# DRY MATTER PRODUCTION, CARBOHYDRATE RESERVE CONTENT AND NITROGEN UTILIZATION IN SOME TROPICAL GRASSES AS INFLUENCED BY NITROGEN FERTILIZATION AND AGE OF PLANTS

## (Produksi Bahan Kering, Kandungan Karbohidrat Cadangan dan Penggunaan Nitrogen pada Beberapa Rumput Tropis Akibat Pengaruh Pemupukan Nitrogen dan Umur Tanaman)

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## ABSTRAK

Suatu penelitian dilaksanakan di lapangan percobaan Universitas Kyushu Jepang untuk mengevaluasi pengaruh pemupukan nitrogen dan umur tanaman terhadap produksi bahan kering, kandungan karbohidrat cadangan dan penggunaan nitrogen pada alang-alang (*Imperata cylindrica*), rumput bahia (*Paspalum notatum*) dan rumput benggala (*Panicum maximum*). Ketiga spesies rumput dipupuk dengan 0, 0,7 dan 1,5 g/pot N dan dipotong 50 dan 70 hari setelah pemupukan nitrogen. Hasil percobaan menunjukkan bahwa dengan meningkatnya dosis pemupukan N, produksi bahan kering, rasio daun – (tunggul + bagian tanaman bawah tanah), konsentrasi N dan pengambilan N pada ketiga spesies meningkat. Alang-alang mengalokasikan lebih besar proporsi bahan keringnya ke bagian bagian tunggul dan bagian tanaman di bawah tanah dari pada ke bagian daun dibanding dengan rumput bahia dan rumput benggala. Pemupukan nitrogen tidak mempunyai pengaruh yang konsisten terhadap kandungan karbohidrat cadangan, proporsi nitrogen yang ditemukan kembali pada tanaman dan efisiensi penggunaan nitrogen. Pemotongan 70 hari setelah pemupukan nitrogen meningkatkan produksi bahan kering dan pengambilan nitrogen tetapi menurunkan konsentrasi nitrogen pada ketiga spesies rumput. Dengan makin tuanya tanaman, rasio daun dengan (tunggul + bagian tanaman bawah tanah) menurun pada alang-alang tetapi pada rumput bahia dan rumput benggala meningkat. Alang-alang kurang responsif dalam hal pengambilan nitrogen dibandingkan dengan rumput bahia dan rumput benggala.

**Kata kunci:** Pemupukan N, Umur tanaman, Alang-alang, Rumput bahia, Rumput benggala, Produksi bahan kering, Karbohidrat cadangan, Penggunaan N

## ABSTRACT

An experiment was conducted at Kyushu University Experimental Field Japan, to evaluate the effect of nitrogen fertilization and cutting age on dry mater yield, reserve carbohydrate content and nitrogen utilization in alang-alang, bahia grass and guinea grass. The grasses species were fertilized with 0. 7 and 1.5 g N/pot and cut at 50 and 70 days after nitrogen fertilization. Results of the experiment showed that as nitrogen rates increased, dry matter yield, foliage (stubble + underground parts) ratio, nitrogen concentration and nitrogen uptake of the three species increased. Alang-alang allocated a greater proportion of dry matter to stubble and underground plant parts than to foliage compared to those of bahia grass and guinea grass. Nitrogen fertilization had no consistent effect on reserve carbohydrate content, apparent nitrogen recovery and nitrogen use efficiency. Cutting at 70 days increased dry matter yield and nitrogen uptake but reduced nitrogen concentration of the three grass species. As plant grew older, foliage (stubble + underground parts) ratio decreased in alang-alang but in bahia grass and guinea grass it increased. Alang-alang was less responsive to applied nitrogen in term of nitrogen uptake compared with those of bahia grass and guinea grass, however as the plants grew older, guinea grass showed the highest nitrogen use efficiency compared with those of alang-alang and bahia grass.

**Key words:** Nitrogen fertilization, Age of plants, Alang-alang, Bahia grass, Guinea grass, Dry matter production, Reserve carbohydrate, Nitrogen utilization

## INTRODUCTION

In most areas of high human population density in the tropics as Indonesia, traditional agricultural pattern placed little emphasis on ruminant animals. Cattle and buffalo are part of rice production system and these animals are only considered as draught power and scavenger of crop residues or wasted plants. The densely populated animals area commonly located in fertile soils that get reasonable rainfall such as in islands of Java and Bali. Within this area, opportunity for large scale development of pasture for cattle grazing is limited, but outside of Java and Bali such as in Sulawesi island, there are large areas of marginal land which could be developed with sown pastures. In the higher rainfall areas, large areas of marginal land are under rainforest. Other areas, which may have been under rainforest are presently covered by natural grassland. Very commonly, the major component of this grassland is alang-alang (*Imperata cylindrica*). While these grasslands support only low level of production, they offer a great potential for improvement through introduction of adapted pasture grass or legume species and correct use of fertilizer.

The marginal lands are characterized by low soil nutrient status, insufficient rainfall to support regular cropping and soils are difficult to cultivate by traditional methods. In the tropics, the outstanding soil deficiency is nitrogen. Nitrogen fertilization of natural and sown pasture species grown in marginal land should be practiced with caution, due to the prices of nitrogen fertilizers are very expensive and nitrogen fertilizers are readily loss from the soil. Application of fertilizer to low responsive species may be uneconomical when the fertility requirements of grass are low or the methods of applying of fertilizer are incorrect. In addition, responsiveness of grass species to nitrogen fertilization are varies. This experiment was conducted with aiming of comparing dry matter yield, reserve carbohydrate content and nitrogen utilization in alang-alang (*Imperata cylindrica*), bahia grass (*Paspalum notatum*) and guinea grass (*Panicum maximum*). Therefore the purpose of this research was to evaluate the effect of nitrogen fertilization and cutting age on dry mater yield, reserve carbohydrate content and nitrogen utilization in alang-alang, bahia grass and guinea grass.

## MATERIALS AND METHODS

The experiment was conducted at Kyushu University experimental field. Tropical grasses used were alang-alang (*Imperata cylindrica*) bahia grass (*Paspalum notatum*) and guinea grass (*Panicum maximum*). Alang-alang rhizome cutting which previously had been grown for one month in a growth cabinet, guinea grass seedling and rhizome cutting of bahia grass with leaves and roots attached directly taken from the field, were transplanted into 17 cm diameter pots filled with 3.5 litres of soil at the rate one plant/pot. After growing for one month in the pots, fertilizers were applied. Nitrogen treatments were 0, 0.7 and 1.5 g/pot (0, 160 and 350 kg N/ha). Nitrogen fertilizer used was urea (46% N). Phosphorus and potassium as basal dressing at the rates of 2 g and 1 g/pot respectively, were applied.

The experimental design used was a 3 x 2 factorial with three levels of nitrogen fertilizers, two times of cutting that were replicated three times. Cuttings were conducted at 50 and 70 days after nitrogen fertilization by cutting of plants at 5 cm above ground level. The foliage, stubble and underground parts were separated, oven dried at 70° for 24 hours and ground. Parameters investigated were dry matter yield, foliage (stubble + underground) ratio, carbohydrate reserve content, nitrogen concentration, nitrogen uptake, apparent nitrogen recovery and nitrogen use efficiency.

Samples of whole plants were analyzed for total nitrogen by Kjeldhal procedure with a salicylic acid modification to recover nitrate – nitrogen (AOAC, 1984). Samples of rhizomes and stubbles in alang-alang, stolons and rhizomes in bahia grass and stubbles in guinea grass were used for analysis of carbohydrate reserve contents. The procedure for analysis was based on Somogyi (1952). Nitrogen uptake was determined as the concentration of total nitrogen times dry matter yield (DMY). Apparent nitrogen recovery was calculated by (g N in plant at Nx – g N in plant at N0 (unfertized plants)/applied N (g) at Nx x 100) and nitrogen use efficiency was calculated as (DMY at Nx – DMY at NO)/applied N at Nx X 100.

## RESULTS AND DISCUSSION

The dry matter yield, carbohydrate reserve content and nitrogen utilization as influenced by nitrogen fertilization and cutting age in the three species are presented in Table 1.

Dry matter yields increased significantly with increasing nitrogen level in the three species. As expected, the lowest dry matter yield increase was recorded in alang-alang and the highest in guinea grass. Delayed harvest significantly increased dry matter yields in the three species, however, alang-alang showed the highest percentage increase in dry matter yield.

The low productivity and the lack of response to improved soil nitrogen in alang-alang confirm the earlier experimental results reported in the literatures (Holmes *et al*., 1976; Falvey, 1981). Although alang-alang belongs to C4 grass, its growth rate is lower than most other C4 grasses. This might be caused by low light saturation and occurrence of photorespiration (Sajise, 1973) and the higher distribution of photosynthates to underground plant parts. The increase in yield from delayed harvest might be due to increasing leaf area and light interception as resulted from longer growth period.

The accumulated dry matter was differently partitioned into respective plant parts in the three species. In this experiment, the lowest relative proportion of foliage to stubble plus underground parts was recorded in alang-alang then followed by bahia grass and guinea grass. This finding was in agree with (Daneshgar and Jose, 2009; Saxena and Ramakriskhnan, 1983).

**Table 1**. Dry matter yield, foliage – (stubble+underground) ratio, carbohydrate reserve content, nitrogen concentration, nitrogen uptake, apparent nitrogen recovery and tissue nitrogen use efficiency in alang-alang, bahia grass and guinea grass

| Treatment | Dry matter yield (g/pot) | Foliage-stubble+ under-ground ratio | Carbohydrate reseve content (%) | N concentrati-on (%) | N uptake (g/plant) | Apparent nitrogen recovery (%) | Nitrogen use efficiency (%) |
|---|---|---|---|---|---|---|---|
| | | | Alang-alang | | | | |
| Nitrogen levels (g/pot) | | | | | | | |
| 0 | 8.23[a] | 0.34[a] | 8.65[a] | 0.72[a] | 0.042[a] | | |
| 0.7 | 11.79[b] | 0.36[a] | 8.86[b] | 0.72[a] | 0.071[b] | 6.85[a] | 16.22[a] |
| 1.5 | 15.80[c] | 0.59[a] | 9.81[b] | 0.90[b] | 0.110[c] | 5.90[a] | 12.54[a] |
| Cutting | | | | | | | |
| I | 6.57[a] | 0.52[a] | 7.73[b] | 1.18[b] | 0.08[a] | 5.81[a] | 9.13[a] |
| II | 25.97[b] | 0.34[a] | 6.54[a] | 0.38[a] | 5.81[b] | 8.44[b] | 19.64[b] |
| | | | Bahia grass | | | | |
| Nitrogen levels (g/pot) | | | | | | | |
| 0 | 19.13[a] | 0.59[a] | 13.55[a] | 0.67[a] | 0.11[a] | | |
| 0.7 | 34.04[b] | 0.97[b] | 14.42[a] | 0.74[a] | 0.24[b] | 36.63[a] | 46.31[a] |
| 1.5 | 44.61[c] | 1.07[b] | 13.62[a] | 0.94[b] | 0.38[c] | 38.80[a] | 36.92[a] |
| Cutting | | | | | | | |
| I | 21.65[a] | 0.69[a] | 12.56[a] | 0.96[b] | 0.21[a] | 37.12[a] | 33.51[a] |
| II | 43.85[b] | 1.40[b] | 15.17[b] | 0.61[a] | 0.41[b] | 38.31[a] | 49.72[b] |
| | | | Guinea grass | | | | |
| Nitrogen levels (g/pot) | | | | | | | |
| 0 | 13.70[a] | 1.15[a] | 7.51a | 0.56[a] | 0.07[a] | | |
| 0.7 | 41.85[b] | 1.40[b] | 8.46[b] | 0.41[a] | 0.21[b] | 42.9[a] | 87.42[a] |
| 1.5 | 79.13[c] | 1.55[b] | 8.49[b] | 0.58[a] | 0.45[c] | 55.8[b] | 156.19[b] |
| Cutting | | | | | | | |
| I | 36.64[a] | 1.08[a] | 7.82[a] | 0.71[b] | 0.26[a] | 54.66[a] | 84.00[a] |
| II | 53.13[b] | 1.65[b] | 8.49[b] | 0.33[a] | 0.28[a] | 44.00[a] | 159.61[b] |

[a,b] means sharing different letters within each column in each treatment of a grass species are significantly different at 5 % level.

In the three species, foliage to stubble plus underground parts ratio increased significantly as increasing N rates. The foliage to stubble plus underground parts ratio increased significantly as delaying cutting in bahia grass and guinea grass, however, in alang-alang it decreased. The increase of shoot-root ratio as increasing of N rates is not uncommon found in grasses, such as in semi arid grasslands (Power and Alessi, 1971) and *Euphorbia esula* (Ringwall *et al.,* 2000), but Heggenstaller (2009) noted the grass specific effect on shoot-root ratio and nutrient partitioning in some warm season grasses as influenced by nitrogen fertilization.

The relative proportion of dry matter allocated to various plant organs influences the success of plant in different environment. In this experiment, compared with bahia grass and guinea grass, alang-alang showed the lowest shoot to underground parts ratio at all rates of nitrogen applied. Further, as alang-alang grew older, relatively more dry matter partitioned into underground parts. Low rate of shoot growth reduces potential water absorption and reduces the amount of moisture required to maintain the turgor of aerial tissue, conversely, accelerated root growth promotes the capacity for water and mineral absorptions (Humphreys, 1981).

Reserve carbohydrate level affects the success of propagating in rhizomatous plants. The level of reserve carbohydrates in alang-alang was lower than that of bahia grass and decreased as plants grew older. This indicates that rhizomes of alang-alang contain a lower reserve carbohydrates compared with stolons in bahia grass. This is not surprising since the long rhizomes in alang-alang are not photosynthetic organ while short stolons in bahia grass are capable of photosynthesis. However, the low carbohydrates reserve in alang-alang is compensated by long rhizome having a large number of buds. If undisturbed, the plants spread by the growth of rhizomes beneath the soil surface and if disturbed like ploughing, fragments of rhizome can regrow and increase infestation.

Nitrogen concentration in alang-alang and bahia grass showed higher values than those of guinea grass when similar rates if nitrogen applied. These higher nitrogen concentration might be attributed to the longer vegetative period of the two species compared with guinea grass. At harvest time, alang-alang and bahia grass remained vegetative, while guinea grass had produced inflorescence. Nitrogen concentration in guinea grass was not influenced by nitrogen rates, although dry matter yield increased highly significant as increasing nitrogen rates. This indicates that a high nitrogen concentration is not required for high growth in guinea grass and it can attain the highest efficiency of nitrogen utilization to produce a high dry matter yield.

Alang-alang was less responsive to applied nitrogen in terms of nitrogen uptake, apparent nitrogen recovery and nitrogen use efficiency compared with those of bahia grass and guineagrass. This indicates that cultivates species of bahia and guinea grass under condition of high nitrogen supply show a higher response to applied nitrogen, but species taken from natural or semi natural grassland of alang-alang shows considerably lower responses. The low responsiveness to applied nitrogen also reported in othe natural grasses i.e., *Sorghum plumosum*, *Themeda australis* and *Chrysopogon fallax*, where recovery fluctuated between 5.6 to 7.1 percent (Norman 1962 quoted by Crowder and Chheda, 1982). The lower responsiveness in alang-alang compared with Setaria anceps and *Brachiaria decumbens* also was reported by Nurhasirah (1996). The apparent nitrogen recovery of alang-alang in this experiment was also lower than reported in temperate grasses such as Kentucky bluegrass, smooth bromegrass and orchardgrass (Zemenchick and Albrecht, 2002). The low nitrogen uptake in alang-alang may predominantly be attributed to the lower growth rate but not to lower nitrogen requirement to maintain near-optimal tissue concentration as found in guinea grass. Further, alang-alang showed a higher nitrogen requirement in producing tissues, especially after the plants grew old. This indicates that slow grower of alang-alang has an adventage where nitrogen supply is low and may have a capacity to survive and dominate in plant community under condition of limited nitrogen supply widely found in tropical soils.

## CONCLUSIONS

1. Alang-alang allocated a greater proportion of dry matter to stubble and underground plant parts compared to those of bahia grass and guinea grass but foliage (stubble + underground parts) ratio of the three species declined as increasing nitrogen rates.
2. In terms of nitrogen uptake, alang-alang was less responsive to nitrogen fertilization compared with bahia grass and guinea grass, however guinea grass showed the highest apparent nitrogen recovery and nitrogen use efficiency compared with alang-alang and bahia grass.
3. As plants grew older, nitrogen use efficiency of the three species increased.

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