# Research reports

## Competition between red sprangletop (*Leptochloa chinensis*) and rice (*Oryza sativa*) under different nitrogen levels

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### Abstract

**A study on competition between red sprangletop (*Leptochloa chinensis* (L.) Noes) and rice (*Oryza sativa* L.) under different nitrogen levels was conducted under greenhouse conditions from August 1994 to March 1995. Results showed that the rice plant height and tiller number were reduced by red sprangletop. The effects were more pronounced after treatment with nitrogen fertilizer 30 days after seeding (DAS). Chlorophyll contents of rice leaves were relatively high (+39 SPAD) when treated with nitrogen fertilizer. Rice panicle numbers were significantly reduced by competition with red sprangletop but increased with increasing nitrogen levels. Higher percentages of filled grain were obtained where competition by red sprangletop occurred or under high nitrogen rates. A significant reduction in rice grain yield due to the red sprangletop competition was obtained, being consistent, irrespective of nitrogen level (39–48%). No correlation was found between percentage yield loss and increase in nitrogen levels. The reduction in the concentration of nitrogen due to red sprangletop competition ranged from 0.03 to 0.13 g per plant (4.0–21 kg N ha$^{-1}$).**

### Introduction

In the rice agro-ecosystem, nitrogen applied directly to the crop tends to stimulate the growth of weeds and enhance weed competition. Weeds commonly take up added nutrients more rapidly and in larger quantifies than crops (Chisaka 1977, Moody 1990).

Nitrogen fertilizer accounts for about 67% of the total amount of fertilizers applied to the rice crop in tropical areas (De Datta and Nantasomsaran 1991). Modern rice varieties such as MR84, which are widely planted in Malaysian wet ricefields, require more nitrogen than the traditional varieties. This enhances the growth of rice crops, but also encourages high weed populations.

To achieve high rice yields, both N fertilization and weed management are essential (De Datta 1981). Usually nitrogen is the first element to become limiting as a result of crop weed competition. In some situations, nitrogen fertilization has been found to compensate for yield losses from poor weed control but at the same time growth of weeds has increased, particularly in heavily weed infested fields (De Datta *et al.* 1986, Sharma *et al.* 1986).

Among grassy weeds, red sprangletop (*Leptochloa chinensis* (L.) Nees) occurs in high populations in the Muda ricefield area. Ho (1995) reported that during the off season of 1987, *Echinochloa* sp. and *L. chinensis* infestation in combination caused severe yield losses ranging from 30 to 100%. Therefore, since the Muda area is the largest rice granary area in Malaysia, crop yields losses due to this noxious weed are substantial.

This study was initiated to investigate the severity of the competition between *L. chinensis* and rice under greenhouse conditions and with different levels of nitrogen. The information obtained should enable farmers to understand the management requirements of rice in areas of high weed infestation, particularly red sprangletop.

### Materials and methods

An experiment was conducted in the greenhouse at the School of Biological Sciences of the Universiti Sains Malaysia, Penang, from August 1994 to March 1995. A split plot design with four replicates (one was harvested at 60 DAS and the other three continued until harvest 125 DAS) was used. The main plot treatments comprised presence or absence of red sprangletop in the rice. Sub plot treatments were the rates of nitrogen, i.e. 0, 45, 90, 135, 180 and 225 kg N ha$^{-1}$. Nitrogen applications were split with one third applied at 10 and 35 DAS and at the primordia stage (55 DAS). Nitrogen was applied as a urea prill.

Each pot was filled with 6 kg soil (20% clay, 60% sand and 20% silt) collected from Alor Serdang, Kedah. The requirement of urea for each pot was based on the weight of 1 ha soil using the formula:

$$y = \frac{x}{w} \times \frac{100}{m} \times n$$

where:

$y$ = amount of urea needed (g pot$^{-1}$)
$x$ = dry weight of soil (kg pot$^{-1}$)
$w$ = dry weight of soils ha$^{-1}$ (= 2 million kg ha$^{-1}$)
$m$ = nitrogen content of urea (% N)
$n$ = application rate of urea (g ha$^{-1}$)

For one third of each nitrogen rate, the amounts of urea needed for 6 kg soil were 0, 0.1, 0.2, 0.3, 0.4 and 0.5 g urea per pot. Additionally, 45 kg $P_2O_5$ ha$^{-1}$ and 30 kg $K_2O$ ha$^{-1}$, that is 0.3 g triple superphosphate and 0.15 g KCl respectively, were applied to each pot. Plants were watered every morning to maintain flooding depth in the pots.

Three pre-germinated seeds of the rice variety MR84 (125 days) and four pre-germinated seeds of red sprangletop collected from MADA (Muda Agricultural Development Authority) were sown together in each pot.

Plant heights, tiller numbers, chlorophyll contents of rice and red sprangletop were recorded at 30 and 60 DAS. A chlorophyll meter (SPAD-502, Soil-Plant Analysis Development (SPAD) Section, Minolta Camera Co., Osaka, Japan) was used to assess the level of chlorophyll content as the SPAD values of intact leaves. The chlorophyll meter provides a simple, quick and non-destructive method for estimating leaf chlorophyll content (Peng *et al.* 1993). At 60 DAS the dry weights and nitrogen contents of the rice and red sprangletop were also measured. The nitrogen contents of plant samples were analysed using a semi-micro Kjeldahl digestion method (Shirlaw 1967, Hesse 1971).

Data processing was based on the program IRRISTAT and significant differences were tested at the 5% level using Duncan Multiple Range Test (DMRT) (Gomez and Gomez 1984, Gomez *et al.* 1992).

### Results

*Vegetative growth of rice plants*

At 30 DAS, plant height was unaffected by the competition from red sprangletop or by nitrogen level. By 60 DAS rice plants alone were taller (Table 1) at all nitrogen levels than the no nitrogen treatment and on average were significantly taller ($P<0.05$). Where there was competition from red sprangletop differences were not as marked, although plants that received N at 225 kg ha$^{-1}$ were significantly taller than those that received 0 or 45 kg N ha$^{-1}$.

**Table 1. Height (cm) of rice as affected by nitrogen fertilization and competition of *L. chinensis* at 60 DAS[A].**

| Nitrogen rate (kg N ha$^{-1}$)[B] | Competition of *L. chinensis* | | Average |
|---|---|---|---|
| | without | with | |
| 0 | 79.3 c | 76.8 c | 78.1 |
| 45 | 84.0 b | 77.5 bc | 80.8 |
| 90 | 84.5 b | 81.8 ab | 83.2 |
| 135 | 86.8 ab | 82.8 a | 84.8 |
| 180 | 86.0 ab | 82.0 ab | 84.0 |
| 225 | 90.3 a | 84.3 a | 87.3 |
| Average | 85.2 a | 80.8 b | – |

[A] Average of 4 replications; DAS = days after seeding; In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
[B] One third N applied at 10, 35 and at 55 DAS, respectively.

**Table 2. Tiller number of rice as affected by nitrogen fertilization and competition of *L. chinensis* at 60 DAS[A].**

| Nitrogen rate (kg N ha$^{-1}$)[B] | Competition of *L. chinensis* | | Average |
|---|---|---|---|
| | without | with | |
| 0 | 30 d | 17 d | 24 |
| 45 | 35 c | 20 cd | 28 |
| 90 | 38 c | 23 bc | 31 |
| 135 | 45 b | 28 ab | 37 |
| 180 | 50 a | 31 a | 41 |
| 225 | 54 a | 33 a | 44 |
| Average | 42 a | 25 b | – |

[A] Average of 4 replications; DAS = days after seeding; In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
[B] One third N applied at 10, 35 and at 55 DAS, respectively.

**Table 3. Chlorophyll content (SPAD) of rice leaves as affected by nitrogen fertilization and competition of *L. chinensis* at 30 DAS[A].**

| Nitrogen rate (kg N ha$^{-1}$)[B] | Competition of *L. chinensis* | | Average |
|---|---|---|---|
| | without | with | |
| 0 | 38.0 b | 36.4 b | 37.2 |
| 45 | 39.3 a | 37.1 ab | 38.2 |
| 90 | 39.1 ab | 37.6 ab | 38.4 |
| 135 | 39.7 a | 37.6 ab | 38.7 |
| 180 | 39.6 a | 37.8 a | 38.7 |
| 225 | 39.5 a | 37.8 a | 38.7 |
| Average | 39.2 a | 37.4 b | – |

[A] Average of 4 replications; DAS = days after seeding; In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
[B] One third N applied at 10, 35 and at 55 DAS, respectively.

**Table 4. Number of rice panilces per plant as affected by nitrogen fertilization and competition of *L. chinensis* at harvest.**

| Nitrogen rate (kg N ha$^{-1}$)[B] | Competition of *L. chinensis* | | Average |
|---|---|---|---|
| | without | with | |
| 0 | 22 d | 16 c | 19 |
| 45 | 30 c | 20 bc | 25 |
| 90 | 34 bc | 19 bc | 27 |
| 135 | 39 b | 23 ab | 31 |
| 180 | 46 a | 23 ab | 35 |
| 225 | 46 a | 27 a | 37 |
| Average | 36 a | 21 b | – |

[A] Average of 3 replications; DAS = days after seeding; In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
[B] One third N applied at 10, 35 and at 55 DAS, respectively.

At 30 DAS, tiller numbers were also not significantly affected by nitrogen fertilization although the average number of tiller decreased from 34 tillers per plant under weed free to 23 tillers per plant under weed competition. With or without nitrogen, red sprangletop caused significant interference against rice.

Numbers of rice tillers increased significantly as nitrogen rate increased at 60 DAS. Without competition, the optimum rate of nitrogen was obtained at 180 kg N ha$^{-1}$, and under competition was 135 kg N ha$^{-1}$. In the absence of competition, the average tiller number (42 tillers per plant) was significantly greater ($P<0.05$) than under competition (25 tillers per plant) from red sprangletop (Table 2). Where no nitrogen was applied, but competition occurred, rice had only 17 tillers per plant. Conversely, under no nitrogen and no competition regimes, rice produced 30 tillers per plant indicating significant suppression (43%) of tiller formation. At all nitrogen rates, under weed free conditions, tiller numbers increased 17–80% relative to those that received no nitrogen. Where weeds were present tiller production was significantly increased from 18 to 94% over the range of nitrogen rates compared to that without nitrogen.

Measurements at 30 DAS showed that the chlorophyll content of rice leaves was significantly lower ($P<0.05$) on plants without high levels of added nitrogen. However, there were no differences in chlorophyll contents of the leaves over the rates of nitrogen tested (Table 3). Subsequently, at 60 DAS plants without added nitrogen and under weed competition produced the lowest chlorophyll contents (30.1 SPAD) (Figure 1). Under competition the chlorophyll content increased from 34.6 to 39.3 SPAD as the nitrogen rate increased. Similarly under weed free conditions chlorophyll content increased from 35.6 to 39.7. Thus, nitrogen application significantly increased the amount of rice chlorophyll content.

The rice plants under weed free conditions contained about 0.02 to 0.4 g N per plant (3.0–64.0 kg N ha$^{-1}$). Seemingly, the rate of 180 kg N ha$^{-1}$ produced the highest nitrogen content i.e. 64 kg N ha$^{-1}$, declining at the rate of 225 kg N ha$^{-1}$ (54 kg N ha$^{-1}$). Under competition from red sprangletop, rice plants contained about 0.02–0.13 g N per plant (3.0–21 kg N ha$^{-1}$) and red sprangletop contained about 0.03–0.13 g N per plant (4.0–21 kg N ha$^{-1}$) (Figure 2). Total amounts of nitrogen present in rice and red sprangletop were similar to that of the rice plants alone at the three higher rates.

The dry weight of rice straw consistently and significantly increased from 45.0 to 99.3 g plant$^{-1}$ as the nitrogen level increased (Figure 3). The same trend was obtained with rice straw under competition from red sprangletop and the dry weight of red sprangletop straw showed a similar response. However, under competition, there was a significant correlation between nitrogen rate and dry weight of red sprangletop ($r^2 = 0.92$) or nitrogen rate with dry weight of rice ($r^2 = 0.96$).

*Yield components and grain yield*

Table 4 showed that the average number of panicles per plant were reduced from 36 to 21 with reductions ranging from 17 to 50% at the different nitrogen levels by the red sprangletop. Under competition, a highly significant relationship was found between rate of nitrogen and panicle number per plant ($r^2 = 0.90$) and panicle number with the grain yields ($r^2 = 0.90$). This yield component affected grain yield significantly ($P<0.05$) as a result of the interference of red sprangletop. In addition, number of grain per panicle was only affected by the competition but not by the rate of nitrogen.

Higher percentages of filled grains were obtained as nitrogen rate increased with or without competition from red

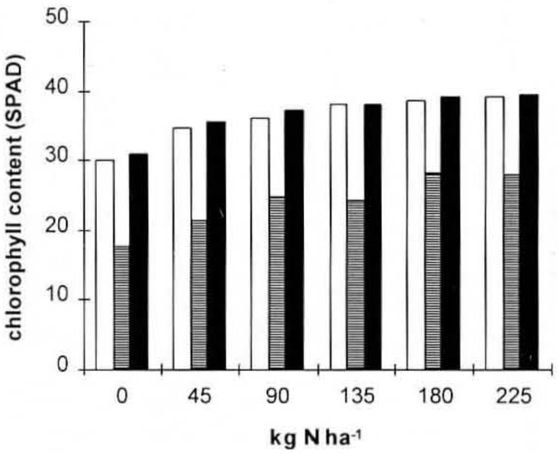


**Figure 1. Chlorophyll content of the leaves of rice and red sprangletop under different rates of nitrogen fertilization at 60 DAS. □ rice comp., ▤ red sprangletop comp., ■ rice weed free.**

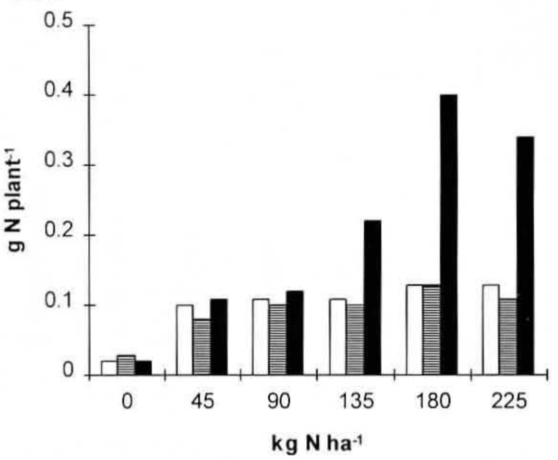


**Figure 2. Nitrogen content of rice plant and red sprangletop under different rates of nitrogen fertilization at 60 DAS. □ rice comp., ▤ red sprangletop comp., ■ rice weed free.**

sprangletop (Table 5). Surprisingly, competition did not affect on the percentage of filled grain.

Table 6 showed when there was no competition, nitrogen rates did not affect the weight of 1000 grains. However, in the presence of competition, a slight effect of nitrogen rates was found on the weight of 1000 filled grains.

The interference of red sprangletop on rice production caused a significant yield reduction, ranging from 39 to 48% (Figure 4), but there was no significant correlation between nitrogen rates and the percentage of yield reductions ($r^2$ = 0.09).

Under weed free conditions the grain yield of rice was affected by nitrogen level (Table 7). Without nitrogen, the yield was only 31.6 g per plant and the yields increased up to 209% when applied with 225 kg N ha$^{-1}$.

Under weed competition and no nitrogen treatment, the yield obtained was only 17.4 g per plant, i.e. 45% lower than that of rice without nitrogen and without red sprangletop (Table 7). Increasing nitrogen rates produced a similar trend to weed free conditions of increasing rice yields. Rice plants which were fertilized had up to 216% higher grain yield than rice without nitrogen. But, in terms of yield reductions, the degree of competition from red sprangletop was not affected by nitrogen rate. The yield obtained from the same nitrogen level under with and without presence of red sprangletop caused yield reduction ranged from 39 to 48%. These values did not differ compared to the yield reduction without nitrogen. Significant correlations ($P<0.05$) were found between rice grain yield and the dry weight of rice straw ($r^2$ = 0.98) and between rice grain yield and the dry weight of red sprangletop straw ($r^2$ = 0.95).

## Discussion

Until 30 DAS, nitrogen fertilization and competition of red sprangletop did not show any significant effects on plant heights and tiller production. In the early stage, roots could not fully utilize the nitrogen applied into the soil. However, De Datta (1985) reported that volatilization is one of the main reasons for the nitrogen losses in the soil, particularly when the plant canopy was not able to cover the surface area. He stated that ammonia volatilization from urea top-dressed into flood water after transplanting was 47% of N applied within 10 days after fertilizer application. When urea was top-dressed prior to panicle initiation or soil incorporated before transplanting, ammonia volatilization loss was 10–11% and 15–20% of the applied fertilizer, respectively. Depending on the method of application, volatilization loss ranged from 0.25 to 25%. Nitrogen losses due to denitrification were 25% and surface run-off contributed about 10%.

At 30 DAS red sprangletop had little effect on rice plant height, but decreased tiller number significantly. It was observed that during the first three weeks, the height of red sprangletop was lower than rice plant. Consequently, there was no competition for light occurred. At 60 DAS, competition and nitrogen fertilization had significant effects on plant heights and rice tillers. The optimum rates of nitrogen was 135 kg N ha$^{-1}$ under weed free condition, and 90 kg N ha$^{-1}$ under competition. At both nitrogen rates, rice plants grew better than those in the lower nitrogen rates. Interference from the rice plants was greater against red sprangletop until the rice crops reached the optimum nitrogen rate. However, this nitrogen rate was quite high compared to the recommendation rate of nitrogen for transplanted rice. But Dingkuhn *et al.* (1991) and Washio (1992) suggested that the amount of fertilizer used for direct seeded rice should be increased by 20–30% when compared to

**Table 5. Percentage of filled grain of rice as affected by nitrogen fertilization and competition of *L. chinensis* at harvest.**

| Nitrogen rate (kg N ha$^{-1}$)[B] | Competition of *L. chinensis* | | Average |
|---|---|---|---|
| | without | with | |
| 0 | 82.1 b | 86.9 c | 84.5 |
| 45 | 87.4 ab | 90.2 bc | 88.8 |
| 90 | 89.2 a | 93.3 ab | 91.3 |
| 135 | 87.3 ab | 92.6 ab | 89.9 |
| 180 | 91.7 a | 97.7 a | 94.7 |
| 225 | 92.3 a | 94.3 ab | 93.3 |
| Average | 88.3 a | 92.5 a | – |

[A] Average of 3 replications; DAS = days after seeding; In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
[B] One third N applied at 10, 35 and at 55 DAS, respectively.

**Table 6. Weight (g) of 1000 grains of rice as affected by nitrogen fertilization and competition of *L. chinensis* at harvest.**

| Nitrogen rate (kg N ha$^{-1}$)[B] | Competition of *L. chinensis* | | Average |
|---|---|---|---|
| | without | with | |
| 0 | 21.5 a | 21.5 b | 21.5 |
| 45 | 21.6 a | 21.7 ab | 21.7 |
| 90 | 21.2 a | 22.5 a | 21.9 |
| 135 | 21.1 a | 22.1 ab | 21.6 |
| 180 | 21.7 a | 22.5 a | 22.1 |
| 225 | 21.6 a | 21.7 ab | 21.7 |
| Average | 21.5 a | 22.0 a | – |

[A] Average of 4 replications; DAS = days after seeding; In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
[B] One third N applied at 10, 35 and at 55 DAS, respectively.

**Table 7. Grain yield of rice (g per plant) as affected by nitrogen fertilization and competition of *L. chinensis* at harvest.**

| Nitrogen rate (kg N ha$^{-1}$)$^B$ | Competition of *L. chinensis* | | Average |
|---|---|---|---|
| | without | with | |
| 0 | 31.6 d | 17.4 d | 24.5 |
| 45 | 50.2 c | 28.4 c | 39.3 |
| 90 | 60.0 c | 36.3 bc | 48.2 |
| 135 | 72.0 b | 39.7 b | 55.9 |
| 180 | 88.6 a | 46.0 ab | 67.3 |
| 225 | 97.7 a | 55.0 a | 76.4 |
| Average | 66.7 a | 37.1 b | – |

$^A$ Average of 3 replications; DAS = days after seeding; In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

$^B$One third N applied at 10, 35 and at 55 DAS, respectively.

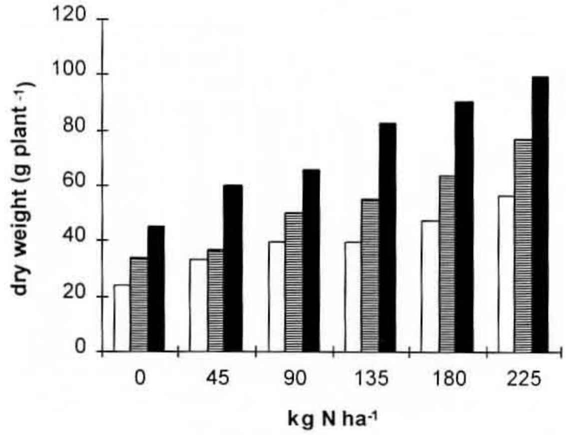


**Figure 3. Dry weight of rice straw and red sprangletop straw under different rates of nitrogen fertilization. □ rice comp., ▤ red sprangletop comp., ■ rice weed free.**

transplanted rice. This difference is associated with over production of vegetative materials such as leaves and tiller. Therefore, Ditomaso (1995) reminded that the timing of fertilizer applications could take advantage of maximal rates of nutrient uptake into crop roots at specific development stages only.

The same trend was also observed on the chlorophyll content of the rice leaves which occurred after 30 DAS. Chandler (1979) and De Datta (1981) pointed out that the greatest competition occurred when the crops and weeds had similarity in growth habits, such as root growth and foliage characteristics. These plants would make nearly the same demands upon the environment and usually weed competition was more severe during the early stage of plant growth.

Comparatively, the chlorophyll content of rice and red sprangletop had the same trend as the total nitrogen absorbed by both rice and red sprangletop when they grew together or when the rice was grown without competition (Figures 1 and 2). The total nitrogen uptake of rice and red sprangletop grown in competition was similar to the total nitrogen absorbed by the rice alone (without competition). This suggests that weeding is a key factor to obtain high grain yield when high nitrogen rates are applied. Nitrogen uptake by rice plants was about 0.02–0.4 g N per plant (3.0–64.0 kg N ha$^{-1}$). Under competition, rice and red sprangletop had similar nitrogen uptake, thus under high nitrogen fertilization, red sprangletop must be controlled. Matsushima (1980) found that the rice plants contained 0.70–1.57% of nitrogen at heading stage while Nyarko and De Datta (1991) stated that a ton of rice straw and grain removes an average of 16 kg N ha$^{-1}$, 3 kg P ha$^{-1}$ and 17 kg K ha$^{-1}$.

According to Patterson (1987), among the major plant nutrients, nitrogen was more critical than other elements where weed and crop needed the same growth requirement. Kwesi and De Datta (1989) added that the optimum N rate for rice was lower than that of weeds, therefore rice and weeds will compete for N if the optimum N rate for rice is applied and weeds are not effectively controlled. In the field, the optimum N rate will vary with the effectiveness of weed control. Moderate rates below the optimum for rice are beneficial to weeds and subsequently increase their competitive ability over rice. Weeds consume more N than rice when N is available.

During harvest, the dry weight of rice straw was significantly decreased by red sprangletop competition. The population of four plants of red sprangletop per rice hill caused significant yield reduction on rice. To obtain high dry weight of rice straw and high grain yield, 135–180 kg N ha$^{-1}$ should be applied with or without competition.

Among the yield components, number of panicles per plant and percentage of filled grains were closely related to grain yield. Under weed competition and low nitrogen rate, the numbers of rice tillers, and panicles were reduced and this reduced the filled grain. Higher nitrogen increased the percentage of filled grain and increased the formation of panicles.

Matsushima (1980) and De Datta (1981) found that fertilizers applied as a base dressing or top-dressed during early growth increase the number of panicles and the number of spikelets per panicle. For increasing the percentage of ripened grains and for encouraging the development of kernels, rice should not be deficient in nitrogenous fertilizer during the ripening period.

With the presence of the red sprangletop competition with or without nitrogen, the yield losses ranged from 39 to 48%. However, under competition from red sprangletop, increased nitrogen obviously caused an increase in yield obtained. About 45% yield reduction was found in plants without nitrogen, and 44% of yield reduction was obtained at the rate of 225 kg N ha$^{-1}$. These values indicated that increased nitrogen rates did not increase the degree of yield reduction, but with competition yield obtained was relatively low compared to those without competition.

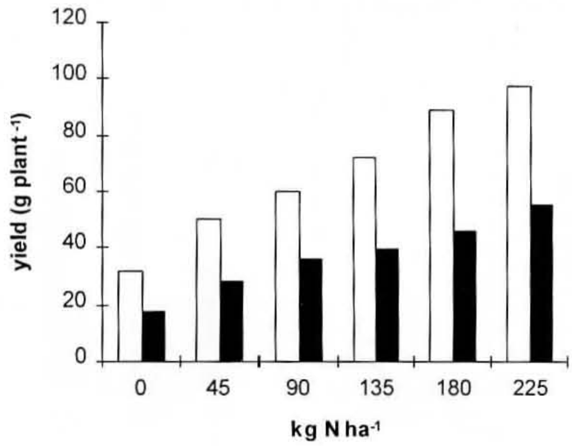


**Figure 4. Grain yields of direct seeded rice as affected by the competition of red sprangletop under different nitrogen levels. □ rice weed free, ■ rice in competition.**

There was no significant correlation between yield losses and nitrogen level tested. Therefore, the severity of the competition of red sprangletop with rice plants was not reflected by the rate of nitrogen applied. However, this was different with barnyard grass. Stauber *et al.* (1991) stated that high fertility, especially nitrogen, could increase barnyard grass interference.

Rice yield was 32 g per plant when there was no fertilizer and no red sprangletop competition, 55% higher than where there was weed competition. Evidently, nitrogen caused increase in the rice yields either with or without competition. But at the same rate of nitrogen, competition reduced rice yields ranging from 52 to 61%. Therefore, inefficiency in nitrogen fertilization occurred when there was no proper weed control. Prasad and De Datta (1979) mentioned that controlling weeds where there was no nitrogen fertilizer increased yields between 1.1 and 1.5 t $ha^{-1}$, indicating the importance of weed control in farmers fields. If weeds are not adequately controlled, fertilizer should not be applied.

De Datta *et al.* (1986) added that greater yield losses due to weeds have been observed at low and high rates of applied N than at intermediate levels. At low N levels, plants compete first for N and later for light whereas with adequate supply of N, plants compete primarily for light. In the absence of weeds, as the rate of fertilizer application increased, rice yield also increased.

Nitrogen availability to the crops will be maximized by increasing the rate and improving the technique of N application. De Datta (1985) reported that high fertilizer rate and improved nitrogen application techniques have increased grain yield from 0 to 73% over fertilizer rates and application techniques used by farmers.

Therefore, heavy infestation of red sprangletop must be controlled effectively in order to increase nitrogen efficiency during rice production. Poor weed control of this species will bring about high yield reductions, reduced nitrogen efficiency and increased cost of production.

## Conclusions

It can be concluded that the competition of red sprangletop suppressed plant height and reduced tiller number of rice at 60 days after seeding, while chlorophyll content of the rice leaves increased under nitrogen fertilization. Rice plant alone absorbed 0.024–0.40 g N per plant (4.0–64 kg N $ha^{-1}$), but when competition from red sprangletop is present, nitrogen uptake by rice plants and red sprangletop was about 0.02–0.13 g N per plant (3.0–21 kg N $ha^{-1}$) and 0.026–0.13 g N per plant (4.0–21 kg N $ha^{-1}$), respectively.

Competition from red sprangletop caused yield reductions in rice ranging from 39 to 48% irrespective of nitrogen level. Therefore, nitrogen rates did not affect the degree of yield reduction. Without nitrogen, yield of rice under weed free condition was 55% higher than the yield of rice under competition from red sprangletop. Therefore, in fields with red sprangletop, nitrogen fertilization must be followed with proper weed control in order to obtain high rice yield.

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