

**Influence of nitrogen fertilizer and duration of Purple Nutsedge (*Cyperus rotundus*) interference on Onion (*Allium cepa*) growth and yield in minor seasons in Batticaloa, Sri Lanka**

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**ABSTRACT**

Purple Nutsedge (*Cyperus rotundus*) is difficult to manage and persists in onion (*Allium cepa*) fields of the tropics. Critical period of weed control can be highly influenced by Nitrogen fertilizer (N) application. Thus, determine the critical period of purple nutsedge control in onion for different levels of nitrogen fertilizer is useful in making decisions on the need for and timing of purple nutsedge control in both biological and economic perspectives. A field study was conducted from June – September, 2010 in Sri Lanka to evaluate the influence of nitrogen application on the critical period of purple nutsedge control in onion. Nitrogen fertilizer was applied at rates equivalent to 100, 150, and 200 kg ha<sup>-1</sup>. A quantitative series of treatments of both increasing duration of purple nutsedge interference and length of weed-free period were imposed within the different rates of N. The beginning and end of the critical period of purple nutsedge control based on 5% acceptable yield loss level were determined by fitting logistic and Gompertz equations to relative yield data representing increasing durations of purple nutsedge interference and weed-free period, respectively. The beginning of the critical period of the purple nutsedge control for onion varied with N application rate. The addition of N hastens the end of the critical period of the purple nutsedge control. Critical period of purple nutsedge control for onion reduced with increasing N. Plant height, dry weight and bulb diameter were significantly ( $P < 0.05$ ) influenced by interaction effect of purple nutsedge infestation period and Nitrogen application rate. In addition, Nitrogen application rates and duration of weed free period significantly ( $P < 0.05$ ) interacted with onion height, dry weight and bulb diameter. Overall, this study revealed that reductions in nitrogen use may create the need for more intensive purple nutsedge management in onion fields in the minor seasons of the Batticaloa.

**Key words:** Logistic and Gompertz equations, Nitrogen application rate, Tropics, Weed-free period

**INTRODUCTION**

Onion is a member of Alliaceae family and is of great benefit to humans due to its dietic and medicinal values. Onion is an integral part of our daily diet and its use is very common in almost all food preparations (Hossain and Islam, 1994). It is also used as preservative and medicine (Vohra *et al.*, 1994). Onion is one of the most important vegetables grown in tropical Asia.

Purple nutsedge interference is one of the major constraints to onion production in the tropics. Onion is a poor competitor to weeds due to its short stature, non branching habit, sparse foliage, shallow root system and extremely slow growth in the initial stages, when compared to the rapid growth of weeds.

Purple nutsedge is considered the most serious weed in cultivated crops throughout more than 70 tropical and subtropical countries. Traditional



commonly used methods such as hand weeding and cultivating have not effectively controlled this weed (Barreto, 1970) because tubers and leaf meristem of basal bulbs of the weed are located 2 to 15 cm below the soil surface (Wills and Briscoe, 1970) and escape damage from these practices. From a weed management standpoint, purple nutsedge is a serious problem due to the lack of selective herbicides to control them (Stall *et al.*, 1994) when interfering with onion. Therefore, use of multiple weed control strategies in the form of integrated weed management is crucial in controlling nutsedge in onion.

Integrated weed management (IWM) involves a combination of cultural, mechanical, biological, genetic, and chemical methods for effective and economical weed control (Swanton and Weise, 1991). The principles of IWM should provide the foundation for developing optimum weed control systems and efficient use of herbicides. The critical period for weed control (CPWC) is a key component of an IWM program. CPWC is defined as the time duration required to keep a weed-free condition to avoid crop yield reduction (Swanton and Weise, 1991). A study carried out in Sri Lanka by Liyange *et al.* (2016) found that the CPWC for big onion in Dry Zone was ranged between 9-68 days after transplanting.

Development of integrated weed management (IWM) systems for onion that target persistent weeds such as purple nutsedge requires a greater understanding of when purple nutsedge interference can be tolerated before crop yield is reduced. Knezevic *et al.* (2002) reported that knowledge of the CPWC and the factors that affect it are essential for making decisions on the appropriate timing of weed control and in achieving the efficient use of herbicides.

Information on the critical period of purple nutsedge control in Onion could help improve timing of post emergence herbicide applications. The CPWC could be used also to enhance the efficiency of other methods of weed management, including cultivation. Reducing the number of herbicide treatments as a result of better timing and efficiency may reduce potential environmental contamination and the selection pressure for herbicide-resistant weeds (Hall *et al.*, 1992).

Timing of weed control measures is important to maintain optimum crop yield. Determining the CPWC could help reduce yield losses due to weed interference (Knezevic *et al.*, 2002). Critical period of weed control can be highly influenced by crop management practices. Particularly amount and place of application of fertilizers. Onion is a shallow rooted crop; a fairly high concentration of nutrient should normally be maintained at the surface of the soil for its optimum growth and yield. The importance of urea, triple super phosphate and muriate of potash on the growth and yield of onion is widely reported yet research has not been conducted on the influence of nitrogen fertilization on onion–purple nutsedge interference relationships. Therefore, there is a need to evaluate the effects of nitrogen on the critical period of purple nutsedge control in onion. Therefore, the objective of this study was to determine the critical period of purple nutsedge control in onion for different levels of nitrogen fertilizer in a minor season of the Batticaloa in Sri Lanka.

## **MATERIALS AND METHODS**

A field experiment was conducted from June – September, 2010 at the Agronomy farm, Eastern University, located in the low country dry zone of Sri Lanka (7-8°N, 80-81°E) where the average elevation of the experimental site is 3.2m above sea level. This agro climatic zone is

characterized by a bimodal rainfall pattern with a major rainy season from October to January followed by a minor season from May to September. Onion is predominantly cultivated in the minor season in this region. This is because

onion is sensitive to floods which occur frequently in the major season which receives 1600 mm of rainfall per annum. The soil type of the experimental site was Non Calcic Brown soil (Panabokke, 1996).

Table 1. Rainfall and ambient temperature during the experiment

Month	Monthly Total Rainfall (mm)	Number of rainy Days	Mean monthly temperature (°C)
June	21.3	2	30.5
July	10	2	30.5
August	129.1	7	29.7
September	106	8	28.8

The experiment was established in a factorial arrangement of treatments within a split-plot design with three nitrogen application levels (100, 150, and 200 kg ha<sup>-1</sup>) as the main-plot factor and time of weed control and duration of weed interference as the split-plot factor. The split-plot experimental units consisted of 3m X 1m plots. In each plot, onion (variety Vethalan) was

Planted at the recommended spacing of 10 cm X 10 cm (Department of Agriculture, 1989). Main plots were arranged in randomized complete blocks with three replications. For each main plot, two sets of treatments ((a) increasing duration of weed interference; and (b) increasing length of weed free period) were imposed on the split-plot experimental units to represent both different duration of purple nutsedge interference and different timings of purple nutsedge controlled after onion planting. For the first set, plots were kept weed free until 10, 20, 30, 40, 50 and 60 days after planting of onion. Thereafter, purple nutsedge pre-sprouted tubers were planted at a density of 40 plants/m<sup>2</sup> and allowed to grow until the onions were harvested. In the second set, onion and purple nutsedge pre-sprouted tubers were

planted simultaneously where purple nutsedge were allowed to grow until 10, 20, 30, 40, 50, or 60 days after planting of onion. Thereafter, onion plots were kept weed free until harvest. To maintain the weed-free period, hand weeding was practiced. In addition, seasonal long purple nutsedge infested onion plots and seasonal long weed-free onion plots were included. Other weeds emerged in experimental plots were controlled manually throughout the experiment. Nitrogen rates of 100, 150, and 200 kg ha<sup>-1</sup> were applied in the form of Urea (46% N). Other plant nutrients (P and K) and water were supplied following current crop recommendations (Anon, 2002).

Onion plants were harvested when 75% of the leaves turned yellow. Bulb diameter, plant height and bulb yield of onions were measured by harvesting plants within a 0.5m<sup>2</sup> quadrat. Both front and rear onion rows of each experimental unit were excluded from the harvests to minimize border effects. Total plant dry weight of onion, was measured by harvesting five plants and drying at 70° C to constant moisture content. A Vernier Caliper was used to measure the bulb diameter.

Nonlinear regression analysis using PROC NLIN in SAS 9.1 was used to model relative yield as a function of increasing duration of purple nutsedge interference and length of the weed-free period.

A logistic equation, modified slightly from the form proposed by Hall *et al.* (1992),

$$RY = \left( \left[ \frac{1}{(D \times \exp[K \times (T - x)] + F)} \right] + \left[ \frac{(F - 1)}{F} \right] \right) \times 100 \dots\dots\dots (1)$$

where RY is relative yield (% of the season-long weed-free yield), T is the duration of purple nutsedge interference measured from the time of planting in days, x is the point of inflection in days, and D, K and F are constants.

$$Ry = a \times \exp(-b \times \exp[-k \times T]) \dots\dots\dots (2)$$

Where RY is relative yield (% season-long weed-free yield), *a* is the yield asymptote, *b* and *k* are constants, and T is the length of the weed-free period after crop planting measured in days.

Determination of the critical weed free period for purple nutsedge control in these experiments was based on an acceptable yield loss level of 5%. Using a predetermined 5% level of accepted yield loss, the beginning and end of the critical period of purple nutsedge control were determined using the Gompertz and logistic equations (1 and 2). The beginning of the critical period was defined as the crop stage by which weed interference reduced yields by 5%. Similarly, the end of the critical period was defined as the crop stage to which the crop must be free of weeds to prevent yield loss from exceeding 5%.

The UNIVARIATE procedure with in SAS 9.1 was used to determine the residuals for normality and check for the outliers in the data. All the data collected

was used to determine the effect of increasing duration of purple nutsedge interference on relative yield of onion and to determine the beginning of the critical weed free period of purple nutsedge for each nitrogen rate:

The Gompertz model (Hall *et al.*, 1992) was used to describe the effect of increasing length of the weed-free period on relative yield and to determine the end of the critical period of purple nutsedge control for each nitrogen rate:

for the different parameters were homogeneous. The effects of increasing the duration of purple nutsedge interference and the length of the weed-free period on bulb diameter, plant height and total plant dry weight were evaluated using ANOVA. The DMRT test was performed for Mean separation at 0.05 probability level. The significance of interaction between nitrogen rate and increasing the duration of purple nutsedge interference on onion plants height, total dry weight of onion plants, bulb diameter and interaction between nitrogen rate and length of the weed-free period on onion plants height, total dry weight of onion plants and bulb were evaluated at the 0.05 probability level.

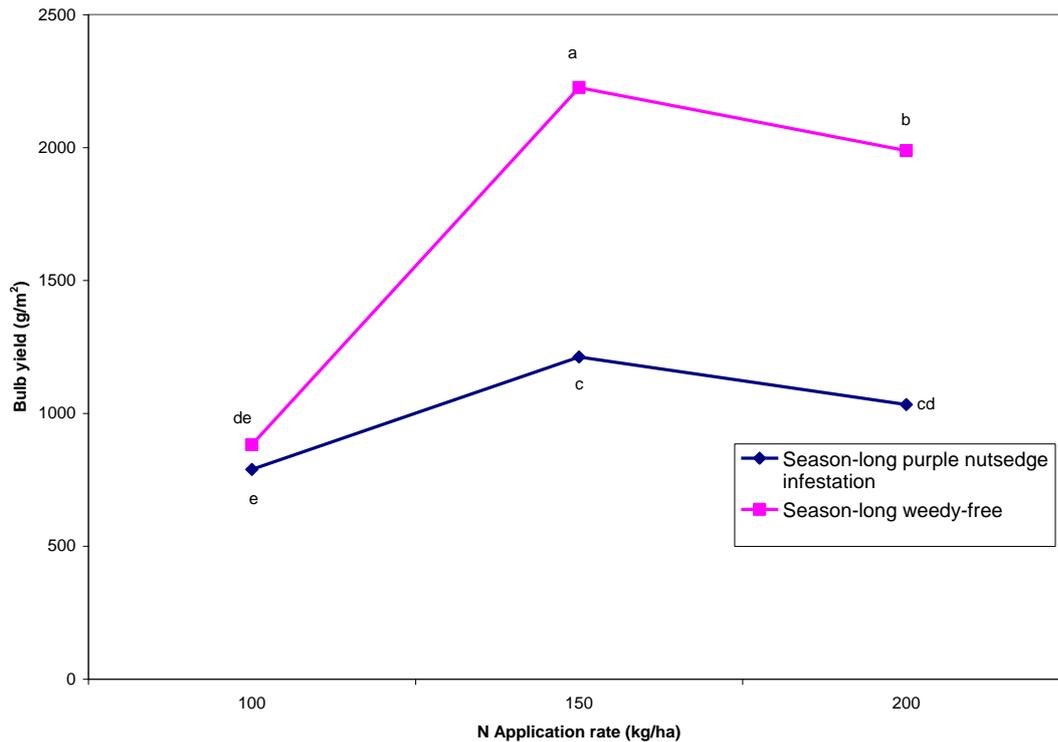
## RESULTS AND DISCUSSION

### Onion Yield Response to Nitrogen

Nitrogen fertilizer significantly affected onion yield in the presence or absence of the weed (Figure 1). Onion bulb yield was lowest in the 100 kg treatment both under season long weed-free and weedy

conditions. In contrast, both weed competition treatments produced the highest onion yield in 150kg N/ha. A significant ( $P<0.05$ ) yield increment was observed when nitrogen application rate was increased from 100 to 150 kg/ha in both treatments. Nitrogen plays an important role in reaching the optimum yield and is essential to increase the bulb

size and yield of onion. This result is supported by the findings by Patel and Patel (1990), where nitrogen had significant effects on bulb yield and with Patel and Vachhani (1994) who reported that onion yield increased with increased nitrogen. Parwal and Singh (1993) also reported a yield increase in onion with increasing nitrogen levels.



**Figure 1. Onion (*Allium cepa*) yield as affected by three nitrogen rates in the presences or absence of purple nutsedge infestation. Values with different letters are significantly different ( $P<0.05$ )**

Under season-long weed free conditions, onion yield was significantly ( $P<0.05$ ) reduced when Nitrogen application rate increased from 150 kg/ha to 200 kg/ha. This result coincides with those of Ghaffoor *et al.* (2003) who reported that at a fertilizer level of 150:100:50 NPK kg/ha, produced the best results in terms of the number of leaves per plant, bulb survival, bulb diameter, marketable yield, cull percentage and total yield. High nitrogen application rates might be retarding the onion growth, and research is needed to determine the causal effects.

With season-long purple nutsedge infestation, no significant yield difference in onion was observed between Nitrogen application rates of 150 kg/ha and 200 kg/ha. Hewson and Roberts (1973) and Qasem (1992) reported that weeds absorb Nitrogen excessively and therefore are capable of affecting its availability to the crop. Thus there was no significant difference in bulb yields between 150 kgN/ha and 200 kgN /ha in the presence of purple nutsedge over the entire season. With 100 kgN/ha, yield difference

between season-long Purple nutsedge infestation treatment and season-long weed free treatment was lower than that obtained with other Nitrogen rates. With 150 kg and 200 kgN/ha, bulb yield difference between season-long purple nutsedge infestation and season-long weed free treatment was high. This indicates that purple nutsedge competition was greater in the presence of Nitrogen. Weeds may be

more competitive when fertility is enhanced with Nitrogen fertilizers because of the increased uptake efficiency of many weed species (Di Tomaso, 1995). These findings agree with the results of the present study, where higher Nitrogen application rate increases the competitive ability of purple nutsedge which led to a reduction in onion bulb yield.

### Parameter estimates for logistic and Gomperts models

Table 2. Parameter estimates for logistic model derived for Onion (*Allium cepa* L.) at three levels of nitrogen application

Parameter estimates						
N rate kg/ha	K	F	D	X	RMSE	
100	0.1902(0.0159)	1.9552 (0.0299)	0.8598 0.0911)	16	4.6267	
150	0.1492 (0.0182)	1.8296(0.0537)	0.9198 0.1408)	19	13.4043	
200	0.1414 (0.0275)	1.8197 (0.0942)	0.8857(0.2169)	21	33.9605	

Abbreviation: - RMSE, root mean square error.

A logistic model was fitted to relative yields of onion (expressed as a percentage of the weed-free control) as a function of increasing duration of purple nutsedge interference (in days). (Equation 1) All the parameter estimates in logistic models were significant ( $P < 0.05$ ) for the three

Nitrogen application rates (Table 2). This provides sufficient evidence to conclude that parameters of the logistic model were not equal to zero in three nitrogen application rates and relationship between relative yield and duration of purple nutsedge interference was significant.

Table 3. Parameter estimates derived for the Gompertz model for Onion (*Allium cepa* L.) at three levels of nitrogen

Parameter estimates				
N rate (kg/ha)	a	b	K	RMSE
100	107(7.8967)	0.7791 (0.0784)	0.0406 (0.0115)	43.7271
150	105.5(5.6579)	0.9475(0.0903)	0.0532(0.0118)	53.5146
200	104.2 (4.3033)	0.7575(0.0721)	0.0579(0.0127)	43.5734

Abbreviation:- RMSE, root mean square error.

The Gompertz model was fitted to relative yields of onion (expressed as a percentage of the weed-free control) as a function of increasing length of weed-free period (in days). (Equation 2) All the parameter

estimates for Gompertz model was significant ( $P < 0.05$ ) at the three Nitrogen rates (Table 3). This explained that parameter of Gompertz model was not equal to zero in three nitrogen application

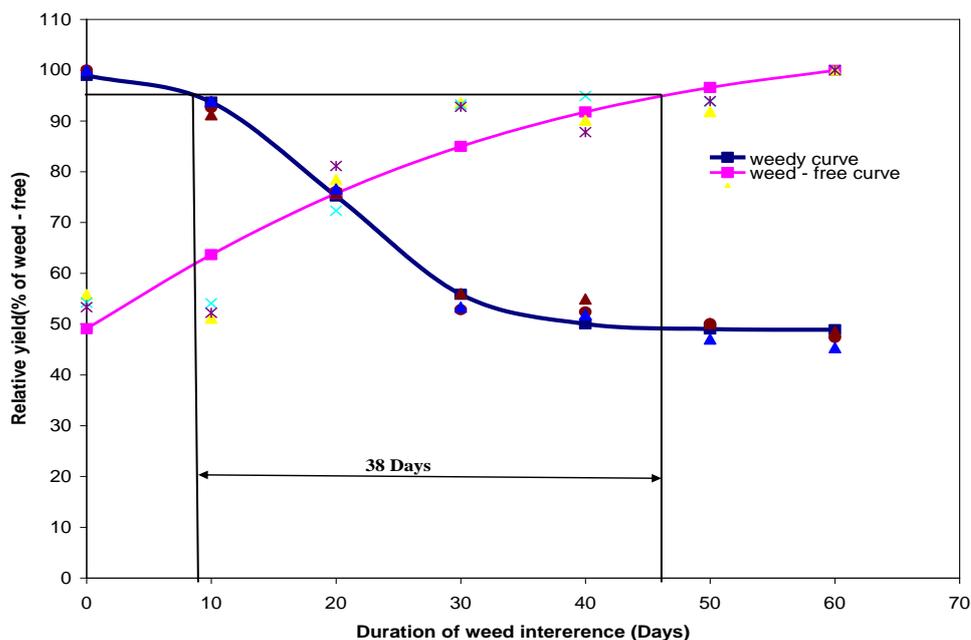
rates and relationship was significant between relative yield of onion and weed free period.

### Initiation of critical period of purple nutsedge control on onions

The initiation of critical period of purple nutsedge control on onion yield varied with nitrogen application rates (Figures 2, 3 and 4). These findings coincide with Weaver *et al.* (1992) who reported that, the availability of nutrients such as Nitrogen can influence the timeliness and extent of early season competition with weeds. With 100 kgN/ha, the inception of the critical period of purple nutsedge control was 9 days after planting. When Nitrogen application rate was changed from 100 kg/ha to 150 kg/ha, the critical period of purple nutsedge was initiated at 8 days. At

the same time, with 200 kg N/ha, the beginning of critical period of purple nutsedge was extended by 1 day.

The critical timing of weed removal begins between two and four-leaf stages of onion when grown with small-seeded annual weeds such as common lambsquarters (*Chenopodium album* L.) and redroot pigweed (*Amaranthus retroflexus* L.) (Hewson and Roberts, 1971; Dunan *et al.*, 1996). There was no yield loss due to small-seeded, annual weed species such as prostrate knotweed (*Polygonum aviculare* L.) and redroot pigweed interference until the two-leaf stage of onion. (Hewson and Roberts, 1971) or longer (Menges and Tamez, 1981), which agrees with the present study.



**Figure 2. The critical period of purple nutsedge control for Onion (*Allium cepa* L.) at 100kg N/ha**

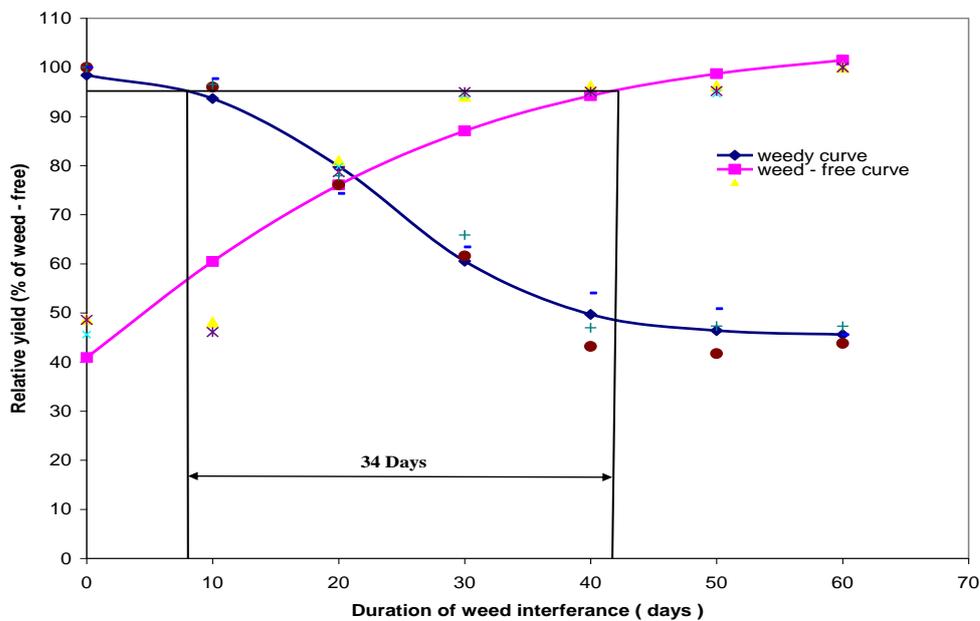
Increasing nitrogen application rate from 150 kg/ha to 200 kg/ha extended the beginning of the critical period of purple nutsedge, which clearly indicated a reduction of purple nutsedge tolerance to onion. High rates of nitrogen is toxic to the purple nutsedge which may increase the

tolerance level of onion when it competes with onion at these excessive nitrogen application rates. Evans *et al.* (2003) showed that reduced rates of Nitrogen resulted in an earlier initiation of the critical period for weed control (CPWC) in corn. Casper and Jackson (1997) reported

that above ground plant growth is often mediated by below-ground nutrient acquisition, and vice versa. Evans (2001) also reported that Nitrogen increased early-season corn growth rates, aiding in more timely corn leaf area expansion and improving the resiliency of corn leaf nitrogen content to weed interference. These findings do not agree with the results of the present study. Competition for light has been identified as the primary cause of crop yield loss in many crop-weed associations (Lindquist and Mortensen 1999). Wicks *et al.*, (1973) reported that onions are susceptible to

weed interference because the crop is slow to emerge, has a low initial growth rate, and its narrow, erect leaves produce little shade. Therefore, the differences in the beginning of the critical period of purple nutsedge for onion cannot be explained by the influence of light. It can be attributed primarily to differences in purple nutsedge response to different nitrogen application rates. Addition of nitrogen induces the competitive ability of purple nutsedge up to 150 kg N/ha, but when nitrogen is increased to 200 kg/ha, which is toxic to purple nutsedge develops a reversed trend.

### End of critical period of purple nutsedge



**Figure 3. The critical period of purple nutsedge control for Onion (*Allium cepa* L.) at 150 kg/ha of nitrogen**

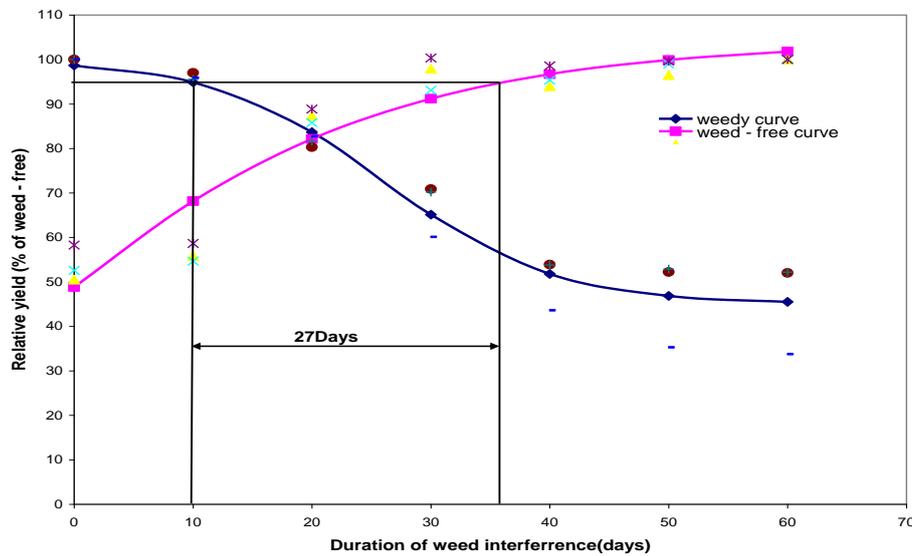
The end of the critical period for purple nutsedge control for onion varied with different nitrogen application rates (Figures 2, 3 and 4). At 100kg N/ha, the end of the critical period for purple nutsedge control for onion was 47 days after planting. When N rates increased from 100 kg/ha to 150 kg/ha it was reduced to 42 days after planting and further declined to 37 days after planting at 200 kg/ha Nitrogen This finding is similar to the study of Kalyanamurthy (2002),

which reported that onion requires a weed free period of 45 days. At the same time, the present study clearly indicated that increasing nitrogen application rate reduces the end of the critical period for purple nutsedge. These finding also coincide with Evans *et al.* (2003) who reported that increased rates of nitrogen resulted in an earlier termination of the critical period for weed control (CPWC) in corn.

### Critical period for controlling purple nutsedge

Logistic (weedy) and Gompertz (weed free) curves used to identify the critical timing of purple nutsedge removal and critical weed-free period overlapped in a

manner that resulted in a critical period of purple nutsedge control, where the critical timing of purple nutsedge removal preceded the end of the critical weed-free period



**Figure 4. The critical period of purple nutsedge control (CPWC) for Onion (*Allium cepa* L.) at 200 kg/ha of nitrogen**

The critical period of purple nutsedge control for onion varied with different nitrogen application rates (Figures 2, 3 and 4). These findings supported by previous studies demonstrated that cultural crop production practices (e.g., fertilization regime, row spacing, and planting date) can influence weed-crop interactions and duration of the CPWC (Evans *et al.*, 2003; Klingaman and Oliver, 1994; Knezevic *et al.*, 2003; Williams, 2006). At 100kg N/ha, Critical purple nutsedge control period was 38 days, it was reduced to 34 days when the rate was increased from 100kg/ha to 150kg/ha. The critical period of purple nutsedge control was further reduced by 8 days when nitrogen was increased from 150 kg/ha to 200 kg/ha. The present study clearly indicates that reduced nitrogen application rate increases the critical weed period. Similar results were observed by Knezevic *et al.* (2000), who explained that insufficient nitrogen

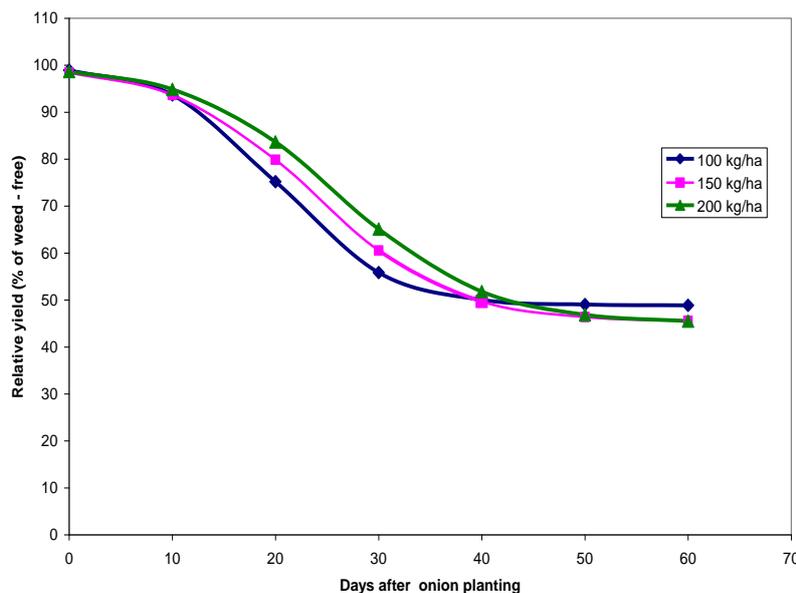
can reduce corn (*Zea mays* L.) tolerance to weeds and can lengthen the critical period of weed control. Hall *et al.* (1992) and Teasdale, (1998) reported that the outcomes of weed interference most often associated with crop yield reductions include (1) reduced amount and duration of green leaf area and (2) reduced crop height or increased height differential between the crop and weeds. Evans *et al.* (2003) reported that an increase in nitrogen application decreased the length of the critical weed-free period because of rapid canopy closure resulting from higher crop Leaf Area Index (LAI). Increased LAI of the crop reduces both the quality and quantity of light reaching weeds in the lower layers of the canopy, hindering the establishment and growth of subsequent weeds (Teasdale, 1995). This is supported by the fact that increasing nitrogen rate reduced the critical period. Onion has a short stature, non branching habit and

sparse foliage. Therefore, onion could not reduce the quality and quantity of light reaching purple nutsedge when compared to crops such as maize. This present study identifies the causal factor for differences in critical period of purple nutsedge control for onion, to be the variation of purple nutsedge response with different nitrogen application rates.

### Logistic models for different Nitrogen application levels.

Logistic models varied with different nitrogen application rates (Figure 5.), which revealed that increased duration of purple nutsedge decreased onion yields. This result is consistent with that of Hewson and Roberts (1971) who reported that the duration of annual weed interference decreased onion yield

primarily by lowering bulb diameters. There are no differences in yield losses of onions between nitrogen application rates due to Purple nutsedge infestation up to 10 days after Onion planting. Increasing nitrogen rates and purple nutsedge infestation periods from 10 to 40 days after planting shifted logistic curves upwards, which explained that the yield reduction was lower when nitrogen is increased. As bulb development may be take place during this period, onion requires more nitrogen. At low levels of nitrogen, purple nutsedge could absorb more nitrogen than the Onion crop which results in low availability of nitrogen to onion. This could be the reason for obtaining low Onion bulb yield, when nitrogen is applied at low rates.



**Figure 5. Relative yield (RY) of onions as affected by duration of Purple nutsedge infestation period at three different nitrogen rates**

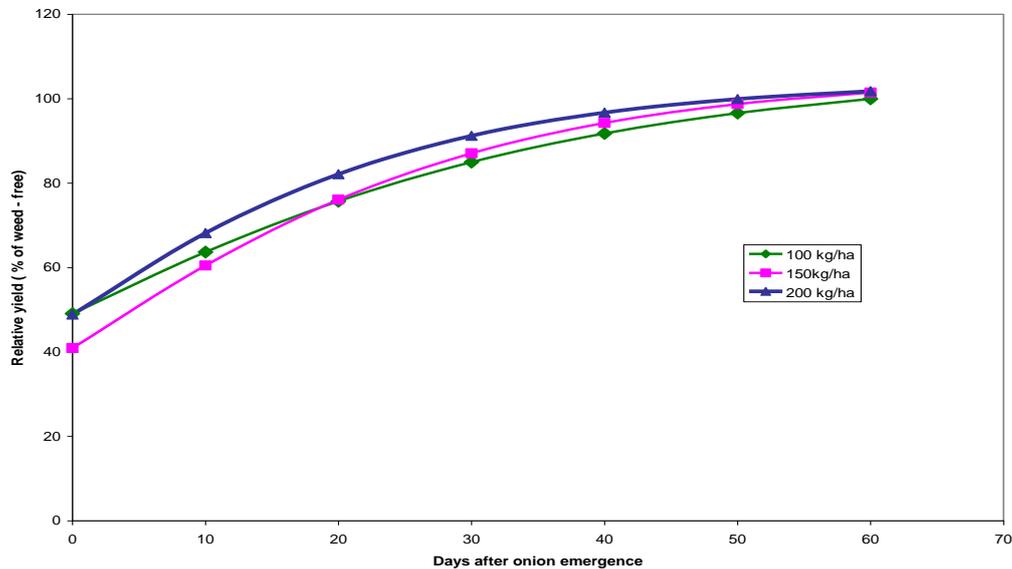
These results are similar to those of Davis and Liebman (2001), who reported that in low fertility soils weeds use nitrogen more efficiently when compared to crops. When the purple nutsedge infestation period was increased beyond 40 days the lowest yield

loss was observed at lower nitrogen application rate. Dhima and Eleftherohorinos (2001) reported that nitrogen fertilizer increases the competitive ability of weeds more than that of a crop, and crop yield could remain

unchanged or could decline. Nitrogen application with increased infestation duration may increase the competitive

ability of purple nutsedge, when weed infestation continues for over 40 days after planting.

### Gompertz models for different nitrogen applications



**Figure 6. Relative yield (RY) of onion as affected by duration of weed free period at three different nitrogen application rates**

The Gompertz model varied with nitrogen application rates which revealed that, with a weed free period up to 20 days after onion planting, yield loss was high at 150kg N/ha, than at other rates (Figure 6). With a weed free period of more than 20 days after onion planting, a low onion yield loss was also observed at high nitrogen application rates. Nitrogen affects processes such as the dynamics of biomass partitioning, the architecture and morphology of the root system (Durieux *et al.*, 1994). It is logical to hypothesize that change in root system architecture and morphology can influence plant growth by improving the ability of a crop to acquire water and essential nutrients during periods of intense crop-weed interference or periods when yield is highly vulnerable. Enhanced resource acquisition could increase the size and longevity of green leaves. This increases the size and longevity of the leaf area available for light interception (Wolfe *et al.*, 1988). With an extended purple nutsedge free period and an increase in nitrogen

application, onion can produce well developed root systems, which improves the ability to acquire water and essential nutrients than purple nutsedge which emerge at later stages of onion growth. This could be the reason for the observation of low yield loss in high nitrogen level, when weed free period was increased beyond 20 days after onion planting.

### Effect of nitrogen application rates and duration of purple nutsedge infestation on growth and yield of onion

#### Plant height of onion

The height of onion plants was significantly affected by nitrogen and duration of purple nutsedge infestation periods (Table 4). With 150kg N/ha and 200kg N/ha, purple nutsedge infestation period up to 30 days did not affect plant height. Thereafter, Onion plant height was significantly reduced when purple nutsedge infestation period increased.

Further, with 100kg N/ha, Onion plant height was not significantly ( $P>0.05$ ) different between purple nutsedge infestation treatments up to 10 days after onion planting. When the purple nutsedge infestation exceeded 10 days after planting onion plant height was significantly ( $P<0.05$ ) reduced. These results clearly show that at lower nitrogen application rates, presence of the weed for short duration affects plant height to a greater extent. These results may be due to a greater uptake of nitrogen by purple nutsedge at low levels of nitrogen leading to low availability of Nitrogen to onions.

### Bulb diameter of onion

Nitrogen and duration of purple nutsedge infestation period significantly affected

bulb diameter (Table 4). At 100kg N/ ha and 200kg N/ha, purple nutsedge infestation up to 30 days after planting did not affect onion bulb diameters significantly. Moreover, when purple nutsedge infestation period exceeded 30 days after onion planting, bulb diameter was significantly reduced at these N rates. In contrast, at 150kg N /ha, onion bulb diameters were not significantly different between purple nutsedge infestation treatments up to 20 days after planting. This finding suggests that, purple nutsedge competition with onion begins early at 150kg N/ha. This may be due to the fact that purple nutsedge growth is higher at 150kg N/ ha than at other nitrogen application rates.

Table 4. Effect of nitrogen application rates and duration of Purple nutsedge infestation period on plant height, dry weight and bulb diameter of onion

N level	Purple nutsedge infestation period	Height(cm)	Bulb Diameter(cm)	Dry Weight ( $\text{g/m}^2$ )
100	0	31.67 <sup>a</sup>	2.26 <sup>a</sup>	1868.57 <sup>a</sup>
	10	30.00 <sup>a</sup>	2.23 <sup>a</sup>	1900.02 <sup>a</sup>
	20	27.33 <sup>b</sup>	2.03 <sup>ab</sup>	1658.26 <sup>b</sup>
	30	26.67 <sup>b</sup>	1.90 <sup>ab</sup>	1149.53 <sup>c</sup>
	40	25.00 <sup>b</sup>	1.63 <sup>bc</sup>	1019.91 <sup>dc</sup>
	50	19.00 <sup>c</sup>	1.26 <sup>c</sup>	1008.51 <sup>dc</sup>
	60	16.00 <sup>d</sup>	1.26 <sup>c</sup>	928.62 <sup>d</sup>
150	0	32.67 <sup>a</sup>	2.60 <sup>a</sup>	3270.30 <sup>a</sup>
	10	32.67 <sup>a</sup>	2.56 <sup>ab</sup>	3403.30 <sup>a</sup>
	20	32.33 <sup>a</sup>	2.40 <sup>ab</sup>	2566.56 <sup>b</sup>
	30	32.33 <sup>a</sup>	2.26 <sup>b</sup>	2120.18 <sup>c</sup>
	40	28.67 <sup>b</sup>	1.80 <sup>c</sup>	1541.19 <sup>d</sup>
	50	22.60 <sup>c</sup>	1.80 <sup>c</sup>	1517.42 <sup>d</sup>
	60	21.00 <sup>c</sup>	1.63 <sup>c</sup>	1491.53 <sup>d</sup>
200	0	37.00 <sup>a</sup>	2.93 <sup>a</sup>	2742.80 <sup>a</sup>
	10	36.33 <sup>a</sup>	2.90 <sup>a</sup>	2552.00 <sup>ab</sup>
	20	36.30 <sup>a</sup>	2.80 <sup>ab</sup>	2216.10 <sup>bc</sup>
	30	34.66 <sup>a</sup>	2.73 <sup>ab</sup>	1774.00 <sup>dc</sup>
	40	28.33 <sup>b</sup>	2.60 <sup>b</sup>	1381.60 <sup>de</sup>
	50	24.00 <sup>c</sup>	2.33 <sup>c</sup>	1258.80 <sup>e</sup>
	60	23.00 <sup>c</sup>	1.96 <sup>d</sup>	1186.10 <sup>e</sup>
Probability	N	<0.05	<0.05	<0.05
	I	<0.05	<0.05	<0.05
	N X I	<0.05	<0.05	<0.05

Means within N application rate followed by the same letters are not significantly different at 5% probability

### Total plant dry weight of onions

The impact of duration of purple nutsedge infestation on total dry weight of onion was significantly influenced by Nitrogen (Table 4). At 100kg N/ha and 150kg N/ha, a significant reduction in total dry weight was observed when purple nutsedge

infestation period increased from 10 to 20 days after onion planting. In contrast, no significant difference was observed in total dry weight between these periods at 200kg N/ha. At 200 kgN/ha is toxic to purple nutsedge which might reduce the competition between purple nutsedge and onion.

### Effect of nitrogen application rates and duration of Weed free periods on onions

#### Plant height of onions

Table 5. Effect of nitrogen application rates and duration of weed free period on plant height, dry weight and bulb diameter of onions.

N level	Weed free period	Height(cm)	Bulb Diameter (cm)	Dry Weight (g/m <sup>2</sup> )
100	0	17.00 <sup>c</sup>	1.13 <sup>c</sup>	549.91 <sup>c</sup>
	10	19.66 <sup>c</sup>	1.33 <sup>c</sup>	569.60 <sup>c</sup>
	20	26.00 <sup>b</sup>	1.03 <sup>b</sup>	838.45 <sup>b</sup>
	30	28.66 <sup>ab</sup>	2.23 <sup>a</sup>	1020.22 <sup>a</sup>
	40	31.30 <sup>a</sup>	2.40 <sup>a</sup>	973.78 <sup>ab</sup>
	50	31.30 <sup>a</sup>	2.40 <sup>a</sup>	1063.18 <sup>a</sup>
	60	31.00 <sup>a</sup>	2.46 <sup>a</sup>	1051.82 <sup>a</sup>
150	0	19.66 <sup>c</sup>	1.70 <sup>c</sup>	1265.6 <sup>c</sup>
	10	21.00 <sup>c</sup>	1.73 <sup>c</sup>	1332.6 <sup>c</sup>
	20	26.00 <sup>b</sup>	1.86 <sup>c</sup>	2225.4 <sup>b</sup>
	30	28.33 <sup>b</sup>	2.13 <sup>b</sup>	2819.4 <sup>a</sup>
	40	33.33 <sup>a</sup>	2.40 <sup>a</sup>	2868.9 <sup>a</sup>
	50	33.66 <sup>a</sup>	2.43 <sup>a</sup>	2874.8 <sup>a</sup>
	60	35.00 <sup>a</sup>	2.53 <sup>a</sup>	2937.9 <sup>a</sup>
200	0	22.00 <sup>c</sup>	1.93 <sup>c</sup>	1381.5 <sup>b</sup>
	10	25.66 <sup>b</sup>	2.20 <sup>c</sup>	1556.2 <sup>b</sup>
	20	27.66 <sup>b</sup>	2.60 <sup>b</sup>	2199.6 <sup>a</sup>
	30	37.00 <sup>a</sup>	2.93 <sup>a</sup>	2326.7 <sup>a</sup>
	40	37.66 <sup>a</sup>	2.96 <sup>a</sup>	2416.5 <sup>a</sup>
	50	38.00 <sup>a</sup>	3.10 <sup>a</sup>	2450.0 <sup>a</sup>
	60	39.33 <sup>a</sup>	3.10 <sup>a</sup>	2560.3 <sup>a</sup>
Probability	N	<0.05	<0.05	<0.05
	I	<0.05	<0.05	<0.05
	N X I	<0.05	<0.05	<0.05

Means within a nitrogen application rate followed by the same letters are not significantly different at 5% probability

A significant interaction was observed between nitrogen application rates and duration of weed free period on plant

height of onions (Table 5). With 100kg N/ha and 200kg N/ha, weed free periods of more than 30 days had no impact on plant

height of onions. With 150kgN /ha, a weed free period exceeding 40 days after planting also had no impact on plant heights of onions. These results clearly show that with 100kg N/ha and 200kgN ha onion attained an early tolerance to purple nutsedge than at 150kgN/ha. This may be due to better onion growth at 150kgN /ha, than other nitrogen application rates.

### **Bulb diameter of onion**

There was a significant two way interaction between duration of weed free period and nitrogen rates on bulb diameter (Table 5). At 100kg N/ha and 200kg N/ha, onion bulb diameters were not significantly different between weed free periods exceeding 30 days after planting. In contrast, with 150kg N/ha, onion bulb diameter was not significantly different when the weed free period increased beyond 40 days. These results clearly indicate that onion requires a longer weed free period with 150kg N/ ha than at other levels of nitrogen. With 150kg N/ha, purple nutsedge growth is greater when compared with other nitrogen application rate which could increase competition between purple nutsedge and onion, thus causing this effect.

### **Total plant dry weight of onion**

Total plant dry weight was significantly affected by nitrogen and duration of weed free period (Table 5). With 200kg N/ha, no significant differences were observed between Total plant dry weights when weed free periods exceeded 20 days after planting. With 150kg N/ha, total plant dry weight was not significantly different between the treatments when weed free period exceeded 30 days after planting. This result clearly suggests that Onion attained early tolerance to purple nutsedge at 200kg N/ha than with 150kgN/ha. This is because when nitrogen application rate at 200kg/ha toxic to purple nutsedge, and thus it lost its competitive ability.

## **CONCLUSIONS**

This study confirms that the supply of plant available nitrogen to onion and purple nutsedge can significantly influence onion–purple nutsedge competition. This study shows that a 50% reduction in nitrogen applied (200 to 100 kgNha<sup>-1</sup>) extended the critical period of purple nutsedge control by 11 days. Therefore, reductions in the use of nitrogen fertilizer for onion may create the need for more immediate purple nutsedge control that must be sustained for longer times. Differences in the critical period of purple nutsedge control due to nitrogen application highlight the importance of integrating decisions regarding nitrogen management and the timing of purple nutsedge control. Practical implications of this study are that reductions in nitrogen use may justify more intensive purple nutsedge management.

## **SUGGESTIONS**

Further studies are required to verify such speculations and quantify the effects of N and purple nutsedge interference at a physiological level. Information from such investigations would likely lead to an improved understanding of complex mechanisms of onion-purple nutsedge interaction.

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