EFFECTS OF APPLICATIONS OF MULCH AND POTASSIUM ON *CAPSICUM ANNUUM*

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ABSTRACT

*Applications of organic mulch and potassium resulted in increases in yield of chilli fruit (*Capsicum annuum*), of up to 170% and 113% respectively. The effect of mulch was to supply potassium to the plant, and when mulch was applied at 40 t/ha it was equivalent to supplying 210 kg/ha of K. Mortality of plants in the plots which received no mulch or potassium was high. A crop of 2500 kg/ha of dry chilli fruit (10,000 kg/ha fresh) removed approximately 62 kg/ha of K from the soil. The total dry matter per plant was considerably smaller in the plants which received no mulch or potassium. Plastic mulch enhanced plant growth probably because of the reduced competition by weeds for available K. Differences in the pH and moisture content of the soil between treatments were not considered important.*

Key words: Chillies, calcareous soils, mulch, fertilizers, potassium.

INTRODUCTION

Chillies (*Capsicum annuum* L. var. *annuum*) were introduced to the Solomon Islands from Ceylon and India for trial and evaluation as a potential cash crop for local growers (Gollifer 1973). The investigations on cultivar type and fertiliser requirements were carried out at Dala research Station on Malaita Island which lies between 8° and 10° S and 160° and 162° E. The climate is wet tropical, mean maximum temperatures seldom exceed 31°C. The average relative humidity is approximately 80 percent throughout the year, and mean annual rainfall is over 3000 mm for most areas and is well distributed. The soils of the research station are known as the Dala Series, they overlie calcareous material and are low in exchangeable potassium (Ballantyne 1961; Wall & Hansell 1973). Ballantyne (1961) described the soils as all being of fine texture, between a silty-clay-loam and a clay and show no signs of restricted drainage. The percentage of nitrogen is high (0.60 - 0.92 percent) in the undisturbed top soil which is associated with the high organic matter content of this layer. Total phosphorus ranged from 0.36 to 0.80 percent, but availability may, however, be low due to formation of complex iron and aluminium compounds. Total potassium ranged from 0.71 to 1.27 meqiv. per 100 g. The exchangeable potassium was very low, and excluding the top 5 cm ranged from 0.15 to 0.04 mequiv. per 100 g dry soil. The potassium deficiency may well be accentuated by the high exchangeable calcium and/or magnesium status of the soil which gave a ratio of exchangeable calcium to exchangeable potassium of generally wider than 50:1.

Gollifer (1972) reported yield responses in chillies due to applications of potassium of up to 70% over those of the non-fertilised plants. The aggregate yields of fresh fruit were 12,535 and 7,139 kg/ha for the fertilised and control plots respectively by 42 weeks from planting. Furthermore 30% of the plants that received no potassium died due to

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infection of the stem base by the fungus *Sclerotium rolfsii* Sacc., whilst only 4% of the fertilised plants were affected.

A mulch treatment superimposed on a chilli cultivar trial resulted in significant yield increases 47% over those of the non-treated plants. Aggregate yields of fresh fruit over a harvest period of 24 weeks were 5,597 and 3,801 kg/ha for the mulched and non-mulched plants respectively. Additionally by 42 weeks from planting, 50% of the non-treated plants and 11% of the mulched plants were dead. Mortality in this case was not due to infection by *S. rolfsii* as this was controlled by applications of PCNB (Penta chloro nitro benzene).

As the mulch treatment was so beneficial, it was decided that further investigations should be made to determine the role played by mulch on the soils of the Dala Land System. Also as it is difficult to convince subsistence agriculturalists to use fertilizers on their crops it was thought that they would more readily accept the use of mulch as it was a practice formerly used in the Solomon Islands for cultivation of taro (*Colocasia esculenta*) (L.) Schott. mulch being known as *tatavo*. This paper describes two experiments in which mulch and potassium were applied to chillies.

MATERIALS AND METHODS

The aims of the two experiments were to investigate the effects of applications of mulch and potassium (as muriate of potash) on the yield of the Indian chilli cultivar "B16 A-1" grown as a rainfed crop at Dala Research Station, Malaita Island. Seedlings were transplanted into the field when 9 weeks old at a spacing of 0.6 x 1.2 m. In both experiments the potassium was applied in two dressings, one at transplanting and the other 12 weeks later at a total rate of 180 kg/ha of elemental K. PCNB was applied to all plants 11 days after transplanting at a rate of 9.9 kg in 3595 litres of water per hectare. Fruit were harvested at weekly intervals commencing at 9 weeks after transplanting and this was continued for 32 weeks (Experiment 1) or 17 weeks (Experiment 2). Fresh weight yields of fruit and mortality of plants were recorded. The harvestable plot size was thirty and fifteen guarded plants for Experiments 1 & 2 respectively.

Experiment 1

Field planting took place during September 1969. The experimental design was a 2^2 factorial arranged as a randomized block with four replicates. The potassium was applied as outlined above at 0 and 180 kg/ha of elemental K, and the mulch at 0 and 30 t/ha in two dressings at transplanting and 12 weeks later. The mulch consisted of cocoa pods, grass and sweet potato vines which had been mechanically chopped and then composted for 2-3 weeks before application.

Soil samples were taken from the surface and at depths of 10 and 20 cm for determination of the pH (H_2O). The first sampling was done before the treatments were applied and the sample size was sixteen. A further sampling was made immediately prior to the second application of fertiliser and mulch, and the sample size was ten per plot or forty per treatment. Samples of oven-dried mulch were forwarded to Unilevers Plantation Group of London for chemical analysis.

Experiment 2

Field planting took place during July 1970. The experimental design was a split plot with five replicates. The main plot treatments were: (a) organic mulch of similar composition as in Experiment 1, applied in one application at 40 t/ha at 7 days after transplanting; (b) plastic mulch positioned at 7 days after transplanting; (c) bare soil. The sub plot treatments were: (a) potassium; (b) no potassium. The plastic mulch consisted of 0.9 m wide strips of yellow plastic sheeting laid down between the rows of chilli plants leaving 0.3 m gaps in which the plants grew.

Fifteen plants were selected randomly per plot for growth analysis studies and the remaining fifteen were used to provide yield data of fresh fruit. Growth analysis measurements including plant heights, were made at monthly intervals starting at 8 weeks after sowing through to 32 weeks. The sample size was two plants per plot or ten per treatment. The dry matter contents of component plant parts were determined after oven drying at 100°C for 24 h.

Soil temperatures at 7.5 cm depth were determined at 1200 and 1500 h for 120 days with soil thermometers. One thermometer was used for each main plot treatment. Three soil auger samples taken from the 0.15 cm layer were removed per sub plot at weekly intervals on four occasions, and the soil moisture was determined gravimetrically after oven drying at 100°C for 24 h. On collection the samples were sealed in tins until the initial weights had been recorded.

Oven dried samples of leaves and fruit taken from each sub-plot when the plants were 20 weeks old were sent to the Land Resources Division, Tolworth, England for chemical analyses. Soil extracts and plant root samples were forwarded to Rothamsted Experimental Station, England to determine if pathogenic plant nematodes were present. The soil extracts were made using the method described in Peachey (1969).

RESULTS

The yields of fresh fruit are shown in Tables 1 and 3, and mortality of plants in Tables 2 and 4 for Experiments 1 and 2 respectively. The potassium and mulch treatments were both significantly different and had a positive effect on the yield of fruit in Experiments 1 and 2. In the case of plant mortality, the mulch effect was significantly different in Experiment 1, whilst both the mulch and potassium effects were significantly different in Experiment 2, resulting in less plant mortalities. The interaction effect (Table 2) is explained by the fact that applications of potassium resulted in a reduction of mortality in the unmulched plots, but a slight increase in the mulched plots.

Table 1. **Yield of fresh chilli fruit (kg/ha) for the 32 week harvest period (Experiment 1).**

Mulch (t/ha)	Potassium (kg/ha) 0	180	Mean
0	2735	12959	7847
30	14560	16228	15394
Mean	8648	14594	

	s.e.d(0.05)	Sign. effect
K x mulch	+/- 2092.0	*
Mulch	+/- 2087.1	***
K	+/- 2087.1	**
C.V. = 25.4%	S.E. +/- 1476.1	

Table 2. **Mortality (% of chilli plants which died) by 40 weeks (Experiment 1).**

Mulch (t/ha)	Potassium (kg/ha) 0	180	Mean
0	48.0	25.0	36.5
30	8.0	11.0	9.5
Mean	28.0	18.0	

	s.e.d(0.05)	Sign. effect
K x mulch	+/- 7.51	*
Mulch	+/- 7.49	***
K		n.s.
C.V. = 44.0%	S.E. +/- 5.7	

Table 3. **Yield of fresh chilli fruit (kg/ha) for the 17 week harvest period (Experiment 2).**

Mulch	Potassium (kg/ha)		Mean
	0	180	
Organic	12879	15910	14395
Plastic	3195	11374	7285
Bare soil	1160	9502	5331
Mean	5745	12262	

	s.e.d(0.05)	Sign. effect
Kx mulch	+/- 1139.1[1]	**
Mulch	+/- 1148.0	***
K	+/- 1132.7	***

Main plots: S.E. +- 814.0; C.V. = 10.1%

Sub plots: S.E. +/- 446.9; C.V. = 20.0%

[1](approximate for all comparisons)

Table 4. **Mortality (% of chilli plants which died) by 32 weeks (Experiment 2).**

Mulch	Potassium (kg/ha)		Mean
	0	180	
Organic	5.4	5.4	5.4
Plastic	50.8	25.4	38.1
Bare soil	38.0	14.8	25.3
Mean	30.7	15.1	

	s.e.d (0.05)	Sign. effect
Mulch	+/- 9.14	**
K	+/- 7.71	**

Main plots: S.E. +/- 6.5; C.V. = 32.1%

Sub plots: S.E. +/- 3.2; C.V. = 53.0%

Growth analysis

The dry matter of the plant components and plant heights are shown in Table 5 with effect from week 20. The measurements recorded prior to week 20 and all standard errors were excluded for reasons of clarity, as they were not considered to be sufficiently important to present. At each determination, the plant components were larger for the plants which received organic mulch and potassium, and by 28 weeks the dry weights of fruit from these treatments were almost three times as large as those from the other plants. The dry matter of plants generally reached a maximum at 28 weeks and thereafter declined in most treatments, whilst plant height was still increasing at 32 weeks. The plastic mulch had a favourable effect on plant growth as plants from this treatment were larger than those grown in bare soil probably due to reduced competition by weeds.

Nematodes

No plant pathogenic nematodes were found in the soil nor in the roots of chilli plants.

Soil values

The pretreatment soil pH values recorded at 12 weeks, just prior to the second applications of mulch and potassium, and of soil temperatures recorded at 7.5 cm depth are presented in *Table 6.* There was a small positive effect of mulch on the pH which decreased linearly with depth. Temperatures were higher under the plastic sheeting and bare soil than under the organic mulch (Table 6). There was little difference in the soil moisture values among the treatments and gravimetric determinations were discontinued after four samplings.

The concentrations of potassium in oven dry leaf and fruit material, and for leaf magnesium are shown in *Table 7.* The levels of leaf and fruit potassium were significantly higher in the plants

Table 5. **Changes in dry matter of plant components (g/plant) and plant height (cm) over time (Experiment 2).**

Age	Mulch			Potassium		Mulch			Potassium	
(weeks)	O	P	N	-K	+K	O	P	N	-K	+K
	Leaves					**Stems**				
20	41.7	27.6	16.3	23.1	33.9	44.7	36.0	18.5	29.3	36.8
24	70.2	31.4	19.6	27.0	53.8	87.1	52.8	24.6	40.5	69.1
28	91.4	36.3	26.6	27.6	76.3	132.6	55.3	40.1	49.1	102.9
32	66.8	35.9	25.2	26.6	58.6	118.6	71.8	46.9	58.1	100.0
	Roots					**Fruits**				
20	10.1	9.9	6.7	8.2	9.5	60.4	54.9	21.5	34.5	56.6
24	16.0	15.1	7.4	9.6	16.0	139.8	96.5	51.6	70.8	121.2
28	26.9	15.0	11.4	13.3	24.2	149.7	55.7	60.1	47.0	131.1
32	21.1	15.6	11.4	13.0	19.0	101.5	54.7	44.4	40.9	92.8
	Total dry matter					**Height**				
20	156.9	128.4	63.0	95.1	136.8	77.5	68.1	59.9	65.3	71.6
24	313.1	195.8	103.2	147.9	260.1	79.8	69.9	55.6	63.8	72.9
28	400.6	162.3	138.2	135.0	332.5	94.2	70.4	72.1	71.4	86.6
32	308.0	178.0	127.9	138.6	270.4	101.1	81.5	76.2	76.0	96.5

Table 6. **Soil pH values and temperatures at 7.5 cm depth (Experiment 2).**

	pH			Temperature (°C)	
	Surface	10 cm	20 cm	1200	1500
Pretreatment	6.00	5.60	5.10	-	-
No mulch	6.04	5.99	5.48	30.2	32.1
Organic mulch	6.40	6.26	5.70	28.1	29.8
Plastic mulch	-	-	-	32.5	35.3
Mulch effect	+ 0.36	+ 0.27	+ 0.22	-	-

	pH	
	s.e.d(0.05)	Sign. effect
mulch	0.22	*
soil depth	0.04	***

Main plots C.V. = 1.8%

Sub plots C.V. = 3.6

Table 7. **Mean percentages of potassium in oven-dry material of chilli plants (Experiment 2).**

	Leaf K (%)			Fruit K (%)			Leaf Mg (%)		
	-K	+K	Mean	-K	+K	Mean	-K	+K	Mean
Organic	4.61	4.70	4.66	3.01	3.31	3.16	0.98	0.88	0.93
Plastic	0.64	2.43	1.54	1.64	2.69	2.17	1.61	1.19	1.40
Nil	0.90	2.93	1.92	1.82	2.66	2.24	1.24	1.06	1.15
Mean	2.05	3.35	_	2.15	2.89	_	1.28	1.04	_
	s.e.d (0.05)	Sign. effects:							
Mulch	0.33	***		0.25	***		0.15	**	
K	0.35	***		0.28	***		0.14	**	
Mulch x K	0.33	**			n.s.			n.s.	
Main plots:	s.e. +/- 0.237			+/- 0.174			+/-0.100		
Sub plots:	s.e. +/- 0.139			+/- 0.113			+/-0.053		

which received applications of organic mulch or of potassium, particularly the leaf values. The values of leaf magnesium were significantly higher for plants which received no applications of organic mulch or potassium.

Analysis of mulch

Chemical analysis of the dried ground mulch showed that it contained 1.00% N; 0.23% P and 2.15% K which at the rate of 30 t/ha of mulch (25% dry matter) was approximately equivalent to 75 kg N, 18 kg P and 158 kg K per ha.

DISCUSSION

Applications of organic mulch and potassium resulted in increases in yield of chilli fruit of 96% and 69% respectively in Experiment 1, and of 170% and 113% respectively in Experiment 2. The different maximum productivities over time between the two experiments was partly due to the differential mortalities (11.0% compared to 5.4%) for the organic mulch/K combination in Experiments 1 and 2 respectively. The weights of plant components, of total dry matter and of plant height were much reduced in the plants which received no mulch or potassium (Table 5).

As the applications of mulch in Experiments 1 & 2 were equivalent to 158 and 210 kg/ha of elemental K respectively, it appears that the mulch effect was mainly a potassium effect, especially as K is so easily leached out of dead vegetation. The mulch plus potassium treatment produced the largest yields in both experiments and this was probably due to the increased input of potassium resulting from this treatment combination.

Applications of organic mulch and potassium reduced the percentage of plant deaths by 27% and 10% respectively in Experiment 1 and by 26% and 16% in Experiment 2 (Table 2 & 4). As the plants commenced to bear, potassium would be transferred to the fruit and as reserves of soil K were limiting, potassium deficiency probably accounted for mortality. *Sclerotium rolfsii* did not cause execessive plant mortality as infection was controlled by applications of PCNB. Analysis of plant tissues indicated that a crop of dry chillies (2500 kg/ha) removed approximately 62.5 kg/ha of K from the soil. The highest fruit yields recorded (16,288 kg/ha of fresh fruit, Experiment 1) would have extracted approximately 130 kg/ha of K from the soil, and as the treatment combination of organic mulch plus K would have contributed in excess of 340 kg/ha of K, it is likely that in addition to higher uptake of K in the leaf tissue of plants from high K treatments (Table 7), there was also considerable leaching of soluble K from the root zone. This is due to the nature of the soils of the Dala Series, and the high well distributed annual rainfall experienced on Malaita. The significant negative yield interaction between K and organic mulch (Table 1) provides strong evidence that the effect of mulch was to provide K to the crop.

The levels of potassium in the leaves and fruit were much higher in the plants which received applications of organic mulch or potassium (Table 7). Leaf potassium values ranged from 0.64 to 4.70%, and fruit potassium levels from 1.64 to 3.31%. The higher values of leaf magnesium in plants which received no applications of mulch or potassium (Table 7) was probably due to the antagonistic effect of K on Mg uptake (Mengel & Kirkby 1987). Additionally the improved growth caused by alleviation of K deficiency would be expected to result in further depression of leaf Mg concentrations due to growth dilution. Leaf magnesium levels ranged from 0.88 to 1.61%. There were however no significant differences in the fruit magnesium levels, nor between the levels of other elements analysed in the leaf and fruit tissue between treatments. The mulch was fairly rich in K as the cocoa pods and sweet potato vines were taken from fertilised plantings and all plant material contains a component of K. Mulch made from plant material collected from non-fertilised areas, always has a beneficial effect on tree crops and ornamentals on soils of the Dala Series.

It was considered important to determine whether pathogenic plant nematodes were present in the soil and root tissue, as mulch has been known to have a nematicidal effect in bananas (E. Edmunds, pers. comm. 1969). No pathogenic nematodes were found however, in the samples of roots and soil taken from and in association with moribund plants.

The plastic mulch (Experiment 2) resulted in increased yields of fruit (Table 3) and an enhanced plant growth (Table 5), compared to plants grown in bare soil. There were no significant differences in the soil moisture values between treatments. The soil temperatures recorded under the plastic mulch (Table 6) were higher than those of the other two treatments, and this may have affected plant growth and mortality of plants (Table 4). The plastic mulch eliminated weed growth, and thus more soil potassium was available for the chilli plants in this treatment as compared to the bare soil treatment. Weeds were however also suppressed to some extent by the organic mulch.

In Experiment 1, there was a small positive effect of mulch on the soil pH which decreased linearly with depth (Table 6). It is doubtful if such slight changes in pH would have any effect on nutrient availability or uptake. It may however indicate that on the mulched plots, relatively less cations were being leached down the profile or that more were being made available from the mulch. The decrease in pH with soil depth indicates that nutrients are being recycled by the vegetation (Ballantyne 1961).

Further work will be required to determine if the

costs of application of potassium and mulch to enhance yields of chillies in the Solomon Islands are economic, based on current costs and prices. Alternatively, would the mulch be better used on an alternative crop. The local farmers have knowledge of the improved plant performance which results from the use of mulch on soils of the Dala Series

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