 20:294–297.
2. Fisher, R. A. 1975. Yield potential in a dwarf spring wheat an the effect of shading. Crop Sci. 15:607–613.
3. Guneyli, E., O. C. Burnside, and P. T. Nordquist. 1969. Influen of seedling characteristics on weed competitive ability of sorghu hybrids and inbred lines. Crop Sci. 9:713–716.
4. Muenscher, W. C. 1936. Storage and germination of aquatic plant Cornell Univ. Agric. Exp. Stn. Bull. No. 652. 17 pp.
5. Oelke, Ervin. 1977. Harvesting wild rice grown as a field cro Univ. of Minnesota Agric. Ext. Folder 344. 4 pp.
6. Smith, O. D., R. A. Kleese, and D. D. Stuthman. 1970. Cor petition among oat varieties grown in hill plots. Crop Sci. 10:381 384.
7. Smith, R. J., Jr. 1974. Competition of barnyardgrass with ri cultivars. Weed Sci. 22:423–426.
8. Smith, R. J., W. T. Flichum, and D. E. Seaman. 1977. We control in U.S. rice production. U.S. Dep. Agric., Agric. Handbo 497. 78 pp.
9. Steeves, T. A. 1952. Wild rice – Indian food and a mode delicacy. Econ. Bot. 6:107–142.
10. Vesecky, J. F., K. C. Feltner, and R. L. Vanderlip. 1973. W cane and forage sorghum competition in grain sorghum. Weed S 21:28–32.

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Adsorption, Bioactivity, and Evaluation of Soil Tests for Alachlor, Acetochlor, and Metolachlor[1]

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Abstract. Alachlor [2-chloro-2′,6′-diethyl-*N*-(methoxymethyl)acetanilide], acetochlor [2-chloro-*N*-(ethoxymethyl)-6′-ethyl-*o*-acetotoluidide] and metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide] were adsorbed in similar amounts, approximately one-third that of the reference compound prometryn [2,4-bis(isopropylamino)-6-(methylthio)-*s*-t azine] by Ca-organic matter and seven soils. Adsorpti isotherms for the four herbicides by Ca-montmorillon were of the same shape, but different bonding mechanis: were involved. Adsorption and bioactivity of the acetanili herbicides were correlated with organic matter, clay conte. and other soil parameters as determined by two differe soil-testing laboratories.

Additional index words. Herbicide inactivation, adsorpti mechanisms, soil testing, organic-matter analysis, promet adsorption.

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INTRODUCTION

The acetanilide herbicides are nonionizable, moderate