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BIOLOGY AND MANAGEMENT OF PURPLE NUTSEDGE (*CYPERUS ROTUNDUS* L.)

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ABSTRACT

Pot trials were conducted using a completely randomized design to investigate the effect of fertilizers, population density, growing period and temperature on viability of purple nutsedge (*Cyperus rotundus* L.) tubers, and the effect of herbicides on re-generation of tubers. Increase in nitrogen and phosphorus fertilizer rates enhanced shoot biomass by 59-961%, underground biomass by 21–279%, tubers numbers by 50–579% and tubers biomass by 21–348%. Individual tuber's weight was, however, decreased by fertilizers application. By increasing growth period [15, 30, …, 75 days after sowing (DAS)] shoot density was increased by 50–850%, shoot biomass by 99–403%, under ground biomass by 10–649%, tuber numbers by 39–1122%, and tubers biomass per pot by 22–982% as compared to the first record of the data (15 DAS). In population density trials, shoot length, shoot and underground biomass, number of tubers per pot and tubers weight were significantly increased up to 15 tubers per pot and deceased thereafter. Drying of tubers in hot sun (42±3 °C) for four days completely lost their viability. Tubers viability was significantly decreased up to three hours freezing, and no sprouting was recorded thereafter. Application of glyphosate (Round up 490GL) and paraquat (Gramoxone) completely killed the above ground growth and reduced the tuber's viability by 89% and 32%, respectively, as compared to control. Present study concludes that purple nutsedge can effectively be managed by herbicide glyphosate as well as by exposing the tubers to sun during hot months of May and June.

Key words: Biology, *Cyperus rotundus,* management, purple nutsedge, weed biology.

INTRODUCTION

Purple nutsedge (*Cyperus rotundus* L.) is one of the most serious weed problems in many parts of the world (Travlos *et al*., 2009; Shabana *et al*., 2010) including Pakistan (Riaz *et al*., 2009). It reproduces mostly through tubers (Sharma and Gupta, 2007; Lati *et al.,* 2011). The spread of the plant in the short term is accomplished through rhizomes, which may extend upward, downward or horizontally (Stoller and Sweets, 1987). When purple nutsedge is cultured in field without interference from other plants, it can produce 10 to 30 million tubers per hectare in a season (Horowitz, 1972). It is a troublesome C_4 weed, characterized by high photosynthetic efficiency, compared to C_3 weeds (Lati *et al.,* 2011). It is a highly competitive weed especially under high soil nitrogen conditions (Santos *et al*. 1998). In crop production systems, purple nutsedge relies on tubers as the primary means of reproduction (Horowitz, 1992).

Decline in crop yields is one of the major impacts of purple nutsedge. Keeley (1987) reported that yield losses could reach 89% in onion (*Allium sativum* L.), 62% in okra [*Abelmoschus esculentus* (L.) Moench], 39-50% in carrot (*Daucus carota* L. subsp. *sativus* Hoffm.), 43% in cucumber (*Cucumis sativus* L.) and 35% in cabbage (*Brassica oleracea* L. var. *capitata* L.). Santos *et al*. (1998) recorded a 70% yield reduction in radish (*Raphanus sativus* L.) due to *C. rotundus* interference. Many researchers have shown that purple nutsedge tubers produce allelopathic substances which inhibit the growth of other plants in the immediate area (Karikari *et al*., 2000; Sharma and Gupta, 2007; Javaid *et al*., 2007). Aqueous extracts of *C. rotundus* are known to reduce the germination and growth of various leafy vegetables (Gusman *et al.,* 2011). Ferulic, caffeic, hydroxyl benzoic, syringic, chlorogenic, and p-coumaric acids are the potential allelopathic compounds in various parts of *C. rotundus* (Alsaadawi and Salih, 2009).

Many researchers have suggested its management strategies. Among them solarization, repeated summer tillage and shading reduced the vegetative growth and tuber production (Holm *et al*., 1977; Wang *et al*., 2009). However, due to its aggressiveness, reproduction capacity, high dispersion and rusticity, its control is difficult and costly (Silveira *et al.,* 2010). Purple nutsedge is difficult to control with herbicides (Gilreath and Santos, 2004). To be effective, herbicide must be translocated throughout the rhizome and tuber network of the plant. A greater understanding of ecology of purple nutsedge will be an initial step in devising appropriate management strategies. The present study was, therefore, carried out to study the biology and management strategies of this troublesome weed species.

MATERIALS AND METHODS

General procedures: Pot studies were conducted to evaluate the effect of different biotic and abiotic factors on purple nutsedge growth and tuber characteristics at College of Agriculture, Dera Ghazi Khan, Pakistan. These experiments were conducted for two years during 2008 and 2009 and data were pooled. Experiments were designed in completely randomized design with four replications.

Effect of fertilizer: In the fertilizer trial, the effect of different ratios of nitrogen and phosphorus (0:0, 1:0, 1:1, 2:1, 2:2, 3:2, 3:3) were tested on different growth parameters of purple nutsedge in pots having sizes of 32.5 cm diameter and 37.5 cm length, containing 27 kg of soil per pot. The ratio of 1 is equal to 2 g of N and/or P_2O_5 and so on. Fertilizer sources used were urea for nitrogen and triple supper phosphate for phosphorus. Ten tubers per pot were sown during 2nd week of June, 2008 and 2009. Irrigation was applied as per requirement of the plants.

Effect of growth period: To evaluate the effect of growth period on above and below ground biomass of plants, five tubers per pot were planted during the 1st week of July of each of the two growing years in pots containing 27 kg of soil each. Nitrogen and phosphorus were applied at 5 g per pot at the time of sowing. Fertilizer sources were used as urea for nitrogen and triple supper phosphate for phosphorus. Irrigation was applied as per requirement of the plants. Observations regarding above and underground biomass and tuber characteristics were recorded 15, 30, 45, 60 and 75 days after sowing (DAS).

Effect of tuber's density: To investigate the effect of density per unit area on growth and tuber characteristics, 5, 10, 15 and 20 tubers were planted (2nd week of June of each year) in pots containing 27 kg of soil. Nitrogen and phosphorus were applied at 5 g per pot each with half nitrogen and full phosphorus at the time of sowing and remaining half nitrogen 30 days after sowing. Fertilizer sources were used as urea for nitrogen and triple supper phosphate for phosphorus. Data regarding above and underground biomass and tuber characteristics were recorded 75 DAS.

Effect of temperature: Equal sized tubers of purple nutsedge were collected from the field. To investigate the viability under high temperature stress, tubers were placed in sun (42±3 °C) for 1, 2, 3, 4 and 5 days (2nd week of May). Five tubers of each treatment with four replications were sown per pot (capacity of 2 kg of soil per pot) to check its viability. Fresh tubers were also sown to serve as control. Data regarding days to germination, total number of plants germinated, shoot length and shoot dry weight were recorded. To investigate the viability under cold temperature stress, initially tubers were placed in deep freezer (-18±2 °C) for one day and observed no sprouting. Then the interval was reduced to 1, 2, 3, 4, 5 and 6 hours freezing. Five cold treated tubers were sown in each pot. Data regarding days to germination, total number of plants germinated, shoot length and shoot dry weight were recorded (75 DAS).

Management of purple nutsedge by herbicides: Ten purple nutsedge tubers were sown in pots having capacity of 27 kg of soil per pot. Nitrogen and phosphorus were applied at 5 g per pot at the time of sowing using urea and triple superphosphate as sources. In one treatment, 15% solution of Dual Gold 960 EC (S. metolachlor) was sprayed over the soil surface of the pot as pre-emergence. In other two treatments herbicides Round up 490GL (glyphosate) and Gramoxone (paraquat) were sprayed at 2% and 1% solution, respectively, at maturity i.e. 60 DAS (at maximum above ground biomass production). Weedy check was also maintained for comparison. In S. metolochlor treatment tubers were not sprouted at all. From other two herbicidal treatments, after death of plants tubers were uprooted and ten tubers per pot with four replications were sown to check their viability.

Statistical analysis: All the data were analyzed by analysis of variance followed by Duncan's Multiple Range Test to separate the treatment means at 5% level of significance (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Effect of fertilizer: Different fertilizer combinations significantly improved the purple nutsedge shoot length (22-267%), root length (18-180%), shoot dry mass (59-961%), under ground dry mass (21-279%), tubers per pot (50-579%) and tubers dry mass per pot (21-348%) as compared to control (Table 1). Conversely, individual tuber weight was decreased by increasing fertilizer dose. As the fertilizer doses increased the shoot length was gradually increased. Highest shoot length was recorded with maximum fertilizer dose (3:3 N:P). However, initially increased in shoot length was more by increasing the dose of phosphorus as compared to nitrogen. Almost similar trend was observed in root length, shoot and underground dry biomass. Tubers per pot and tubers dry weight per pot were also increases as the dose of fertilizer increased (Table 1). Application of both nitrogenous and phosphates fertilizers enhanced purple nutsedge plant and tubers growth. However, phosphorus contribution was much higher as compared to nitrogen. The growth of purple nutsedge was increased many folds with increase in fertilizer dose. Mores-Payan *et al*. (2000) found that purple nutsedge is 15 times more competitive for nitrogen as compared to cilantro.

Effect of growth period: Increasing growth period significantly improved shoot density by 50 to 850%, shoot length by 21–63%, shoot biomass by 99–403%, under ground biomass by 10–649%, tuber number by 39–1122%, and tubers biomass per pot by 22–982% as compared to the first record of the data i.e. 15 DAS (Table 2). Increase in growth period decreased per tuber weight by 2–11%. Maximum growth of purple nutsedge was recorded with in 30 to 45 days after sowing. Similarly, maximum tubers number and tuber biomass was recorded during this period (Table 2). Purple nutsedge growth was initially slow but growth was found fastest during 30 to 45 DAS. That period might be the most competitive for different crops. The control of this weed might be most beneficial during this period. Juraimi *et al*., (2009) found delayed sowing of crop very critical with respect to the purple nutsedge interference. They stated that the delay of 7 and 15 days, reduction of plant height was observed by 6.97 % and 11.53%, panicle length by 8.21 and 12.32% and grain yield by 15 and 16%, respectively.

Effect of tuber density: Planting density significantly affected different growth and tuber characteristics of purple nutsedge. Shoot density per pot was significantly increased (78–151%) by increasing tubers numbers per pot as compared to the plantation of 5 tubers per pot. Shoot length, shoot biomass, underground biomass, number of tubers per pot and tubers weight were significantly increased up to the planting of 15 tubers per pot then deceased by planting 20 tubers per pot. Planting higher densities of tubers decreased per tuber weight up to 93% (Table 3). The competition within purple nutsedge was found less up to a certain limit but higher planting density limited the plant and tuber growth. This rapid growing plant can quickly form dense colonies due to its ability to produce an extensive system of rhizomes and tubers. Siriwardana and Nishimoto (1987) stated that the upper 30 cm of soil in a field infested with purple nutsedge contained 4900 to 5100 corms and tubers 6 weeks after soil rotovation and irrigation. Of the total number of corms and tubers, 51% were from the parent population. At 6 weeks, only 15% of the total tuber and corm population were not connected to aerial parts. Tubers from the parent population had a higher fresh weight than those from the new population. Parent tubers occurred singly or in chains of up to eight tubers.

Effect of temperature: Exposure of tubers to higher temperature of 42±3 °C from one to three days delayed sprouting of tubers gradually. Further exposure of tubers to this temperature lost their viability (Table 4). Sprouting percentage was also decreased by gradual heating of the tubers in sun. Shoot length and shoot dry biomass were also decreased by heating of tubers. Tubers were also subjected to freezing temperature. Initially, tubers were placed in deep freezer for one day and observed no sprouting. Then the interval was reduced to 1, 2, 6 hours freezing. Tubers viability was significantly decreased up to three hours freezing, after that no sprouting was recorded (Table 5). Tubers of purple nutsedge are the main propagation mean. They may remain viable under harsh environmental conditions. During the present study, the lower temperature was found more deleterious to the tubers viability as compared to higher one. Tubers remained viable under three days heating but under freezing temperature of few hours tubers lost their viability. Rogers *et al*. (2008) also reported that purple nutsedge is less tolerant of low temperature. Webster (2003) observed that nutsedge tuber viability was reduced when temperatures were 45 °C. However, application of these data to field situations may be limited using present technology because the soil temperature cannot be raised to high enough levels for acceptable solarization effects. Utilizing elevated temperatures to eliminate or weaken nutsedge tubers may be a future component of a weed management system. Nishimoto (2001) stated that temperature regulates sprouting; no sprouting occured below 10 °C and above 45 °C. Optimum sprouting occurred between 25 and 35 °C when provided with constant temperatures. Daily soil temperature fluctuation may be a major signal for purple nutsedge emergence, such as when the plant canopy is removed, or when soils are solarized (Kawabata and Nishimoto, 2003).

Table 1. Effect of Nitrogen and Phosphorus on growth and tuber characteristics of purple nutsedge.

Fertilizer ratio	Shoot length (cm)	Root length (cm)	Shoot dry weight (g)	Root dry weight (g)	Tubers pot^{-1}	Tubers dry weight (g) pot^{-1}	Per tuber weight (g)
0-0	14.67 g	30.30 e	3.88 d	17.52 c	14.00 g	9.23 e	0.657 a
1-0	17.9 f	35.70 d	6.20 d	21.23 c	21.00 f	11.16 e	0.534 ab
1-1	35.63 e	57.47 c	29.92 c	50.39 b	49.67 e	27.81 d	0.560 ab
2-1	38.77 d	59.10 c	31.50 c	54.65 b	56.67 d	32.21 c	0.568 ab
2-2	48.2 c	74.37 b	36.43 b	62.62 a	71.33 c	38.03 b	0.533 ab
3-2	51.73 b	83.83 a	38.79 ab	63.36 a	80.33 b	38.22 b	0.476 b
3-3	53.87 a	84.87 a	41.37 a	66.24 a	95.00 a	41.22 a	0.434 b

Values with different letters in a column show significant difference ($P \leq 0.05$) as determined by Duncan's Multiple Range Test.

Table 2:.Effect of growth period on growth and tuber characteristics of purple nutsedge.

Growth period	Shoot density pot-1	Shoot length (cm)	Root length (cm)	Shoot dry weight (cm)	Root dry weight (cm)	Tubers pot-1	Tubers dry weight (g pot^{-1})	Per tuber weight (g)
15 days	5.0 e	22.5 d	15.50 e	1.15 d	1.38 d	4.50 d	1.40 d	0.31 a
30 days	7.5 d	27.3 c	21.50 d	2.29 c	1.52 d	6.25 d	1.71 d	0.27 b
45 days	28.0 c	31.8 b	36.50 c	4.93 b	5.92 c	18.00 c	5.29 c	0.29 ab
60 days	40.5 b	32.3 b	39.50 b	5.20 b	8.58 b	29.25 b	8.83 b	0.30 ab
75 days	47.5 a	36.8 a	53.25 a	5.79 a	10.34 a	55.00 a	15.15 a	0.28 ab

Values with different letters in a column show significant difference ($P \leq 0.05$) as determined by Duncan's Multiple Range Test.

Table 3: Effect of tuber density on growth and tuber characteristics of purple nutsedge.

planted Pot^{-1}	Shoot Tubers density pot^{-1}	Shoot length (cm)	Root length (cm)	Shoot dry weight (g)	Root dry weight (g) (including tubers)	Root dry weight (g) (excluding tubers)	Tubers pot^{-1}	Tubers dry weight (g pot^{-1})	Per tuber weight (g)
5	19.8 d	35.05 c	86.4 a	17.43 d	64.46 d	54.27 b	25.75 d	10.20 c	0.40 a
10	35.3 c	39.50 b	82.3 ab	20.74 c	70.54 c	52.18 b	63.25 c	18.36 a	0.29 b
15	42.3 b	44.83 a	78.9 bc	29.02 a	77.86 a	58.30 a	77.50 a	19.56 a	0.25 b
20	49.8 a	37.53 bc	76.7 c	25.11 b	74.54 b	57.96 a	68.75 b	16.59 b	0.24 b

Values with different letters in a column show significant difference ($P \leq 0.05$) as determined by Duncan's Multiple Range Test.

Table 4: Effect of high temperature on tubers viability and growth of purple nutsedge.

Temperature treatment period	Days to sprouting	Sprouted plants	Shoot length (cm)	Shoot dry weight (g)
Fresh	5 c	4.7 a	28.7 a	1.07 a
One day drying	5 c	5 a	26.2 b	0.91 b
Two day drying	6.2 b	3.2 b	19 c	0.77 c
Three day drying	8 a	1.2 c	9.5 d	0.48 d
Four day drying	0 d	0 d	0 e	0 e
Five day drying	0 d	0 d	0 e	0 e

Values with different letters in a column show significant difference ($P \leq 0.05$) as determined by Duncan's Multiple Range Test.
DAP=Days after planting

Table 5: Effect of freezing temperature on tubers viability and growth of purple nutsedge.

Temperature treatment period	Days to sprouting	Sprouted plants	Shoot length (cm)	Shoot dry weight (cm)
Fresh	5 d	4.7 a	25.5 a	0.98 a
One hour freezing	7 c	3 b	18.5 b	0.82 b
Two hour freezing	8.7 b	2 c	10.7 c	0.54 c
Three hour freezing	11 a	1.2 c	5.5 d	0.29 d
Four hour freezing	0 e	0 d	0 e	0 e
Five hour freezing	0 e	0 d	0 e	0 e
Six hour freezing	0 e	0 d	0 e	0 e

Values with different letters in a column show significant difference ($P \leq 0.05$) as determined by Duncan's Multiple Range Test.

Table 6: Effect of herbicides on tuber sprouting

Treatments	No. of tubers sprouted	Reduction over control (%)
Control	9 a	0 c
Gramaxone	6.5 b	31 b
Glyphosate	1.0 c	89 a
Dual Gold	0.5 c	94 a

Values with different letters in a column show significant difference ($P \leq 0.05$) as determined by Duncan's Multiple Range Test.

Herbicidal Potential against tubers regeneration: All the herbicides significantly affected the tubers viability. S. metolachlor treated as pre-emergence tubers could not sprout on replanting. Highest inhibition in tubers sprouting due to post emergence herbicides was recorded due to glyphosate (89%) followed by paraquat (32%) as compared to control (Table 6). The success of chemical control of purple nutsedge can only be effective when the selection of herbicides should be done on their effectiveness against tubers control. Glyphosate was found the most effective herbicides that can kill the tubers through its translocation ability within plant system even to tubers. Reddy and Bryson (2009) indicated that purple nutsedge density could be reduced with glyphosate applied in soybean. Glyphosate has considerable activity on purple nutsedge and has effectively reduced populations in various cropping systems (Bryson *et al*. 2003; William and Hirase, 2004; Edenfield *et al*. 2005; Webster *et al*. 2008).

Conclusion: Results of the present study concludes that enhanced soil fertility especially phosphorus fertilizers increased the growth and tubers formation in purple nutsedge. This noxious weed can effectively be managed by herbicide glyphosate and to a lesser extent by paraquat as well as by exposing the tubers to sun during hot months of May and June.

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