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R. H. Dilday
USDA/ARS

Paolo Nastasi
University of Arkansas, Fayetteville

Roy J. Smith Jr.
USDA/ARS

ALLELOPATHIC OBSERVATIONS IN RICE (*ORYZA SATIVA* L.) TO DUCKSALAD *(HETERANTHERA LIMOSA)*

R.H. DILDAY
USDA/ARS
Stuttgart, AR 72160

P. NASTASI
University of Arkansas
Stuttgart, AR 72160

R.J. SMITH, JR.
USDA/ARS
Stuttgart, AR 72160

ABSTRACT

More than 50 weed species infest drill-seeded rice in the U.S. and one of the most prevalent aquatic weeks is ducksalad *(Heteranthera limosa)*. During the summer of 1988, a field experiment was conducted to identify rice accessions from the USDA/ARS rice germplasm collection for allelopathic effects to ducksalad. In this field experiment, 5,000 accessions were evaluated for allelopathic activity. Five to seven seeds of each rice accession were planted in hills about 75cm apart in two replications. Allelopathic activity was recorded as 1) radius of the area affected by allelochemical from the base of the rice plant and 2) percentage of weed control within the affected area. Ducksalad was rated at the panicle initiation stage of rice development. Of the 5,000 accessions that were evaluated, approximately 191 were identified as having evident allelopathic activity. The accessions that demonstrated allelopathic activity originated in 26 countries (Afghanistan, Argentina, Australia, Brazil, Columbia, Dominican Republic, France, India, Iran, Iraq, Israel, Italy, Japan, Malaysia, Mexico, Pakistan, Peru, Philippines, Portugal, Republic of Korea, People Republic of China, Soviet Union, Taiwan, Thailand, Turkey, and United States).

INTRODUCTION

Rice is one of the leading food crops of the world. In 1985, the value of rice production in the U.S. was over one billion dollars (Anonymous, 1986). However, annual losses due to weeds in rice have been estimated at about 17% of the potential production or one million metric tons valued at 205 million dollars (Chandler, 1981). More than 50 weed species infest direct-seeded rice in the U.S. (Barrett and Seaman, 1980; Smith *et al.*, 1977). Ducksalad (*Heteranthera limosa* [Sw.] Willd.], is one of the most frequently reported aquatic weeds in rice (Chandler, 1981; Smith *et al.*, 1977). Effective weed control programs for rice include preventive, cultural, mechanical, chemical, and biological practices (Smith *et al.*, 1977; Smith and Moody, 1979). The most recent and perhaps least exploited control practice is the biological method. In recent years, one biological strategy of weed control, allelopathy, has received increased attention. In 1977 it was estimated that the development of new technology from allelopathics "would benefit U.S. agriculture by two percent of its total production, or about two billion dollars annually" (Anonymous, 1977).

Allelopathy, the direct or indirect harmful effect of one plant on another through the production of chemical compounds that escape into the environment occurs widely in natural plant communities (Rice, 1974; Whittaker and Feeny, 1971). Allelopathy is postulated to be one of the major mechanisms by which weeds affect crop growth (Bell and Koeppe, 1972; Gressel and Holm, 1964; Rice, 1974). In addition to the existence of allelopathy in weeds, several workers have reported that crops such as rye (*Selecale cereals* L.), barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), tobacco (*Nicotiana tabacum* L.), sunflower (*Helianthus annuus* L.), and oats (*Avena sativa* L.) release toxic substances into the environment either through root exudation or from decaying plant material (McCalla and Haskins, 1964; Patrick and Koch, 1958; Patrick *et al.*, 1963).

Putnam and Duke (1974) postulated that "wild ancestors" of existing crops may have possessed high allelopathic activity and this character was reduced or lost as they were hybridized and selected for useful characteristics. Fay and Duke (1977) evaluated 3,000 accessions of *Avena* spp. germplasm for production of scopoletin (6-methoxy-7-hydroxy coumarin), a chemical identified as the allelopathic agent in a wide range of wild plants, and found that four accessions exuded up to three times as much as 'Garry', a standard oat cultivar.

The objective of this study was to evaluate germplasm accessions from the rice portion of the USDA/ARS Small Grains Collection for allelopathic activity on ducksalad.

MATERIALS AND METHODS

A field experiment was conducted in 1988 to identify rice accessions with allelopathic properties to ducksalad as part of the USDA/ARS rice germplasm evaluation project. Approximately 5,000 accessions were seeded in hills in a 75 X 75 cm grid. Between five and seven seeds of each accession were planted in hills, with two replications from April 28 to April 30, 1988. The seedlings emerged between April 10 and April 12, 1988. The test was irrigated on May 13 and June 1, 1988 to insure uniform seedling emergence. A permanent flood was applied on June 15, 1988. The test was conducted at the Rice Research and Extension Center, Stuttgart, Arkansas, on a Crowley silt loam (fine montmorillonitic, thermic Typic Albaqualf) naturally infested with ducksalad.

Allelopathic activity to ducksalad was recorded from July 11 through July 20, 1988, or at the panicle initiation stage, for most of the accessions. Two methods were used to record allelopathic activity: 1) the radial area (cm) from the base of the rice plant that had reduced or no weed growth due to allelochemicals, and 2) the percentage of weed control within the affected area.

Plant height (cm), days to maturity, plant type, panicle type, hull cover or pubescence, hull color, lemma color, awning, lodging, and grain type were recorded for each accession. Plant height was measured in cm from ground level to the center of the mature panicle. Maturity was determined by calculating the number of days from the date of seedling emergence to the date that 50% of the panicles had emerged. Plant type, panicle type and lodging were recorded in the field. Grain type, hull cover, hull color, lemma color, and awning were recorded in the laboratory after threshing. The accessions were characterized as having extra long (>7.50 mm), long (6.61-7.50 mm), medium (5.51-6.60 mm) or short grain (<5.50 mm).

A total of 82 kg N/ha as urea was applied to plots based on a three-way split application. Thirty-one kg N/ha as urea were applied in June 14, 1988 when the seedlings were at the fourth true leaf stage of development. The remaining 41 kg N/ha were applied in equal increments on July 7, 1988 and 12 days later on July 26, 1988. The test was irrigated on May 13 and June 1, 1988 to insure uniform seedling emergence. A permanent flood was applied on June 15, 1988.

RESULTS AND DISCUSSION

Field observations from the replicated test identified 191 accessions, or about four percent of the 5,000 accessions with apparent allelopathic

activity to ducksalad. The accessions that demonstrated allelopathic activity originated in 26 countries (Afghanistan, Argentina, Australia, Brazil, Columbia, Dominican Republic, France, India, Iron, Iraq, Israel, Italy, Japan, Malaysia, Mexico, Pakistan, Peoples Republic of China, Peru, Philippines, Portugal, Republic of Korea, Soviet Union, Taiwan, Thailand, Turkey and United States). The range in plant height among the 191 accessions that demonstrated apparent allelopathic activity to ducksalad was from 60 to 190 cm and the days to maturity, from seedling emergence to 50% heading, ranged from 70 to 141 days. The accessions included long, medium and short grain types.

Table 1. Origin, weed response, and plant characteristics of 10 germplasm accessions that demonstrated allelopathic activity to ducksalad *(Heteranthera limosa)*.

Germplasm Identification	Country of Origin	Radial Mean Activity (cm)	Percent Weed Control	Plant Height (cm)	Grain[1] Type	Days to[2] Maturity	Seed[3] Coat Color
India AC 1423	India	17.5 a*	85.0 a	128 c	M	115 b	Red
NSSL 10/28 STP 8	U.S.	16.5 a	85.0 a	136 bc	L	90 cd	Lt.Br
Tono Brea 439	Dom. Rep.	16.5 a	85.0 a	160 a	L	137 a	Lt.Br
Phil MGVR	Philippines	15.0 a	90.0 a	160 a	M	141 a	Lt.Br
Red Khosha Cerma	Afghanistan	15.0 a	85.0 a	143 b	L	89 cd	Lt.Br
Donduni Kunluz	Afghanistan	15.0 a	85.0 a	135 bc	L	104 bcd	Lt.Br
Tsai Yuan Chon	Taiwan	15.0 a	90.0 a	137 bc	S	109 bc	Lt.Br
Mon Z Wuan	China	15.0 a	82.5 a	127 c	M	87 d	Lt.Br
IR 644 1 63 11	Philippines	15.0 a	85.0 a	71 e	M	91 cd	Lt.Br
NATO/9209 Sel// AROS/3/NROS	U.S.	15.0 a	85.0 a	96 d	M	90 cd	Lt.Br
Control	U.S. Cultivars	0.0 b	0.0 b	---	-	---	-----

1/ Grain type: S = short, M = medium and L = long.
2/ Days to maturity: From seedling emergence to 50% of the panicles emerged
3/ Seed coat color: Lt. Br. = Light Brown

* Means within columns with the same letter are not significantly different at the 0.05 level.

There were 10 accessions (Table 1) that demonstrated a radius of activity greater than 15 cm and weed control within the area of activity that was greater than 80%. Other plant characteristics such as days to maturity, plant height, grain type, and seed coat color for the 10 accessions are also listed in Table 1.

The IBPGR-IRRI Rice Advisory Committees report on "Descriptors for Rice *Oryza sativa* L." (Anonymous, 1980) defines different plant characteristics in rice. The following plant descriptions for the 10 accessions are defined in the IBPGR-IRRI report. Tono Brea 439 and NATO/9209 Sel//AROS/3/NROS had an intermediate plant type; whereas the other eight accessions possess an open plant type. All of the accessions had an intermediate panicle type. NATO/9209 Sel//AROS/3/NROS has a glabrous (smooth) hull cover; whereas the other nine accessions had short hairs throughout the hull. Donduni Kunluz had a purple hull; India AC 1423 had a black hull; Phil MGVR had a mottled, speckled, or piebald hull; and the other seven accessions had a straw (yellow) hull. All of the 10 accessions had a straw colored lemma. Tono Brea 439, Phil MGVR, Tsai Yuan Chon, and NATO/9209 Sel//AROS/3/NROS did not have awns; NSSL 10/78 STP 8, Donduni Kunluz, Mon Z Wuan, and IR 644 1 63 11 had short awns and the seed were partly awned; whereas, India AC 1423 and Red Khosha Cerma had long awns and the seed were fully awned. IR 644 1 63 11 and NATO/9209 Sel//AROS/3/NROS had moderately strong culm strength; Mon Z Wuan had a culm strength between moderate and intermediate; Tono Brea 439 had a culm strength between weak and very weak; and the remaining six accessions had a very weak culm.

CONCLUSIONS

Approximately four percent of the 5,000 rice accessions that were evaluated for allelopathy to ducksalad demonstrated some allelopathic activity. A four percent frequency rate suggests that about 600 accessions in the rice collection may suppress ducksalad. The 191 accessions that demonstrated allelopathic activity also exhibited genetic diversity for plant characteristics such as plant height, maturity, grain type, plant type, hull cover, hull color, and culm strength. Tests to isolate and identify the allelochemicals that are responsible for the allelopathic activity are presently being conducted.

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