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Effects of nitrogen fertilization rates on yield and quality of flue-cured tobacco grown on bris sandy soil in Malaysia

(Kesan kadar pembajaan nitrogen pada hasil dan mutu tembakau awet panas di tanah bris di Malaysia)

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Key words: bris sandy soil, yield, grade index, crop index, sugars, nicotine, total N

Abstrak

Kesan kadar pembajaan nitrogen pada hasil dan mutu daun tembakau telah dikaji di tanah bris di Kelantan pada musim penanaman 1986 dan 1987. Empat kadar N iaitu 40, 60, 80 dan 100 kg N/ha diuji pada tahun 1986 manakala 60, 80, 100 dan 120 kg N/ha pada tahun 1987. Varieti tembakau awet panas iaitu TAPM 13 dan TAPM 36 digunakan. Pertambahan pembajaan N ke kadar 80 kg N/ha memberikan peningkatan dari segi hasil dan mutu. Hasil kajian menunjukkan bahawa pertambahan kadar N penting bagi meningkatkan hasil tanpa menjejaskan mutu daun kering yang dikeluarkan. Kajian ini juga menunjukkan terdapatnya kesan tindak balas di antara kadar N dan varieti tembakau pada indeks tanaman dan peratus daun tanpa gred. Berdasarkan kajian yang dijalankan, kadar yang sesuai adalah di sekitar 80 kg N/ha bagi tembakau di tanah bris yang menggunakan pengairan secara tradisional.

Abstract

The effects of N rates on yield and quality of flue-cured tobacco grown on bris sandy soil in Kelantan were studied during the 1986 and 1987 growing seasons. Four rates of N fertilizer (40, 60, 80 and 100 kg N/ha) were tested in 1986 and another four (60, 80, 100 and 120 kg N/ha) in 1987. The tobacco were of TAPM 36 and TAPM 13 varieties. Application in the region of 80 kg N/ha resulted in significantly higher yield and better quality. The results confirmed the importance of increasing N rates to achieve higher yield without jeopardizing the visual quality of the cured tobacco leaves. The results also indicated that there was a significant interaction between N rates and varieties on crop index and on the percentage of non descript grade in 1987. Data obtained suggested that the desirable rate of N is in the region of 80 kg N/ha for tobacco cultivated on bris sandy soil under the traditional supplementary irrigated system.

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Introduction

Nitrogen is the most critical nutrient in producing a tobacco crop of high yield and quality. N fertilizer has greater influence on the tobacco growth, yield, leaf curability, and usability of flue-cured tobacco compared with other nutrients. It well appears that the correct fertilization for tobacco is essential to achieve these desired qualities. The amount of N required depends on the soil type, the depth of the top soil, previous crops and related fertilization programmes, rainfall pattern as well as the grower's own experience. However, because of the high value of the tobacco crop and emphasis on obtaining high yield of green leaves among growers, there is a tendency to use high rates of N fertilizer while neglecting the effects it has on the quality of the cured leaf.

From the literature, it appears that extremely high rates of N can lower the yield of tobacco leaf (McCants and Woltz 1967; Elliot 1975). Weybrew et al. (1983) stated that plants fertilized excessively with nitrogen produced tobacco high in total N and nicotine, low in sugars, and their smoke is strong and pungent. On the other hand, plants underfertilized with N produced tobacco low in nicotine, high in sugars, and the smoke is flat and insipid.

For optimum growth, there should be an abundant N supply early in growth until the plant reaches its optimum size. To obtain normal ripening and a well-matured good quality tobacco, the available supply should be gradually depleted when maximum growth is reached and ripening is in progress (Lawrie 1979). Under local conditions the vegetative phase of the tobacco plant varies from 45 days to 60 days. It is desirable that N in the soil is depleted at the end of the short phase which is about the topping time in order that the leaf maturity may proceed normally. Hence N must be applied early and any necessity for N, side dressing should be done before 35 days after planting (Wan Azman 1985a).

About 70% of the flue-cured tobacco cultivated in Malaysia is grown on sandy soil, which contains low plant available N. The use of fertilizers to supply a major portion of this element is an established production practice and needs to be properly managed so that both yield and quality are optimized. Previous studies showed that an application of 40 kg N/ha is suitable for tobacco cultivation on these bris sandy soils under the traditional supplementary irrigated system (Wan Azman 1985b). However, the earlier results also indicated that there was a linear response to N application up to 60 kg N/ha. Thus, there is still scope to increase the current recommended rate of 40 kg N/ha so that both the tobacco yield and quality can be maximized on these bris sandy soils. This study was carried out to determine the desirable rate of N required for tobacco cultivation on bris sandy soil under the traditional supplementary irrigated system.

Materials and methods

Field trials were conducted to study the effects of N on the yield and quality of tobacco grown on bris sandy soils (Rhu Tapai, Rudua and Rusila series) for the first crop (January) in Kelantan during the 1986 and 1987 growing seasons. Based on the result obtained from previous studies (Wan Azman 1985b) four treatment levels of nitrogen were established in 1986:

Treatment	Rates (kg/ha) and sources of N fertilizer (days after transplanting)		
	NH_4NO_3 (3 days)	KNO_3 (21 days)	KNO_3 (35 days)
N1	40	–	–
N2	40	20	–
N3	60	20	–
N4	60	20	20

However, in 1987 (based on the results obtained in 1986) the treatment levels of

N were:

Treatment	Rates (kg/ha) and sources of N fertilizer (days after transplanting)		
	NH_4NO_3 (3 days)	KNO_3 (21 days)	KNO_3 (35 days)
N1	40	20	–
N2	60	20	–
N3	60	20	20
N4	60	40	20

All the basal fertilizers were applied in two pockets about 10 cm on either side of the plant and 10 cm depth 3 days after transplanting (DAT). The source of N was ammonium nitrate (NH_4NO_3) which was incorporated into a fertilizer mixture to supply 165 kg P_2O_5/ha and 162 kg K_2O/ha to all plots.

The remaining N required was applied as a side dressing 21 DAT and 35 DAT according to the treatments. All the side dressing used potassium nitrate (KNO_3) as a source. Based on method of fertilization studies in Malaysia (Kamarudin and Khairuddin 1987) split application of N produced better yield and quality. Split application of N fertilizer is to minimize leaching especially on bris sandy soil. Split application was only practical at the most twice after the basal application of fertilizers.

The experimental design was a 2^4 factorial laid out in a split-plot with four replications using TAPM 36 and TAPM 13 varieties as the main plot and four rates of N as the sub-plot. Each plot had three rows with 32 plants per row (30 experimental plants per row with a guard plant on either end). The middle row was the harvestable plot in this experiment. The spacing was 102 cm between rows and 56 cm within rows giving a total population of 17 507 plants/ha.

Leaves of the individual plots were harvested when ripe and were cured together. The cured tobacco of individual plot was assessed for yield and quality. All other cultural practices such as disease and pest control, topping and desuckering, weed control, harvesting, curing and grading of the cured leaves

Table 1. The analysis of variance result for 3 sites in 1986 and 1987 (F-value)

Source	df	Yield	Grade index	Crop index	Non descript (%)	Sugar (%)	Nicotine (%)	Total N
1986 growing season								
Site	2	42.44**	43.41**	34.97**	1.42ns	21.86**	0.90ns	0.44ns
Rep. (Site)	9							
Variety	1	0.03ns	12.72**	2.70ns	7.89**	0.47ns	0.32ns	0.00ns
Site x Variety	2	0.22ns	0.30ns	0.55ns	2.82ns	1.23ns	0.31ns	0.76ns
Variety x Rep (site)	9							
N-rate	3	11.81**	2.41ns	10.63**	1.40ns	3.83**	9.59**	6.73**
Site x N-rate	6	1.67	0.81ns	1.26ns	0.42ns	2.18ns	0.89ns	1.90ns
Variety x N-rate	3	0.52ns	0.79ns	0.49ns	0.31ns	1.27ns	0.69ns	1.03ns
Site x Var. x N-rate	6	1.21ns	0.75ns	0.99ns	1.26ns	0.66ns	0.62ns	0.97ns
1987 growing season								
Site	2	28.06**	21.28**	28.92**	17.90**	28.79**	23.97**	11.34**
Rep (Site)	9							
Variety	1	24.44**	32.29**	31.01**	10.08**	0.00ns	0.85ns	0.00ns
Site x Variety	2	0.09ns	10.28**	0.66ns	1.96ns	0.06ns	0.25ns	1.69ns
Variety x Rep (site)	9							
N-rate	3	2.18ns	7.38**	1.36ns	3.95*	8.16**	6.11**	16.77**
Site x N-rate	6	2.85ns	2.64*	1.07ns	0.87ns	0.59ns	0.85ns	1.78ns
Variety x N-rate	3	2.47ns	2.76ns	4.39**	4.32**	0.98ns	0.31ns	0.07ns
Site x Var. x N-rate	6	1.19ns	1.15ns	1.64ns	2.04ns	1.22ns	0.24ns	0.58ns

*Significant at $p < 0.05$
**Significant at $p < 0.01$
ns = non-significant

Table 2. Effect of site on yield and quality of tobacco grown on bris sandy soil (1986 and 1987)

Site	Yield (kg/ha)	Grade index	Crop index	Non descript (%)	Sugar (%)	Nicotine (%)	Total N
1986							
Kg. Sungai, Bachok	1 760b	50a	877a	2.8a	20.6b	1.6a	1.4a
Kg. Pintu Gerbang, Bachok	2 205a	45b	990a	2.6a	26.2a	1.6a	1.4a
Kg. Pulau Ular, Tumpat	1 266c	42b	535b	1.7a	27.8a	1.8a	1.4a
1987							
Kg. Dalam Rhu, Pasir Puteh	1 494b	42b	630b	7.5ab	16.6b	2.7a	1.8a
Kg. Pintu Gerbang, Bachok	2 073a	49a	1 024a	3.3b	18.9b	2.5a	1.4a
Kg. Tujuh, Tumpat	2 120a	41b	862a	11.6a	26.4a	2.0b	1.3a

Means with the same letter indicate non significance at $p < 0.05$

Table 3. Effect of variety on yield and quality of tobacco on bris sandy soil (1986 and 1987)

Variety	Yield (kg/ha)	Grade index	Crop index	Non descript (%)	Sugar (%)	Nicotine (%)	Total N
1986							
TAPM 36	1 749	44	772	2.9	25.0	1.7	1.4
TAPM 13	1 739	47	829	1.8	24.7	1.7	1.4
1987							
TAPM 36	1 756	42	744	9.2	20.7	2.4	1.5
TAPM 13	2 035	46	933	5.7	20.7	2.3	1.5

were carried out as recommended under the traditional supplementary irrigated system (Wan Azman 1985a).

Results and discussion

The analysis of variance for the rate of nitrogen study for two successive years, 1986 and 1987 are shown in *Table 1*. The incorporation of the two varieties was to observe any significant difference in the N requirement for yield and leaf quality improvement. TAPM 36 is a widely planted variety in Malaysia, whereas TAPM 13 is a newly released variety. For both years the effect of site was highly significant for most variables *(Table 2)*. This indicated that we had chosen sites with vast climatic and environmental variation which directly or indirectly influenced the performance of the tobacco. Site and variety interaction effect was significant in 1987, measured by grade index. At Kampong Sungai, Bachok, TAPM 13 performed better than TAPM 36. At Kampong Pintu Gerbang, Bachok, the two varieties produced high grade leaves but both produced low grade leaves at Tumpat. The sites were the representative of bris sandy soils. The results indicated that wherever there was significant difference between varieties, TAPM 13 was always superior to TAPM 36 *(Table 3)*.

In 1987, significant interactions were observed between N-rate and varieties on crop index. Results suggested that the suitable rate of N was at 80 kg N/ha for variety TAPM 36. However, for TAPM 13, further studies must be carried out to determine the optimum fertilizer rate under a wider range of soil, climate and management conditions. The effect of N-rate on variety TAPM 36 measured by percentage of non descript worsen with the increase of N but with TAPM 13, the effect is not significant *(Table 4)*.

The effect of N-rate on yield and physical quality varied between the 2 years. Wherever the effect was significant in 1986, it showed non-significant in 1987. This could be due to the environmental or climatic conditions during the years. The

Table 4. Mean value for N-rate and variety interaction on crop index and percentage of non descript on bris sandy soil, 1987

N-rate (kg N/ha)	Crop index		Non descript (%)	
	TAPM 13	TAPM 36	TAPM 13	TAPM 36
60	896	750	5.4	7.3
80	920	817	6.7	7.5
100	953	733	4.6	9.5
120	962	676	6.1	12.3

Table 5. Effects of nitrogen rates on yield and quality of tobacco on bris sandy soil (1986 and 1987)

Treatment (kg/ha)	Yield (kg/ha)	Grade index	Crop index	Non descript (%)	Sugar (%)	Nicotine (%)	Total N
1986							
40	1 560c	44	696c	2.5	26.0a	1.5b	1.4bc
60	1 691b	45	772b	2.5	25.4a	1.6b	1.3c
80	1 830a	46	848a	2.7	24.4ab	1.8a	1.4ab
100	1 984a	46	887a	1.6	23.6b	1.8a	1.5a
1987							
60	1 806	45a	823	6.4b	21.7ab	2.3b	1.4c
80	1 942	44ab	869	7.1b	22.3a	2.2b	1.4c
100	1 914	43bc	843	7.1b	20.4b	2.4ab	1.5b
120	1 920	42c	819	9.2a	18.4c	2.7a	1.6a

Means with the same letter indicates non significance at $p < 0.05$

1986 crop season was relatively dry compared to 1987 which was wet especially in the middle of the growing period. It was found that 80 kg N/ha gave higher yield and crop index compared with the current recommended level of 40 kg N/ha in 1986 *(Table 5)*. In fact, up to 100 kg N/ha, yield and crop index were still increasing indicating that the response was still not optimum yet. The rate was then increased in the following year. However, result in 1987 indicated that N-rate greater than 80 kg N/ha tended to reduce the yield and crop index. Grade index increased with increasing rates of N in 1986 but decreased with increasing rate of N greater than 80 kg N/ha in 1987.

Nitrogen is an important constituent of nicotine and is the main controlling factor in nicotine production, with the highest nicotine percentage generally occurring at the higher nitrogen rates even though the yield no longer increase. The percentages of sugar and nicotine contents are important characteristics for tobacco quality, which are widely used in manufacturing cigarettes. The sugar content of about 18–25% and nicotine content of about 1.8–2.5% is actually required by cigarette manufacturers in Malaysia (Musa 1985). The nicotine level increased with an increase in the nitrogen rates. Each increment of applied N gave a highly significant increase in nicotine. All the nicotine values were within the acceptable limit. Increasing the rates of N decreased sugar content significantly for both 1986 and 1987 crops. However, the values of the sugar were within the acceptable limit. The levels of total N increased with an increase in applied N for both years. The results agreed with those of other studies (McCants and Woltz 1967; Elliot 1975; Elliot and Court 1978; Hawks et al., 1979; Weybrew et al. 1983; Wan Azman 1985b).

These results revealed that it was advantage to increase the current

recommended rate from 40 kg N/ha to the region of 80 kg N/ha. However, further increase of N greater than 80 kg N/ha showed no significant increase in yield and quality.

Conclusion

Increasing the rate of N application from 40 to 80 kg N/ha resulted in significantly higher yield and quality. This shows that current recommended rate of 40 kg N/ha (Wan Azman 1985b) is insufficient for maximizing the tobacco yield and quality on bris sandy soil under the traditional supplementary irrigated system. Also from the present study it appears that by applying about 80 kg N/ha, the desired sugar and nicotine contents can be achieved.

Significant interaction between N-rate and variety revealed that the suitable N-rate was about 80 kg N/ha for TAPM 36 variety. However, for TAPM 13 variety, further studies should be carried out to determine the optimum N-rate under the various climatic conditions and soil types.

Result from these experiments indicated that an increase in N-rate above 80 kg N/ha had pronounced effect on lowering the leaf quality. Higher N-rate tended to be detrimental to cured leaf quality and was not economical to the growers. From the foregoing, it can be concluded that in order to achieve a tobacco crop of optimum yield and quality on the sandy bris soils of Peninsular Malaysia, N fertilization rate in the region of 80 kg N/ha will suffice. The nitrogen rate recommended in the basal application is 60 kg N/ha for both the varieties to produce tobacco of high yield and quality. However, additional N application is necessary for tobacco on bris sandy soil, for extra yields, when early rains may tend to leach nitrogen out of the root zone. The amount of side dressing is 20 kg N/ha using potassium nitrate, applied at 21 DAT or not later than 35 DAT.

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