UNIVERSITI PUTRA MALAYSIA

EFFECTS OF TIME OF SECOND NITROGEN APPLICATION ON GROWTH AND DEVELOPMENT OF RICE PLANTS

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EFFECTS OF TIME OF SECOND NITROGEN APPLICATION ON GROWTH AND DEVELOPMENT OF RICE PLANTS

By

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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Agricultural Science in the Faculty of Agriculture, Universiti Pertanian Malaysia

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It is hereby certified that we have read this thesis entitled 'Effects of Time of Second Nitrogen Application on Growth and Development of Rice Plants' by Sariam Haji Othman, and in our opinion it is satisfactory in terms of scope, quality, and presentation as partial fulfilment of the requirements for the degree of Master of Agricultural Science

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June 1987

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Pot and field experiments were conducted to study the effect of different times of second nitrogen (N) application on growth, yield, protein content of grain and milling quality of rice (Oryza sativa L variety Seberang). Second N application was carried out at three-day intervals from 39 to 78 and 39 to 81 days after transplanting in pot and field experiments, respectively. Experimental design used was a randomized complete block design with treatments replicated three times.

In the pot experiment, significantly higher yields were obtained from second N application made from late vegetative

(39 days after transplanting) to late primary rachis branch differentiating stage (48 days after transplanting) and at middle stage of spikelet differentiation (57 days after transplanting). Time of second N application had no significant effect on grain yield in the field but second N applied at panicle initiation stage (45 days after transplanting) resulted in the highest grain yield. In the field, second N application made from late vegetative to late primary rachis branch differentiating stage and from extine formation stage (66 days after transplanting) onwards significantly increased panicle number and percentage of filled grains, respectively.

Nitrogen concentration in straw was significantly increased with a delay in second N application. Second N applied at heading (75 days after transplanting) significantly increased N concentration and protein content in the grain. A significantly higher milled rice recovery was obtained from second N application made at early grain filling stage (78 days after transplanting).

Simple linear regression analysis showed that total spikelet number per hill contributed significantly (r=0.880 for pot and r=0.554 for field experiment) to grain yield. Hence, for a medium-term maturing variety such as Seberang grown on Kundor Tualang soil series (Aquic Tropofluvent) under climatic and cultural practices of this study, second N application at panicle initiation stage is recommended to attain the highest grain yield.

Abstrak tesis yang diserahkan kepada Senate Universiti Pertanian Malaysia sebagai memenuhi sebahagian dari keperluan-keperluan untuk Ijazah Sarjana Sains Pertanian

"EFFECTS OF TIME OF SECOND NITROGEN APPLICATION
ON GROWTH AND DEVELOPMENT OF RICE PLANTS"

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Kajian kesan masa pembajaan kedua nitrogen (N) keatas pertumbuhan, hasil, kandungan protin dan mutu pengilangan beras (*Oryza sativa* L varieti Seberang) telah dijalankan di dalam pasu dan sawah. Pembajaan kedua N dilakukan selang tiga hari dari 39 hingga 78 dan 39 hingga 81 hari selepas mengubah, masing-masing bagi kajian pasu dan sawah. Rekabentuk percubaan yang digunakan ialah rekabentuk blok lengkap rawak dengan tiga replikasi.

Pertambahan hasil yang bererti diperolehi dalam kajian pasu dari pembajaan kedua N dari peringkat akhir fasa tampang

(39 hari selepas mengubah) hingga peringkat akhir perbezaan dahan tangkai primer (48 hari selepas mengubah) dan pada peringkat pertengahan pembezaan spikelet (57 hari selepas mengubah). Masa pembajaan kedua N tidak memberi kesan bererti keatas hasil dalam kajian sawah tetapi hasil tertinggi diperolehi dari pembajaan kedua N pada peringkat permulaan pembentukan tangkai (45 hari selepas mengubah). Pembajaan kedua N dari peringkat akhir fasa tampang hingga peringkat akhir pembezaan dahan tangkai primer dan dari peringkat pembentukan extine (66 hari selepas mengubah) hingga peringkat yang seterusnya, masing-masing memberi pertambahan bererti kepada bilangan tangkai dan peratus biji bernas dalam kajian sawah.

Kelewatan pembajaan kedua N memberi pertambahan bererti kepada kandungan N dalam jerami. Pertambahan bererti dalam kandungan N dan protin dalam biji padi diperolehi dari pembajaan kedua N pada peringkat terbit tangkai (75 hari selepas mengubah). Perolehan beras yang tinggi dan bererti diperolehi dari pembajaan kedua N pada peringkat awal masuk isi (78 hari selepas mengubah).

Analisis regresi linear ringkas menunjukkan bahawa jumlah spikelet seperdu memberi sumbangan bererti (r=0.880 dari kajian pasu dan r=0.554 dari kajian sawah) kepada hasil. Oleh yang demikian, bagi varieti dengan tempuh matang sederhana seperti Seberang ditanam di tanah siri Kundor Tualang (Aquic Tropofluvent) dalam cuaca dan dengan amalan kultura seperti kajian ini, pembajaan kedua N pada peringkat permulaan pembentukan tangkai adalah disyorkan untuk mendapatkan hasil tertinggi.

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa* L) is an important food crop and forms the staple diet of the people in Malaysia. The total area cultivated with rice is 622,500 ha of which about 430,000 ha are in Peninsular Malaysia where 70 percent of the area is provided with irrigation and drainage facilities (Lim, 1986). The national average yield is about 3.0 Mg ha^{-1} although higher yields have been obtained from some areas where soils are fertile with adequate irrigation and drainage facilities.

In Malaysia, the method of planting rice is mainly transplanting although direct seeding has recently been introduced in limited areas. This could be due to the more stable yield from transplanted rice which is easier to manage and harvest, especially where mechanization is not possible.

Fertilizer is a necessity in rice cultivation for attaining high yields. The Malaysian Government has therefore provided a fertilizer subsidy scheme for rice farmers since 1979 aimed at encouraging farmers to use fertilizers and continue planting rice. The objective of this subsidy is to reduce production costs and thereby increase profits. Through this scheme, farmers with less than 2.4 ha are given 4.0 kg ammophos (11:48), 40 kg urea and 80 kg NPK mixture (17.5-15.5-10.0) for each ha they plant.

Although fertilizer application is widely practised in this country, yields are still generally low. One of the reasons for this could be the improper timing of application, especially N. Among the nutrients required by rice plants, N is the most important fertilizer element which gives the highest response in terms of grain yield. However, the efficiency of applied N for rice is extremely low, whereby only 30-40 percent or sometimes even less is recovered by the rice plant (De Datta, 1978). Hence, one of the best ways of increasing the efficiency is by timing N application to synchronize with the demand of the rice plant (Nagarajah et al., 1975). For efficient grain production, N is required at several growth stages and its application at each of these stages will influence development of the yield components and subsequently grain yield. Studies in Japan indicated that yield was more influenced by time of N application than the rate applied (Kimura and Chiba, 1943a).

Split application of N has been recommended to increase uptake efficiency and to provide continuous supply of N for rice. For transplanted rice, two split applications, one half of total N applied as basal and incorporated before transplanting or broadcast at early tillering and the remaining half topdressed at panicle initiation stage (about 25 days before heading) was found to give satisfactory results

(Matsushima, 1979). But some reports showed that second N application at 30 days before heading (Koyama *et al*., 1973) or just before the reduction division stage which is about 18 days before heading (Matsushima, 1979) resulted in a yield comparable to, if not better than that when N was applied at 25 days before heading. On the other hand, N topdressing at heading was found to increase N concentration and hence protein content in the grain (De Datta *et al*., 1972). The percentage of head rice which is of greatest economic value was also reported to be improved by N topdressing at heading (Seetanun and De Datta, 1973).

The present study was conducted with the following objectives:

1. to study the effect of time of second N application on growth, yield, protein content and milling quality of rice variety Seberang, and

2. to determine the growth stage at which second N application is most effective in increasing grain yield.

CHAPTER 2

LITERATURE REVIEW

RICE RESPONSE OF N FERTILIZER

Nitrogen is the major limiting nutrient element for rice production. It is especially so in tropical countries where highly N responsive rice varieties are grown. Most experiments have shown that large increase in yield almost always result when N fertilizer is added. Roy (1981) reported an average increase of 38 to 101 percent from treatments with additional N over rice yield of control plots in experiments and demonstrations on farmers' field in most of the rice growing areas. Cumulative results of the multilocational fertilizer trials conducted in different rice areas of Malaysia from 1982-1985 showed an average grain yield increase of 1.0 Mg ha^{-1} and 1.2 Mg ha^{-1} from the standard treatment of 90 kg N ha^{-1} over controls without N in transplanted and direct seeded rice, respectively (MARDI, 1984). More than two-fold yield increase from N fertilizer has also been reported by Sims and Place (1968), where grain yield of 6812 kg ha^{-1} was obtained with the application of 157 kg N ha^{-1} as compared to 3050 kg ha^{-1} from plots without N application for variety Vegold.

Although high yielding varieties require heavy rates of N for maximum grain yield, excessive application of this nutrient results in a yield reduction. This could be due to increased lodging, heavy mutual shading of leaves, delayed maturity, increased damage from insect pests and diseases as well as low grain quality (Hall *et al.*, 1968 and Evatt, 1964). Excessive application of N may also pollute the environment through overflow or leaching of N from rice fields (Ukita *et al.*, 1972).

NITROGEN EFFICIENCY IN WETLAND RICE

Although new high yielding varieties which respond well to N are available and extensively planted, the efficiency of N fertilizer uptake for rice is rather low. A recovery of between 30 and 40 percent, and in some cases even less, of applied N by wetland rice has been reported (Prasad *et al.*, 1970 and De Datta, 1978). Even with good agronomic practices, similar low recovery in the tropics was observed (Prasad and De Datta, 1979). With best agronomic practices, the recovery of ^{15}N-labelled fertilizer by the crop may be as high as 68 percent (De Datta *et al.*, 1968).

The low efficiency of N uptake from wetland rice is due to the submergence of the soil. In waterlogged soils, chemical and biological conditions induce a peculiar transformation of N together with the operation of several loss mechanisms simultaneously (Ponnamperuma, 1977 and Craswell and De Datta, 1980). The main losses of N in wetland rice soils are through nitrification-denitrification, ammonia volatilization and leaching (MacRae *et al.*, 1968).

Nitrification-denitrification Losses of N

Of the ways in which N may be lost from flooded soils, nitrification and subsequent denitrification are generally accepted to be the most important, where losses ranging from 25 to 90 percent have been reported (Manguiat and Yoshida, 1973). Nitrification-denitrification losses are greater when the soil undergoes annual drying and flooding which are typical of soils for rice cultivation in the tropics (MacRae et al., 1968). Ammonium fertilizer applied to the surface layer of submerged soils is oxidized to nitrate by the nitrifying bacteria. Subsequent movement of nitrate into the reduced or anaerobic soil layer results in losses through denitrification as elemental N and nitrous oxide gases (Craswell and De Datta, 1980). From tracer technique study, Yoshida and Padre (1974) observed that nitrification and subsequent denitrification of ammonium sulfate was most active in the top 2.0 cm soil surface and these activities extended to a depth of 5.0 cm.

Ammonia Volatilization

Application of ammonium-containing or ammonium-forming fertilizer on the wetland soil surface often results in ammonia losses through volatilization (Wahhab et al., 1957 and Kresge and Satchell, 1960). Studies by Mikkelsen and De Datta (1979) indicated that ammonia volatilization losses could vary from 0.25 to 20 percent depending on the method of N application. Losses from surface applied N when poorly incorporated during