J. Trop. Agric. and Fd. Sc. 27(2) (1999): 143–150

Effects of rate and frequency of fertilizer application for chilli (*Capsicum annuum* L.) on peat

[Kesan kadar dan kekerapan pembajaan bagi cili (*Capsicum annuum* L.) di tanah gambut]

A. C. Leong* and H. Salbiah**

Key words: chilli, plastic mulch, rate, frequency, fertilizer, yield, cost-saving

Abstrak

Cili ialah sayuran buah yang kedua popular ditanam di Malaysia. Terdapat permintaan yang berterusan bagi cili segar di pasaran tempatan dan eksport. Penggunaan sungkupan plastik bersinar untuk menutup batas banyak digunakan oleh petani-petani. Namun, kekerapan dan kadar pembajaannya sama, walaupun ditanam tanpa menggunakan sungkupan plastik. Oleh yang demikian, kekerapan dan kadar pembajaan perlu dikaji semula dalam sistem penanaman sekarang. Tiga kadar pembajaan dan kekerapan membaja dinilai menggunakan kultivar cili MARDI, MC4. Kajian ini dijalankan di MARDI Jalan Kebun, Klang pada tahun 1993 dan 1994 menggunakan faktorial 3 x 3 berulangan disusun secara rekabentuk blok lengkap terawak (RCBD). Tiada perbezaan didapati pada hasil dan buah yang boleh dipasarkan antara pembajaan mengikut kadar yang disyorkan dan 75% daripada baja yang disyorkan. Walau bagaimanapun kedua-dua rawatan tersebut memberi hasil yang tinggi berbanding 50% daripada kadar yang disyorkan. Oleh itu, pemberian baja pada kadar 75% daripada baja yang disyorkan, boleh digunakan pada tanaman cili menggunakan sungkupan plastik. Ini bermakna pengurangan sebanyak 25% pada pembajaan dan juga jumlah yang 'sama' pencemaran air oleh baja-baja yang terlarut. Disyorkan pembajaan diberi sekali sahaja, sebagai baja asas pada cili yang ditanam menggunakan sungkupan plastik. Pemberian baja secara berperingkat-peringkat tidak diperlukan. Dianggarkan penjimatan sebanyak RM421/ha dalam penanaman cili menggunakan sungkupan plastik dengan satu pembajaan pada kadar 75% daripada yang disyorkan boleh diperoleh. Analisis daun secara pukal bagi %N, %P dan %K membuktikan pembajaan sekali pada kadar 75% baja yang disyorkan adalah mencukupi.

Abstract

Chilli is the second most popular fruit vegetable grown in Malaysia. There is a constant demand for fresh chilli, both in the local and export market. The use of reflective plastic mulch to cover the raised planting beds is commonly practised by local farmers when cultivating chilli in the open field. However, the rate and frequency of fertilizer application are still the same as planting of chilli without plastic mulch. Therefore, there is a need to review the rates and frequency of

*Horticulture Research Centre, MARDI Jalan Kebun, Locked Bag 186, 41720 Klang, Malaysia
**Economics and Technology Management Research Centre, MARDI Headquarters, P. O. Box 12301, 50774 Kuala Lumpur, Malaysia
Authors' full names: Leong Ah Chye and Salbiah Husin

fertilizer application under the present cultivation system. Three fertilizer rates and application frequencies were evaluated using MARDI's cultivar MC 4. The replicated 3 x 3 factorial experiment was laid out in a RCB design on drained oligotrophic peat in MARDI Research Station, Klang in 1993 and 1994. No significant yield and marketable fruit differences were detected between fertilizer application at the current recommended rate (RR) and at 75% RR, but both treatments-yielded significantly higher than the treatment at 50% RR. Fertilizer rate at 75% RR can be recommended for chilli planted under plastic mulch. This meant a 25% reduction in fertilizer application, implying a 'similar' amount of reduction in water pollution by leached fertilizers. Fertilizer applied once only, as basal application, is sufficient for chilli planted under plastic mulch. There is no need for split fertilizer applications. A saving of RM421/ha was estimated in chilli cultivation using plastic mulch with fertilizer application at 75% RR, applied only as a basal application. The composite foliar analysis of %N, %P and %K reconfirmed that 75% RR in one fertilizer application is sufficient.

Introduction

Chilli is the second most popular fruit vegetable, next to long bean, in Malaysia. In 1996 the total area planted with chilli was 3 553 ha out of a total of 18 212 ha of fruit vegetables (Anon. 1996). Malaysia exported 7 995 t of fresh chilli worth RM4.921 million and imported 13 318 t worth RM8.916 million in 1996 (Anon. 1996a). Therefore Malaysia is a net importer for fresh chilli. In order to save foreign exchange there is a need to increase chilli production locally.

The use of reflective plastic mulch is the current recommended cultural practice in the cultivation of chilli in Malaysia. Plastic mulch can delay and reduce virus disease incidence by reducing the number of alate aphids landing on chilli plants (Mohamad Roff and Ong 1991). Besides repelling aphids, Hopen and Debker (1976) found that the plastic mulch can also control some soil pathogen and weeds, reduce evaporation, control leaching of nutrients and trigger plant growth. The plastic mulch completely covers the planting bed. As a result the mulch can probably minimize run-off and gaseous emissions of the applied nutrients. Gaseous emissions of N via ammonia (NH_3) volatilization and denitrification have been identified as the dominant mechanism of fertilizer N loss in many agricultural systems (Peoples et al. 1995). In addition there is also a possibility of reducing the frequency of fertilizer application. As such there is a need to investigate whether the plastic mulch can serve such purposes. Therefore, a study was conducted to determine the effects of different rates and frequency of fertilizer application in chilli on peat.

Materials and methods

The trial was conducted on drained oligotrophic peat in Kelang, Selangor over two crops. The second crop was carried out on a new site. The first and second crop were carried out respectively in January 1993 and December 1994. Soil analysis was carried out prior to planting. The average N, soluble P and exchangeable K cation for peat respectively were 1.16%, 27 ppm and 0.40 meq/100 g.

Chilli (MC4) seeds were sown in nursery trays and transplanted into open field, one month later. The seedlings were planted on 20 cm high beds covered with reflective plastic mulch. The surface of the mulch is grey-silverish in colour with black underside.

Three fertilizer rates and application frequencies were arranged in a 3 x 3 factorial in one block. A randomized complete block design with four replicates

was used. The three fertilizer rates in kg/ha were:

- 250N, 40P, 200K (The current recommended rate (RR) for chilli) (Vimala, P., MARDI, Jalan Kebun, Klang, pers. comm. 1993)
- 188N, 30P, 150K (75% of the RR)
- 125N, 20P, 100K (50% of the RR)

The fertilizers used were ammonium sulphate, triple superphosphate (TSP) and muriate of potash to supply N, P and K respectively in all the fertilizer rates. TSP was provided in the first application only. The three different frequencies of application were:

- All in basal
- $^1/_2$ in basal and $^1/_2$ at 60 days after transplanting
- $^1/_4$ in basal and $^1/_4$ each at 30, 60 and 90 days after transplanting (common practice).

The basal fertilizers were mixed into the soil before laying the reflective plastic mulch over the beds. The side fertilizer application was placed in the cross slits made on the plastic mulch between plants. The plot size was 3.6 m x 6 m with 2 beds/plot. The planting distance used was 60 cm x 60 cm with 2 rows/bed, giving a total of 40 plants/plot.

On peat, the soil pH was raised to 5.5 using ground magnesium limestone at 2.5 t/ha for every 0.15 pH unit increase. Liming was carried out 2 weeks before the transplanting of chilli. The common trace elements were applied as basal dressing together with the major fertilizers one day before planting in accordance with Leong et. al. (1985). No supplementary irrigation was carried out except on the first day after transplanting. Spraying against pests and diseases were carried out only when necessary.

Composite leaf samples were collected from each treatment prior to first harvesting of the chilli fruit. Chilli fruit was harvested at about 70 days after transplanting. Subsequent harvest was carried out at 2–3 days interval.

Results and discussion

Yield and marketable fruit number per plot

From the analysis of variance table carried out over 2 crops *(Table 1)*, it was found that only the different fertilizer rates and the frequency of application x crop cycle interaction were significant in both the yield and fruit number per plot. All other treatments and their interactions were non significant.

From *Table 2*, it was noted that there were no significant yield differences between the recommended fertilizer rate (RR) and 75% RR. However these treatments yielded significantly higher than the treatment at 50% RR. This trend was similarly noted for the marketable fruit number per plot. This showed that 75% RR of the fertilizer applied i.e. 188N, 30P and 150K kg/ha is sufficient for chilli, grown under plastic mulch on peat. This meant a 25% saving in fertilizer cost per se. The use of plastic mulch could have reduce run off, leaching and gaseous emissions of the applied fertilizers, thereby increasing the efficiency of nutrient utilization by the chilli plants. This coupled with the reduced water evaporation from the beds could have also contributed further to better utilization of the applied nutrients by the plants. Planting under plastic mulch also indirectly implied a "25% reduction" in water pollution by the applied fertilizers via run-off and leaching into underground water. It was also noted that the use of reflective plastic mulch had reduced the frequency of pesticide spraying against aphids during the developmental to flowering stage of the chilli plants. This had help to establish healthy plants free of virus diseases thus contributing to high chilli yield.

It was noted from *Figure 1* and *Figure 2* that no significant differences were detected in the frequency of application in the first crop yield and fruit no./plot. However in the second crop, treatment with

Table 1. ANOVA of yield and marketable fruit number of chilli grown on peat

Source		Yield (t/ha)			Fruit no./plot		
	dF	MS	F value	PR>F	MS	F value	PR>F
Crop cycle	1	1.9800	0.4638	0.6115	1341522	8.85*	0.021
Rate	2	25.9022	17.83	0.0001**	743154	22.51	0.0001**
Frequency	2	3.9857	2.74	0.0745	42883	1.30	0.2823
Rate x Frequency	4	1.1475	0.79	0.5376	26337	0.80	0.5326
Rate x Crop cycle	2	2.6218	1.80	0.1756	50448	1.53	0.2274
Frequency x Crop cycle	2	8.2091	5.65	0.0063**	165282	5.01	0.0106*
Rate x Freq. x Crop cycle	4	0.5372	0.37	0.8290	9797	0.30	0.8787
Error	48	1.4530			33018		
Mean		14.7894			2495.611		
SE		1.2054			181.709		
C.V.%		8.15			7.28		

*denotes significance at 5% probability
**denotes significance at 1% probability

Table 2. Duncan multiple range test (DMRT) on the fertilizer effect on the yield of chilli on peat over two crops

Fertilizer rate	Mean yield (t/ha)	Mean fruit no./plot
Recommended rate (RR)	15.67 a	2638.3 a
75% RR	15.05 a	2549.5 a
50% RR	13.64 b	2299.0 b

Means with similar letters are not significantly different

only the basal application yielded significantly higher than the treatments with split applications.

The results suggested that basal application i.e. only one application of fertilizer is sufficient for chilli in peat grown under plastic mulch. There is no need for split fertilizer application as currently practised. The single application also meant a substantial saving in labour cost and contributed to a lower cost of production. However this contrasted with the findings of Ingle et al. (1992) and Subhani et al. (1990) respectively in clay and sandy loam soil, where four split fertilizer applications recorded the highest chilli yield. This was probably the result of open field planting, without the use of plastic mulch where the applied fertilizers are not “protected” from the natural elements and it was proper to split the application of the fertilizers. The use of plastic mulch could have minimized the adverse effects of the weather on the exposed applied fertilizers. In addition the mulch also reduced the frequency of weeding to only around the planting hole and the interbed furrows. With minimal weed competition, the chilli plants grew vigorously. The robust growth contributed to a higher yield performance. Gollifer (1993) similarly noted that plastic mulch enhanced chilli plant growth attributed to reduced weed competition. The plastic mulch thus provides a very conducive and protective environment ensuring a continuous readily available nutrients to the chilli plants from transplanting to harvesting.

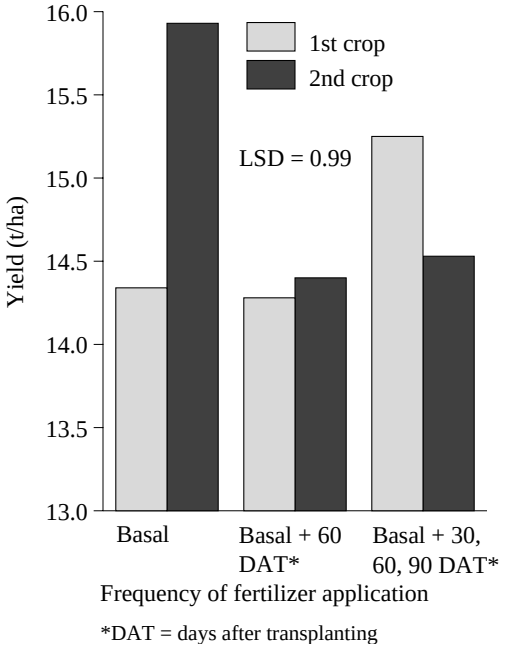


Figure 1. Effects of fertilizer application frequency and crop number on the yield of chilli

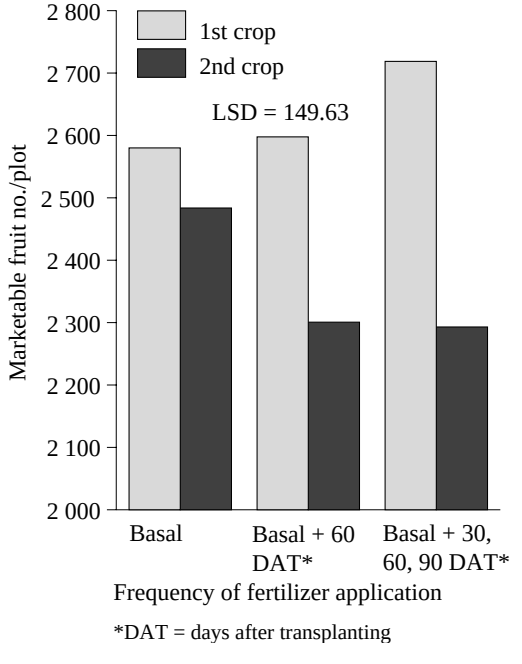


Figure 2. Effect of fertilizer application and frequency and crop number on the marketable chilli fruit no./plot

Seasonal variation especially the distribution of rainfall from planting to harvesting could have attributed to different responses of the chilli plant to different frequency of fertilizer application in the yield and marketable fruit number per plot. From the graph *(Appendix 1)*, for the total and frequency of rainfall over a total period of 150 days over the two crops, it was observed that the second crop experienced a heavier and more evenly distributed rainfall than the first crop. The interval between precipitation seldom exceeded 3 days. This could have favour the single basal application by providing a constant moist soil environment for continuous uptake of nutrients by the chilli plants. This might not be the case in the first crop, where a longer interval between lower levels of precipitation, did not provide a conducive soil environment thus favouring split application of fertilizer as a better mode of application.

Generally it can be stated that a single basal application of the total nutrients required by chilli grown under plastic mulch is sufficient irrespective of the seasonal (rainfall) variation. It can be inferred from the rainfall data over the 2 crops that supplementary irrigation should be provided if no rainfall occurs for more than 3 days.

Nutrient content in chilli leaf

No significant differences in the % of N, P and K were detected in the composite leaf samples between different time of fertilizer application in the first crop cycle. Similarly no differences were detected in the %P and K for different rates of the applied fertilizers *(Table 3)*. Only the treatment with the recommended fertilizer rate recorded a significantly higher % of N than the other treatments. Despite the significance, this was however not reflected in the yield obtained, possibly indicating a luxury consumption of N by the chilli plant. The higher N did not contribute further to the chilli yield. This confirmed that 75% of the recommended fertilizer rate, applied only once as a basal

Table 3. Duncan's multiple range test on the nutrient content in chilli leaf in the first crop

Treatment	Content %		
	N	P	K
Fertilizer rate			
Recommended rate (RR)	4.64 a	0.24 a	2.39 a
75% of RR	4.39 b	0.25 a	2.25 a
50% of RR	4.34 b	0.25 a	2.21 a
Frequency of application			
Basal	4.40 a	0.25 a	2.33 a
Basal + 60 DAT	4.42 a	0.25 a	2.18 a
Basal + 30, 60, 90 DAT	4.55 a	0.25 a	2.34 a
Mean	4.46	0.25	2.28
C.V.%	5.84	10.2	9.03

DAT = days after transplanting

application is sufficient in the production of chilli under plastic mulch.

Saving in production cost

Straight fertilizers were used instead of compound fertilizers in the trial. The cost of ammonium sulphate, triple superphosphate and muriate of potash were respectively RM400, RM640 and RM440/ton (per. com. Samsiri, purchasing Officer, MARDI 1997). A 25% fertilizer reduction meant a saving of RM196/ha. Split fertilizer applications at monthly interval is a common practice among local chilli growers. Therefore a reduction of four applications to only one basal application will account for saving of RM225/ha based on the assumption of 20 mandays/ha needed to apply the fertilizer at the cost of RM15/day (Anon. 1993). Thus planting chilli under plastic mulch at the rate of 188N, 30P and 150K (equivalent to 75% RR) applied only once in the basal application can reduce cost of production by RM421/ha. If chilli farmers were to use straight fertilizers instead of compound fertilizer, there is going to be a further saving of RM 1334/ha, if the cost of the NPK compound fertilizer was RM960/ton (based on 1997 price).

Conclusion

The use of reflective plastic mulch not only reduce aphid infection in chilli but also improve the efficiency of nutrient utilization. The amount of fertilizer required by chilli under plastic mulch can be reduced by 25% of the current recommended rate. The new rate that can be recommended for chilli under plastic mulch is 188N, 30P and 150K kg/ha and this rate can be applied in one basal application only. This cultural practice can reduce RM421/ha from the production cost. If straight fertilizers were used by farmers instead of the commonly used compound fertilizer, there is a further saving of RM1334/ha. Therefore the use of reflective plastic mulch, with all the beneficial effects and its cost effectiveness, should be fully encouraged as an integral part of the integrated crop management (ICM) package and its contribution to the sustenance of chilli production in the tropics.

Acknowledgements

The authors wish to express their thanks to Ms. Fathmah bt Mokhtar and Mr. Amat Jupri Ahmad for technical assistance and Ms. Anita Abbas for typing the manuscript.

References

Anon. (1993). *Anggaran kos pengeluaran dan pendapatan untuk tanaman dan ternakan 1992.* Serdang: MARDI

—— (1996). Keluasan tanaman pelbagai Jabatan Pertanian, Wisma Tani, Kuala Lumpur. Kuala Lumpur: Jabatan Pertanian

—— (1996 a). *Buku ringkasan perdagangan luar negeri makanan dan hasil pertanian terpilih.* Kuala Lumpur: Kementerian Pertanian

Gollifer, D. E. (1993). Effects of application of mulch and potassium on *Capsicum annuum. Papua New Guinea, J. of Agric. Forestry and Fisheries.* ***36:*** 1, 22–9

Hopen, H. J. and Debker, N. F. (1976). Vegetable crop responses to synthetic mulches. An annotated bibliography. U. of Illinois Agric. Expt. *Station special publication* ***42:*** 48 pp

Ingle, H. V., Gulandhe, S. S. and Allurwar, M. W. (1992). Effect of split application of nitrogen on growth and yield of chilli (*Capsicum annuum* L.) var. CA-960. *J. of Soils and Crops.* ***2:*** 1, 102–3

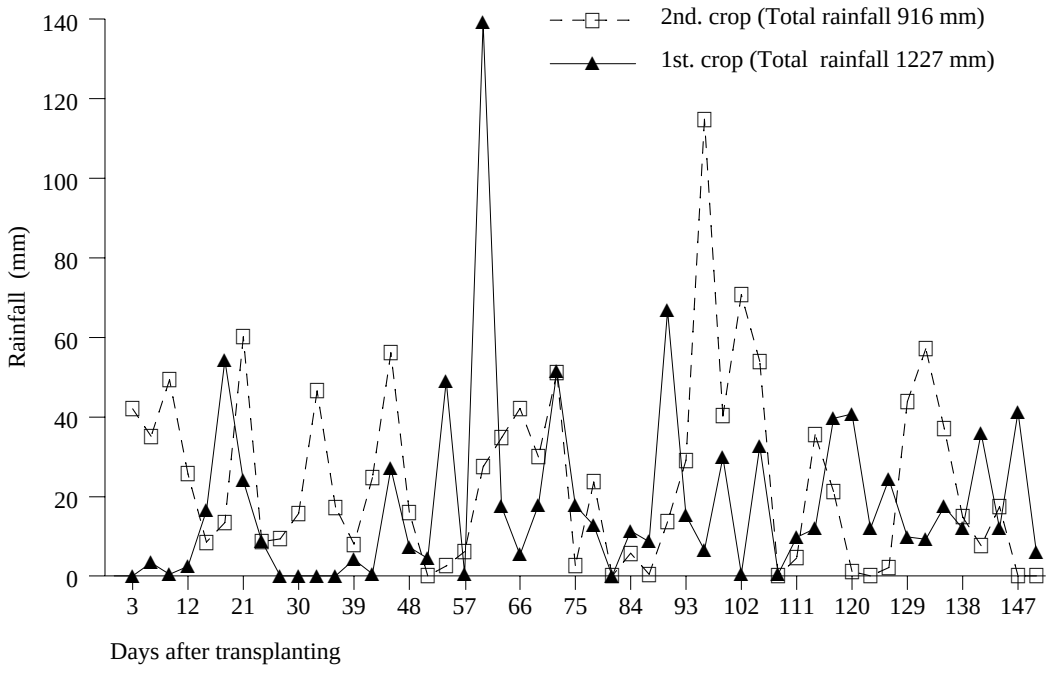
Leong, A. C., Vimala, P. and Ding, T. H. (1985). A guide to chilli cultivation in Peninsular Malaysia. *Teknol. Sayur-sayuran,* ***1:*** 14–9

Mohamad Roff, M. N. and Ong, C. A. (1991). Sungkupan plastik bersinar mengurangkan dan melambatkan kejadian penyakit virus pada cili. *Teknol. Sayur-sayuran, MARDI* ***7:*** 35–41

Peoples, M. B., Freney, J. R. and Mosier, A. R. (1995). Minimizing gaseous losses of nitrogen. In: *Nitrogen fertilization in the environment,* P. E. Bacon (ed.) pp. 565–602. Mercel Dekker, Inc: New York

Subhani, P. M. Ravisankar, C. and Narayana, N. (1990). Effect of graded levels and time of application of N and K2O on flowering, fruiting and yield of irrigated chilli. *Indian Cocoa, Arecanut and Spices J.* ***14:*** 2, 70–3

Accepted for publication 22 August 1999



Appendix 1. Total rainfall recorded at 3 days interval over two crops for chilli on peat