

Competitive Performance of Purple Nutsedge (*Cyperus rotundus* L.) and Onion (*Allium cepa* L.) as Affected by Different Sources of Nitrogen

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ABSTRACT. Experiments were conducted in Yala 2010 and Maha 2010/11 to determine the effects of N sources and purple nutsedge (*Cyperus rotundus* L.) densities on purple nutsedge growth and its interference with onion (*Allium cepa* L.) as organic amendments can promote weed management. A 3×4 factorial design with four replicates per treatment was adopted. The treatments were three different purple nutsedge densities (0, 20, 40 plants/m²) with four N sources i.e. cattle manure, gliricidia (*Gliricidia sepium*) leaves, improved compost and inorganic fertilizer (urea). Onion (variety *Vethalan*) and purple nutsedge were allowed to grow together for 12 week. The results of the two experiments were combined as the treatment by season interaction was not significant ($p>0.05$). Onion bulb yield was significantly affected by purple nutsedge density and N source. No significant ($p>0.05$) effect of N sources on purple nutsedge biomass was observed at a density of 20 plants/m² whereas at 40 plants/m², the effects were significant. Onion N concentration was high when grown with improved compost, whereas N concentration in purple nutsedge was low in this treatment. Purple nutsedge tuber weight and tuber number were significantly ($p<0.05$) suppressed by improved compost. The study indicated that improved compost application maximizes benefits to the onion crop and minimizes any inadvertent benefits to purple nutsedge. Information from this study could be utilized to develop more efficient fertilization strategies as components of integrated weed management programs in onion production systems under field conditions.

Keywords: Bulb yield, competition, improved compost, N concentration, tuber number

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Alliaceae and is a popular vegetable grown for its pungent bulbs and flavorful leaves. It is consumed at its young green stage or after its full development and maturity when it is harvested in the form of a dry bulb. In the Eastern province of Sri Lanka, almost all spicy dishes contain onion as an important ingredient used for cooking purposes. Onions are extensively used as a condiment in Asian cuisines.

Purple nutsedge (*Cyperus rotundus* L.), an economically important perennial weed in 92 countries, is classified as the world's worst weed due to its extensive distribution and competitiveness (Holm *et al.*, 1977). Experience has shown that purple nutsedge is the one of the serious weeds in onion fields in Batticaloa Sri Lanka, which significantly reduces the onion yield.

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Organic soil amendments, such as legume green manures, cover crops, animal manures, and composts, are basic components of low-external-input cropping systems that are valuable for weed management (Liebman & Davis, 2000). Application of organic soil amendments may alter the balance of onion-purple nutsedge interactions. However, there appears to be no information regarding the relative responses of purple nutsedge and onion to changes in the soil environment induced by organic and inorganic fertilizer application. Thus research on inorganic and organic N effects on purple nutsedge growth and competitive interactions with onion would aid the development of fertilization strategies as components of integrated weed management programs in onion cultivation. The objective of this study was to evaluate the effects of N sources and purple nutsedge densities on purple nutsedge growth and interference with onion under controlled conditions as the first step towards developing an integrated weed management program.

MATERIALS AND METHODS

Pot experiments were conducted at the Agronomy farm of the Eastern University, Batticaloa, located in the dry zone of Sri Lanka in the *Yala* season over May to August 2010 and September 2010 to January 2011 to correspond to the *Maha* season. The onion variety Vethalan was used and purple nutsedge was collected from commercial onion fields of Batticaloa. Onion bulbs were planted into the rectangular shaped rigid boxes (1470 cm² surface area) filled with a non calcic brown soil. At the same time, pre sprouted purple nutsedge tubers (weight between 0.5 - 0.7 g) were planted in-between the onion at densities equivalent to 0, 20 or 40 plants/m². Based on the previous observations, this container size was chosen to provide unrestricted growth for both species.

A factorial arrangement with four replications was used for the study in each season, and an experimental unit consisted of one container. Purple nutsedge population densities (0, 20, 40 plants/m²) and four different nitrogen sources (cattle manure, Gliricidia, improved compost and inorganic fertilizer) were arranged in a three by four factorial design within a completely randomized block design for each trial.

Improved compost (beneficial microbial inoculant added to improve N concentration) was prepared by mixing cattle manure, paddy husk and rice bran in a 2:1:1 ratio. A commercial microbial inoculant (EM) and molasses, diluted in water (dilution of 1:1:100) was applied into the mixture until the moisture content reached 30-40%. The mixture was heaped and covered with black colored polyethene until it developed a white mould and a fermented odour.

Table 1. Application rates of N sources

N sources	N (%)	Application rate (t/ha)
Gliricidia	1.97	3.50
Cattle manure	0.64	10.78
Improved compost	1.34	5.30
Inorganic fertilizer (urea)	46.0	0.15

N content of the four organic additives were determined by the Kjeldahl digestion method (Amin & Flowers, 2004). Urea was used as the inorganic N, cattle manure, improved compost and Gliricidia application rates were the organic amendments. The rates of

application of the fertilizer were adjusted to provide 150 kg.N/ha (Table 1). Other plant nutrients and water were supplied to experiment units according to recommendations of the Sri Lankan Department of Agriculture (1989).

In both experiments, onion and purple nutsedge were allowed to grow together for 12 weeks. Onion plants were harvested when leaves turned yellow indicating signs of maturity. Measured variables were marketable bulb yield, bulb diameter, purple nutsedge biomass, tuber weight, plant height and tuber number. At maturity, onion plants plus purple nutsedge were harvested for determination of N concentrations. Plant samples were oven-dried at 70 °C, finely ground, and analyzed for N concentration using the Kjeldahl digestion method (Amin & Flowers, 2004).

The data from two experiments were pooled because there were no significant ($p>0.05$) treatments by season interaction. Analysis of variance was performed to determine significant differences among treatments ($P<0.05$). Correlation analysis was used to characterize the effect of purple nutsedge densities on onion bulb yield in different N sources. Treatment means were compared using DMRT at 5% level.

RESULTS AND DISCUSSION

Onion bulb yield

Table 2. Effects of N Sources and purple nutsedge densities on onion bulb yield and bulb diameter

Population (plant/m ²)	N sources	Onion bulb yield (g/m ²)	Bulb diameter (cm)
0	Gliricidia	1813.83 ^c	2.13 ^b
	Cattle manure	2020.03 ^b	2.46 ^{ab}
	Improved compost	2206.73 ^a	2.68 ^a
	Inorganic Fertilizers	1880.68 ^c	2.66 ^a
20	Gliricidia	1485.55 ^c	2.05 ^a
	Cattle manure	1631.51 ^b	2.01 ^a
	Improved compost	1908.12 ^a	2.07 ^a
	Inorganic Fertilizers	1501.07 ^c	1.67 ^b
40	Gliricidia	1175.64 ^b	1.46 ^b
	Cattle manure	1076.10 ^{bc}	1.34 ^b
	Improved compost	1326.51 ^a	1.71 ^a
	Inorganic Fertilizers	1024.38 ^c	1.32 ^b

Means within a N source followed by the same letter are not significantly different (DMRT at $p = 0.05$)

Effect of N sources on onion yield was significantly influenced by purple nutsedge densities. In the absence of purple nutsedge, improved compost induced the highest onion yield which is significantly greater than those from other N sources (Table 2). Improved compost developed with the microbial inoculants containing beneficial microbes (EM) could thus develop a favorable rhizosphere environment to onion. Similarly, Daly and Stewart (1999) reported that application of EM to onion, pea and sweet corn increased yields by 29%, 31% and 23%, respectively.

With a purple nutsedge density of 20 plants/m², improved compost application produced the highest onion yield. Further, no significant ($p>0.05$) differences in onion yield were observed when Gliricidia and inorganic fertilizer were used. In contrast, at a purple nutsedge density of 40 plants/m², significant difference in onion yield was observed between Gliricidia and inorganic fertilizer application treatments. These findings clearly indicate that in the presence of purple nutsedge in onion plots, improved compost application produced the highest onion yield. As improved compost contained EM this could have a suppressive effect on purple nutsedge. These results supported by the findings of Javaid (2010) who reported that EM can significantly increase crop yields in organic farming systems, which can be partly attributed to the role of EM in developing a more favorable environment for plant growth and yield.

Table 3. Correlations between onion yield and purple nutsedge densities with different N sources

N Source	Prediction equation	R ²	P
Gliricidia	$y = 1805 - 15.3 x$	93.1	<0.05
Cattle manure	$y = 2070 - 23.7 x$	97.6	<0.05
Improved compost	$y = 2276 - 22.0 x$	91.9	<0.05
Inorganic fertilizers	$y = 1917 - 21.7 x$	84.4	<0.05

x variable represents purple nutsedge densities (plant/m²); y variable represents onion bulb yield (g/m²)

A significant ($p<0.05$) linear relationship was observed between onion bulb yield and purple nutsedge density in all treatments. As purple nutsedge density increased, onion bulb yield reduced irrespective of N sources. There was a lower effect of purple nutsedge density on onion yield with Gliricidia, as evidenced by the lower negative gradient of the regression equations (Table 3). Rizvi *et al.* (1992) who recorded that legume leaves elicited allelopathic effects or phytotoxic chemicals that adversely affect plant growth. Gliricidia is a legume which may have phytotoxic effects on purple nutsedge. In contrast, the effect of purple nutsedge density on onion bulb yield was high with cattle manure and improved compost application which is indicated by the regression equations. The present study clearly indicates that onion yield loss was high in improved compost and cattle manure, when purple nutsedge population increased from 20 plants/m² to 40 plants/m². Menalled *et al.* (2004) also documented that composted swine manure increased the competitive ability of common waterhemp (*Amaranthus rudis* Sauer) without increasing soybean [*Glycine max* (L.) Merr.] yield. Improved compost and cattle manure may release nutrients slowly, nutrient absorption in purple nutsedge is more effective than onion. Similarly Qasem (1992) found that many weed species are more effective in absorbing nutrients than the crops they infest, particularly under fertilized conditions. Thus, increased densities of purple nutsedge could absorb more nutrients than onion, and reduce onion yields grown with improved compost and cattle manure.

Onion bulb diameter

Onion bulb diameter was significantly influenced by purple nutsedge density and N source (Table 2). In the absence of purple nutsedge, onion bulb diameter was not significantly ($p>0.05$) different between improved compost and inorganic fertilizer treatments. In contrast, purple nutsedge density at 20 plants/m² and 40 plants/m², bulb diameter was significantly ($p<0.05$) different between improved compost and inorganic applications and bulb diameter of inorganic fertilizer applications was lower than bulb diameter of improved compost. These findings clearly indicate that with improved compost applications, purple nutsedge effect on

bulb diameter was lower when compared with inorganic fertilizer. Improved composted manures may alter physical and biological characteristics of the soil environment in ways that may affect purple nutsedge- onion interaction confirming earlier studies by Liebman and Mohler (2001) on weed and crop interactions.

Onion N concentration

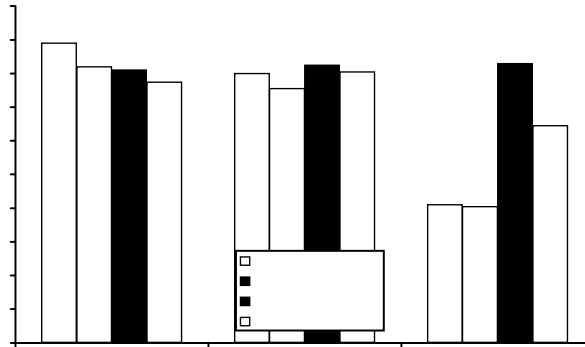


Fig. 1. Effect of N sources on Onion N concentration in three Purple nutsedge densities

Bars on the graph within a density with the same letters are not significantly different (DMRT p = 5%)

A significant impact of N sources and purple nutsedge densities on onion plant N concentrations was evident (Fig. 1). In the absence of purple nutsedge and at a density 20 plants/m², onion plant N concentrations were not significantly different between N sources. In contrast, at a purple nutsedge density of 40 plants/m², onion N concentrations was not significantly (p>0.05) different between improved compost and inorganic fertilizer applications although significantly (p<0.05) different from the N concentrations in onion grown with Gliricidia and cattle manure. However, the onion N concentrations in plants grown with Gliricidia and cattle manure were similar (Fig. 1).

Purple nutsedge N concentration

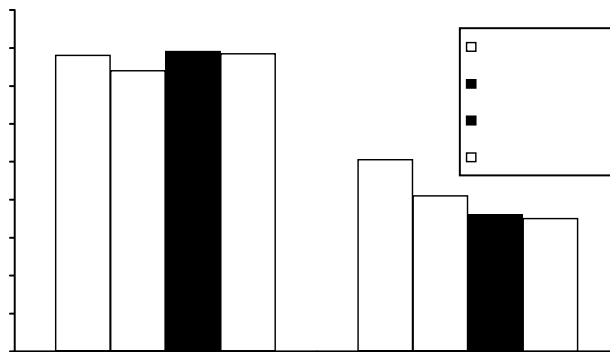


Fig. 2. Effect of N sources on purple nutsedge N concentration at Purple nutsedge density 40plants/m² and 20 plants/m².

Bars on the graph within a density with the same letters are not significantly different (DMRT p = 5%)

Purple nutsedge N concentration was significantly ($p < 0.05$) affected by N sources and the density of the weed. At a purple nutsedge density of 20 plants/m², N concentrations of the weed were not significantly ($p > 0.05$) different between the N sources. However, at a purple nutsedge density of 40 plants/m², cattle manure application produced the highest N concentration in this species which greater than in other treatments (Fig. 2). Previous studies illustrate that livestock manure may affect crop–weed competitive interactions differently than N fertilizer (Davis & Liebman, 2001), perhaps due to speed of N release or form of N. The major part (>90%) of Nitrogen in fresh manure is ammonia while that of compost is nitrate (>70%) (Hao *et al.*, 2004). The forms in which nutrients are provided can have differential effects on weed and crop performance. An illustration of this phenomenon can be seen in the results of Teyker *et al.* (1991), who fertilized maize and *Amaranthus retroflexus* with nitrate or ammonium N sources. Shoot weight of the crop was not affected by N source, but use of ammonium (with the addition of a nitrification inhibitor) reduced the shoot weight of the weed by%. In this study, N sources may be released in different forms of N, and the N form released by cattle manure may be more efficiently absorbed by purple nutsedge when compared with N forms released by other sources.

Total N concentration (onion and purple nutsedge)

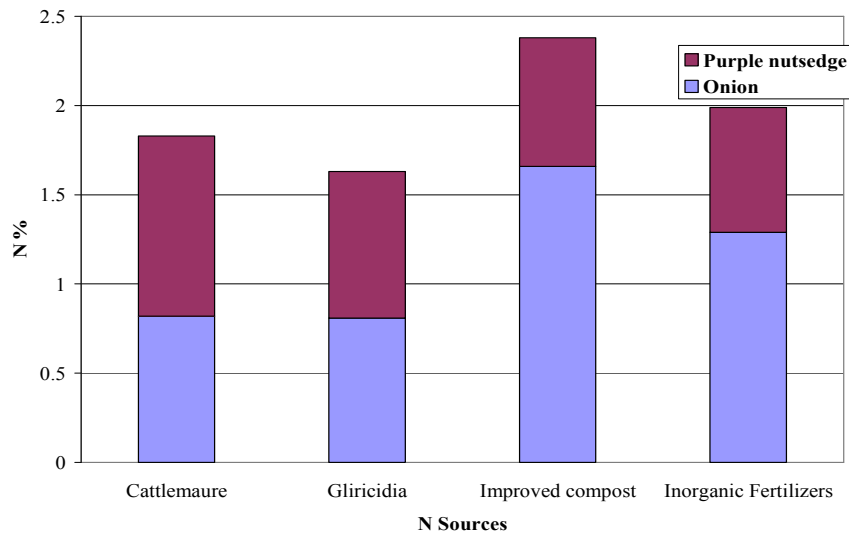


Fig. 3. Onion and purple nutsedge N concentration in relation to N sources at purple nutsedge density of 40 plants/m².

Total (onion + purple nutsedge) N concentration was high with improved compost and inorganic fertilizer application when compared to the concentrations with Gliricidia and cattle manure at a purple nutsedge density of 40 plants/m² (Fig. 3). The purple nutsedge fraction of total (Onion + purple nutsedge) N concentration was low with improved compost and inorganic fertilizer applications when compared to that with cattle manure and Gliricidia. However, at a purple nutsedge density of 40 plants/m², when compared with Gliricidia and cattle manure, onion fraction of total N concentration was high when grown with improved compost and inorganic fertilizer applications. The proportion of N concentrations of weed and onion were similar when grown with Gliricidia and cattle manure. These results clearly indicate that in improved compost and inorganic treatments, onion absorb more N than

Purple nutsedge, this may be due to available N form in these treatments which may be more efficiently absorbed by the crop when compared to the weed, and warrants further study with labeled nutrients.

Table 4. Effect of N Sources and Purple nutsedge densities on Purple nutsedge biomass and Tuber weight.

Population (plant/m ²)	N Sources	Biomass (g/plant)	Tuber weight (g)
20	Gliricidia	4.18 ^a	0.54 ^c
	Cattle manure	4.69 ^a	0.63 ^b
	Improved compost	4.89 ^a	0.34 ^d
	Inorganic Fertilizers	5.01 ^a	0.73 ^a
40	Gliricidia	2.54 ^b	0.34 ^b
	Cattle manure	2.56 ^b	0.36 ^b
	Improved compost	2.71 ^b	0.30 ^c
	Inorganic Fertilizers	4.44 ^a	0.42 ^a

Means within a N source followed by the same letter are not significantly different (DMRT at p = 5%)

Purple nutsedge biomass

There was a significant interaction between N sources and purple nutsedge densities on purple nutsedge biomass (Table 4). At a purple nutsedge density of 20 plants/m², its biomass was not significantly different between the treatments. In contrast, at a purple nutsedge density of 40 plants/m², its highest biomass was recorded with inorganic fertilizer application. Purple nutsedge biomass was not significantly different in treatments with cattle manure, Gliricidia and improved compost. Thus the present study clearly shows that organic amendments suppress purple nutsedge growth. Previous studies have similarly documented that organic amendments may suppress weeds by releasing phytotoxins during decomposition, such as phenolic compounds (Ohno *et al.*, 2000) and short-chain fatty acids (Ozores-Hampton *et al.*, 1999). These compounds have been linked with allelopathic inhibition of weed growth (Liebman & Ohno, 1998; Ohno *et al.*, 2000) and increased in the pathogenicity of soil-borne diseases (Dabney *et al.*, 1996; Toussoun & Patrick, 1963). Dyck *et al.* (1995) found that the use of crimson clover (*Trifolium incarnatum* L.) green manure as an N source decreased common lambsquarters (*Chenopodium album* L.) biomass by 65% and increased sweet corn biomass by 131% compared to a treatment in which a similar amount of N was supplied in the form of NH₄NO₃ fertilizer applied at planting. Perhaps the most important question arising from our study is the accounting of selective suppression of the purple nutsedge, but not onion, by the organic N sources. Mohler (1996) hypothesized that variations in seed size constitute the basis for selective suppression of weeds but not crops. Onion bulb size is different from purple nutsedge tuber size. Therefore, selective suppression is possible and requires confirmation.

Tuber weight

There was a significant (p<0.05) two way interaction between N sources and purple nutsedge density on its tuber weight. At purple nutsedge densities of 20 and 40 plants/m², its tuber weight when grown with improved compost was significantly (p<0.05) lower than in other N (Table 4). Previous studies have reported that compost can contain phytotoxic compounds, including short-chain fatty acids, phenols, and ammonia, each of which can inhibit weed

seed germination (Ligneau & Watt, 1995; Marambe & Ando, 1992; Ozores-Hampton *et al.*, 1999; Roe *et al.*, 1993). In this study, improved compost could have released phytotoxic substances which may be detrimental to purple nutsedge tubers. This may be the reason for lower tuber weight of the weed obtained with improved compost

Table 5. Effect of N Sources and purple nutsedge densities on tuber number and shoot height of purple nutsedge

Population (plant/m ²)	N Sources	Tuber (number/pot)	shoot height (cm)
20	Gliricidia	23.75 ^b	40.50 ^{bc}
	Cattle manure	23.35 ^b	44.00 ^b
	Improved compost	13.65 ^c	36.00 ^c
	Inorganic Fertilizers	40.62 ^a	52.25 ^a
40	Gliricidia	18.62 ^b	34.50 ^b
	Cattle manure	19.87 ^b	27.25 ^c
	Improved compost	9.00 ^c	25.50 ^c
	Inorganic Fertilizers	31.37 ^a	41.25 ^a

Means within a N source followed by the same letter are not significantly different (DMRT at p=5%)

Tuber number

Purple nutsedge tuber numbers were significantly ($p < 0.05$) lowered by purple nutsedge densities and N sources. At purple nutsedge densities of 20 plants/m² and 40 plants/m², improved compost produced the lowest tuber number (Table 5). However, purple nutsedge tuber number was not significantly ($p > 0.05$) different when grown with Gliricidia or cattle manure at a density at 20 plants/m². In contrast it was significantly ($p < 0.05$) different at a density of 40 plants/m². At the same time, highest purple nutsedge tuber number was observed with inorganic fertilizers. These results clearly indicate that tuber production was suppressed by improved compost and it was induced by inorganic fertilizers. This may possibly be due the release of toxic substances from the compost which may disturb the tuber formation.

Shoot height

A significant interaction was observed between N sources and purple nutsedge densities on its height at 0.05 probability level. In purple nutsedge densities of 20 and 40 plants/m², the tallest weeds were recorded with inorganic fertilizer application, which was significantly ($p < 0.05$) greater than heights of the weed growth with improved compost (Table 5). These findings clearly indicate that purple nutsedge growth is more responsive to inorganic N source when compared with organic N sources. Previous study have documented that nutrient uptake and growth of many weed species is stimulated by synthetic fertilizers (Alkamper, 1976; DiTomaso, 1995)

CONCLUSIONS

This study indicated that N sources differentially influenced on onion and Purple nutsedge growth. Improved compost applications increased onion yield but adversely affected purple nutsedge. Although it is unclear why onion and purple nutsedge responded differently to

improved compost, it could be speculated on the basis of mechanisms responsible for the observed results. Purple nutsedge biomasses were lower with organic N sources than with the inorganic N source. Further, Purple nutsedge tuber weight and number were suppressed by improved compost and this could lead to reductions in the purple nutsedge populations in the following season. Although the study did not directly address the underlying mechanism of weed suppression by the organic N sources in this study, it believes that the amendment effect was due to phytotoxicity from the organic N sources, rather than N- related effects. Organic N sources were maximizing benefits to crops and minimizing benefits to purple nutsedge. Manipulation of soil fertility, whether using organic or inorganic amendments, should be considered an important component of long-term purple nutsedge control programs. Information gained in the current study will be used to develop more integrated programs for weed management in onion production systems. More detailed investigations of how N sources affect soil conditions and purple nutsedge and onion morphology and physiology thus required in such weed management strategies.

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