Effect of Purple Nutsedge (*Cyperus rotundus*) Population Densities on Onion (*Allium cepa*) as Influenced by Nitrogen in the Eastern Province of Sri Lanka

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ABSTRACT. *Fertilizer management is an imperative element of integrated weed control that protects crop yields and reduces weed populations over time. This experiment was conducted under field conditions to determine the effect of population density of purple nutsedge (Cyperus rotundus) on the yield of onion (Allium cepa L.) at different N rates. Initial densities of Purple nutsedge were 0, 10, 20 and 40 plants/m^2. Nitrogen was applied as 100 kg/ha, 150 kg/ha and 200 kg/ha. Purple nutsedge and onion (variety Vethalan) were grown together for 12 weeks. There was a significant interaction ($p<0.05$) between Purple nutsedge population densities and N rate on onion bulb yield, total dry weight and bulb diameter. At 100 kg N/ha and 200 kg N/ha, total dry weight of onion was not significantly ($p>0.05$) affected by purple nutsedge population densities. In contrast, at 150 kg N/ha, effect of weed population density on onion total dry weight was significant ($p<0.05$). The highest onion yield loss of 49% was observed at this intermediate nitrogen level with 40 weed plants/m^2. As purple nutsedge densities increased, onion yield decreased. Purple nutsedge biomass, shoot height and average tuber weight were significantly ($p<0.05$) reduced by increased N levels. The results indicate that as N increased above 150 kg/ha, the negative effect of the weed on the crop was minimized. Purple nutsedge and onion have similar optimal rate of N fertilizer. Therefore, reducing the effect of purple nutsedge interference on onion is difficult and complex.*

Key words: *Average tuber weight, Bulb yield, Nitrogen rates, Nutsedge biomass, Nutsedge interference.*

INTRODUCTION

Onion (*Allium cepa* L,), is one of the most important vegetables in the world, whose utility is ranked second to tomatoes (Brice *et al*., 1997). Onion is consumed in different ways by different people and forms an essential part of the daily diet. It is used in every home virtually on a daily basis (Hussaini *et al.*, 2000).

Purple nutsedge (*Cyperus rotundus*) occurs in all agricultural fields, commonly in onion fields. It is considered to be the most noxious and troublesome weed in the world based on reports from a number of countries (Holm *et al.,* 1991). This weed is frequently found in vegetable fields in Sri Lanka, where it is regarded as a species difficult to control. Season-long interference of purple nutsedge has been reported to reduce the yield of cabbage

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(*Brassica oleracea* L.) by 35%, bean (*Phaseolus vulgaris* L) by 41%, cucumber (*Cucumis sativus* L) and upland rice (*Oriza sativa* L) by 43% (William and Warren, 1975: Okafor and De Datta, 1976), lettuce (*Lactuca sativa L.*) by 54% (Morales-Payan *et al.,* 1996a), radish (*Rapanus sativus* L.) by 70% (Santos *et al.,* 1996), and dry bean by 81% (William, 1973). The negative effect of purple nutsedge on the associated crop is density dependent. Purple nutsedge population densities as low as 50 or 116 plants/m^2 have decreased the yield of radish and lettuce by 48 and 54%, respectively (Morales-Payan *et al.,* 1996a; Santos *et al.,* 1996). However, there are no studies on the interference effect of purple nutsedge on the growth and yield of onion in the Eastern province of Sri Lanka.

Onion is an important vegetable crop in the Eastern province of Sri Lanka in terms of extents planted and value. In this region, purple nutsedge can cause significant losses in yield and quality of onions. Traditionally, hoeing and cultivation have been used for purple nutsedge control in onion. These methods are costly and time consuming for farmers. At the same time, these mechanical methods can cause significant damage to the shallow rooting systems of onion.

Integrated weed management has the potential to reduce herbicide use (and associated costs) and control weeds in the long term (Buhler, 1999). Manipulation of crop fertilization may be a means of reducing weed interference in crops (DiTomaso, 1995). Nitrogen is the major nutrient added to increase crop yield especially in the tropics (Raun and Johnson, 1999; Camara *et al*., 2003). Increasing N supply has enhanced the detrimental effect of purple nutsedge interference with vegetable crops such as lettuce, radish and cilantro (*Coriandrum saticum* L) (Morales-Payan *et al.,* 1996a,1996b; Santos *et al.,* 1996). Thus, N manipulation could be an important part of a purple nutsedge management system in onion and other vegetable crops. In contrast, there are no reports about the effect of N on nutsedge–onion interactions. A better understanding of the possible influence of N availability of onion netsedge interactions could lead to modifications in fertilization practices resulting in reducing yield losses due to the presence of the weed. The objective of this research was to determine the effect of population densities of purple nutsedge on the yield of onion under different N rates.

MATERIALS AND METHODS

A field experiment was conducted from February–May, 2010 at the Agronomy farm, Eastern University, Chenkalady, Batticaloa. Onion bulbs (variety Vethalan) and pre-sprouted purple nutsedge tubers were planted simultaneously. Experimental plots were watered daily up to field capacity.

The treatments were arranged in a Randomized Complete Block Design with three replications. An experimental unit consisted of one plot. The plot size was 3 × 1 m. An additive series of purple nutsedge population densities (0, 10, 20 and 40 plants/m^2) at three N rates (100, 150 and 200 kg/ha) were arranged factorially. Nitrogen was supplied as urea and incorporated into the soil before planting. Other plant nutrients were supplied as per current crop recommendations of the Department of Agriculture. The crop and weed were allowed to interact for 12 weeks. The crop was harvested when most of the leaves turned yellow and the bulbs had grown to harvestable size. Purple nutsedge plants were also harvested at the same time. The measurements made were total marketable bulb yield (g/m^2), average bulb size (cm), total dry weight of onion (g/m^2) and average plant dry weight (g), shoot height (cm) and average tuber weight (g) of purple nutsedge. Yield losses were calculated as percentage of the weed-free control (0 nutsedge density). Analysis of variance was carried out using

SAS to determine significant differences among treatments ($P<0.05$). Regression analysis was used to characterize the effects of purple nutsedge population densities under different N levels on purple nutsedge mean tuber weight and total dry weight.

RESULTS AND DISCUSSION

Total dry weight of onion

Nitrogen and purple nutsedge density had a significant effect ($p<0.05$) on total dry weight of onion. The interaction effect of the weed and N on total dry weight of onion was also significant (Table 1). With Nitrogen at 100 kg/ha and 200 kg/ha, total dry weight of onion was not significantly affected by purple nutsedge population densities. At the same time, a density of 40 plants/m^2 purple nutsedge with 150 kg/ha significantly reduced total dry weight of onion when compared to other population densities. As stated by Harper (1977), with 100 kg/ha Nitrogen rate, onion and purple nutsedge may have developed poor root systems with stunted canopies causing minimum interactions and competition.

Naseen *et al*. (2007) reported that above 160 kg N/ha decreased the leaves/plant and plant height in onion. Agreeing to that, in the present study, high Nitrogen level stunted onion and purple nutsedge plants. The lack of interactions between onions and the weed at high rates of N may be due to this factor.

Table 1. Effect of N and purple nutsedge population densities on total dry weight, bulb diameter and bulb yield

Nitrogen rate	Population (plants/m^2)	Total dry weight (g/m^2)	Bulb Diameter (cm)	Bulb yield g/m^2
100 kg/ha	0	1064.0^{cd}	2.5^{c}	967.23^{bc}
	10	948.2^{cd}	2.2^{d}	829.06^{cd}
	20	877.4^{d}	1.9^{e}	764.16^{cd}
	40	474.6^{d}	1.2^{f}	538.56^{d}
150 kg/ha	0	2292.2^{a}	2.87^{b}	1910.12^{a}
	10	2029.4^{ab}	2.5^{c}	1637.25^{a}
	20	1829.2^{ab}	2.2^{d}	1203.87^{b}
	40	881.1^{d}	1.8^{e}	974.11^{bc}
200 kg/ha	0	2073.7^{ab}	3.3^{a}	1974.95^{a}
	10	1846.0^{ab}	2.87^{b}	1778.53^{a}
	20	1807.3^{ab}	2.6^{bc}	1631.71^{a}
	40	1512.5^{bc}	2.4^{cd}	1192.64^{b}
Probability	Population	0.000	0.000	0.000
	Nitrogen	0.000	0.000	0.000
	Interaction	0.010	0.002	0.006

Within a column, means sharing a common letter are not significantly different ($p=0.05$)

In the absence of a purple nutsedge population, optimum total onion plant dry weight was obtained at rates between 150 kg N/ha and 200 kg N/ha. This result confirms the findings of Kumar *et al.* (1998), that numbers of leaves/onion plant were enhanced by supplying 150 kg/ha nitrogen. At purple nutsedge population densities of 10 and 20 plants/m^2 the onion plant attained optimum total dry weights at the same N levels. Thus, the weed population of 10 plants/m^2 and 20 plants/m^2 do not significantly affect the availability of N to onions. In the presence of 40/m^2 purple nutsedge, optimum total dry weight of onion was not achieved with this Nitrogen application rate. This implies that the population of 40 Nutsegde plants/m^2 significantly reduced the availability of N, and affected onion growth.

Onion bulb yield

Nitrogen and purple nutsedge population densities significantly ($p<0.05$) influenced onion yield. A significant ($p<0.05$) interaction between nitrogen rates and purple nutsedge population densities on onion bulb yield was recorded (Table 1).

As purple nutsedge density increased, onion bulb yield decreased. There was a lower effect of purple nutsedge density on onion bulb yield as nitrogen rates were reduced, (100 kg/ha). Maximum onion bulb yields were obtained in the absence of nutsedge plants with 200 kg N/ha. At 200 kg N/ha the effect of purple nutsedge density on onion yield was lower than when 150 kg N/ha was applied. These results agree with Van Delden *et al.* (2002) who reported that common chickweed (*Stellaria media* (L.) Vill.) interference with potato (*Solanum tuberosum* L.) was reduced at higher soil N levels.

At 100 kg N/ha, onion yield losses were 14.3% with 10 purple nutsedge/m^2, 21% with 20 purple nutsedge/m^2 and 44.3% with 40 purple nutsedge/m^2 (Fig. 1). The highest yield losses were observed with 150 kg N/ha (14.3%) with 10 purple nutsedge/m^2, 37% with 20 purple nutsedge/m^2 and 49.0% with 40 purple nutsedge/m^2. With 200 kg N/ha, the yield losses were lower than with 150 kg N/ha. Similar results were reported by Tollenaar *et al.* (1994) where applying N to maize/weed mixtures (mostly *Amaranthus retroexus* L., *Chenopodium album* L. and *Setaria viridis* (L.) Beauv.) increased maize yield and competitive ability and reduced weed biomass. This was particularly evident in maize hybrids selected for greater N uptake and higher rates of net photosynthesis per unit of leaf N. Similarly, McKenzie (1996) observed that increasing rates of N fertilizer reduced weed tiller density and relative frequency in perennial ryegrass pastures, an effect attributed to the ability of the crop to produce more leaf area and shade weeds more effectively under high-fertility conditions. Variation in crop and weed responses to soil fertility regimes under experimental conditions indicate the need to understand interactions between management practices and species-specific physiological and morphological characteristics.

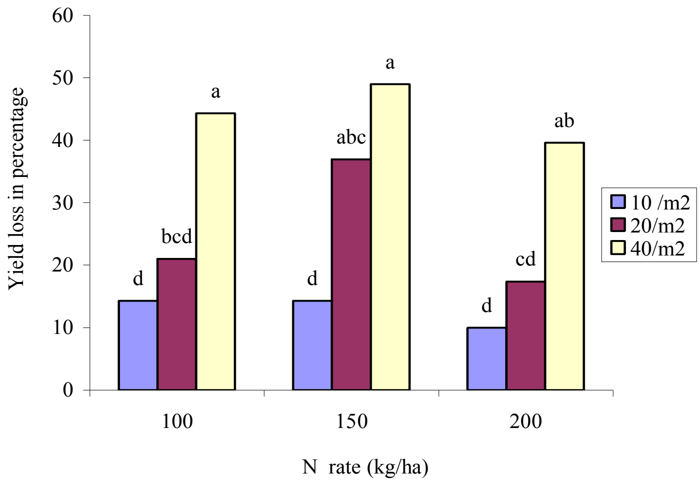

Fig.1. Effects of purple nutsedge densities and nitrogen rates on onion yield reduction. Different letters indicate significant differences at P=0.05 using Duncan's multiple range test.

Onion bulb diameter

Diameter of onion bulb was significantly affected by purple nutsedge population densities with 100 and 150 kg/ha N. At 200 kg/ha N, in the absence of purple nutsedge, onion bulb diameter was significantly greater. However, there was no significant difference in onion bulb diameter at nutsedge populations of 10 plants/m^2 and 20 plants/m^2. Similarly, there was no significant difference in onion bulb diameter at nutsegde populations of 20 plants/m^2 and 40 plants/m^2.

Average plant dry weight of purple nutsedge

Nitrogen and density had significant ($p<0.05$) effects on average plant dry weight of purple nutsedge and on the interaction effects of the weed population and N (Table 2).

Table 2. Effect of N and purple nutsedge population densities on plant dry weight, shoot height and tuber weight of purple nutsedge in the presence of onion

Nitrogen rate	Population level (Plants/m^2)	Weed dry weight (g)	Weed shoot height (cm)	Tuber weight(g)
100 kg/ha	10	2.847^{cd}	22.700^{c}	0.3867^{c}
	20	2.4400^{de}	20.100^{cd}	0.3100^{c}
	40	2.4367^{de}	11.433^{d}	0.2567^{c}
150 kg/ha	10	4.1200^{a}	40.733^{a}	1.0467^{a}
	20	3.2500^{bc}	33.967^{ab}	0.6667^{abc}
	40	3.0367^{c}	27.267^{bc}	0.5233^{bc}
200 kg/ha	10	3.5133^{b}	41.933^{a}	0.8200^{ab}
	20	2.8433^{cd}	33.100^{ab}	0.5333^{bc}
	40	2.3633^{e}	25.167^{c}	0.3800^{c}
Probability	Population	0.000	0.000	0.000
	Nitrogen	0.000	0.000	0.000
	Interaction	0.004	0.537	0.198

Within a column, means sharing a common letter are not significantly different ($p=0.05$)

Average dry weight of purple nutsedge was not significantly affected by different purple nutsedge population densities at 100 kg/ha N. With a higher N rate (200 kg/ha), there was a significant reduction in average dry weight of purple nutsedge, especially when population densities increased. Davis (1965) observed that dry weight of individual redroot pigweed *(Amaranthus retroflexus*) decreased as density increased. Radosevich and Holt (1984) stated that plant growth characters show plasticity in relation to density or other environmental stresses. This could be the reason for the reduction in total dry matter in purple nutsedge with high N rates.

Nutsedge biomass were similar at 100 kg/ha and 200 kg/ha (Fig. 2). The highest purple nutsedge total dry weights were recorded at intermediate rate of 150 N kg/ha. This indicated that in the presence of onion, purple nutsedge biomass accumulation declined between 150 and 200 kg/ha. Apparently, N rates caused detrimental effects to nutsedge which might be due to possible toxic effects of N. Similar results for purple nutsedge dry weight were obtained when this weed was grown with radish under different N regimes (Santos *et al.*, 1996). In these studies, purple nutsedge produced maximum dry weight when N did not exceed 200 kg/ha, causing nutrition stresses on weeds and decay of plant material.

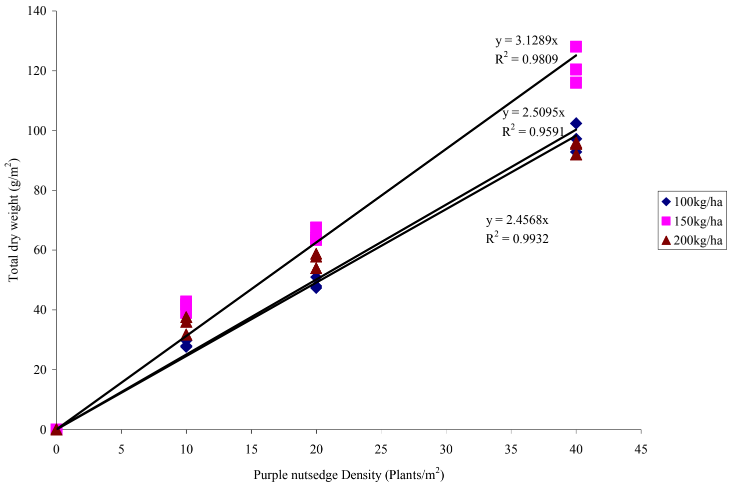

Fig. 2. Total dry weight of nutsedge as affected by population density under different N levels in the presence of onion

Purple nutsedge shoot height

Nitrogen and purple nutsedge population densities significantly ($p<0.05$) affected the shoot height of purple nutsedge plants, although there was no interaction effect (Table 2). At high N (200 kg/ha) shoot height of the weed was significantly reduced in a population of 40 plants/m^2. This might be due to the plasticity character of the weed.

Average tuber weight

Nitrogen rates and purple nutsedge population densities significantly ($p<0.05$) affected the average tuber weight of purple nutsedge. The interaction between N rates and purple nutsedge population densities on tuber weight of purple nutsedge was not significant (Table 2).

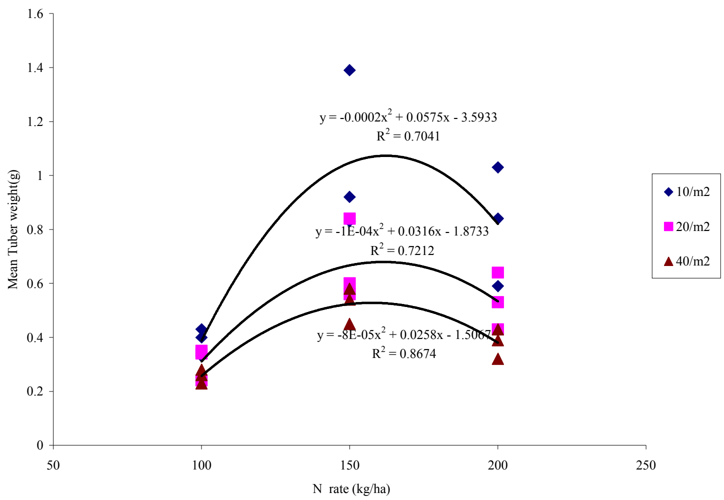

Fig. 3. Relationship between N rate and tuber weight

The maximum average tuber weight of nutsedge was observed between 150 kg N/ha and 200 kg/ha, and N rates greater than 150 kg N/ha reduced the values. When the purple nutsedge population was 40 plant/m^2, the maximum average tuber weight was 150 kg N/ha. These results agree with the findings of Morales-Payan *et al.* (1998) where purple nutsedge had the highest tuber weight with 140 kg N/ha. Those findings indicated that in the presence of pepper plants, purple nutsedge biomass accumulation significantly declined between 140 kg and 210 kg N/ha. It is apparent that N rates within this range caused detrimental effects to nutsedge, which might be due to toxic nutrient effects.

CONCLUSIONS

Population densities of over 40 plants/m^2 are common in nutsedge infested onion fields. The fact that even nutsedge population densities as low as 10 plants/m^2 with low N rate were capable of reducing onion yield by 14.3% appear to justify the need for nutsedge suppression in this crop, even at densities usually considered to be low. Moreover, the commonly found nutsedge population densities of 40 plants/m^2 caused an onion yield reduction of nearly 50% at 150 kg Nha, proving that unchecked nutsedge interference can reduce the yield of this crop. Purple nutsedge shoot height, tuber weight and total biomass negatively respond to high nitrogen rates. Therefore, in purple nutsedge and onion mixtures, the onion crop is more competitive at lower nitrogen levels and with intermediate Nitrogen levels. Purple nutsedge and onion seem to have similar optimal rates of N fertilizer. A sub optimal rate of N fertilizer gives purple nutsedge a competitive advantage, while a higher rate of N fertilizer provides onion a competitive advantage. As purple nutsedge has a similar optimal rate of N fertilizer, reducing the purple nutsedge competition in onion crops by manipulating Nitrogen rate is difficult and complex. Further research is required to characterize the specific mechanisms of competition of this weed with onion.

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