Turmeric - maize and onion intercropping systems. III. Nutrient uptake

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ABSTRACT

Experiments were conducted at Bhavanisagar and Coimbatore (Tamil Nadu, India) to determine uptake of nutrients as influenced by intercropping systems with turmeric (*Curcuma longa*) - maize (*Zea mays*) and onion (*Allium cepa*), and to study nitrogen uptake pattern by various plant parts of turmeric in such situations. The results revealed that nutrient uptake by the intercropping systems was higher than the uptake of either of the sole crops of turmeric, maize and onion. The total uptake of nitrogen by various intercropping systems varied from 61 to 80 per cent more than the uptake of nitrogen by the sole crop of turmeric at Bhavanisagar and 57 to 77 per cent at Coimbatore. Similarly it varied from 82 to 104 per cent more than the sole crop of maize at both the locations. A similar result was obtained in onion also. Similar trends were observed in uptake of phosphorus and potassium in the intercropping systems. The results indicated that for sustainable production of intercropping systems, meeting the combined nutritional requirements of component crops is essential.

Key words : intercropping systems, nutrient uptake, maize, onion, turmeric.

Introduction

Many studies have shown greater uptake of nutrients where intercropping has produced a yield advantage. As with water, greater nutrient uptake is usually presumed to be possible because of greater root concentrations or some complementary exploration of the profile. In some instances greater nutrient uptake might be due to the use of nutrients unavailable to sole crops. Intercropping, thus probably makes greater demands on the soil and in the long term yield advantages may have to be paid for with higher nutrient inputs (Willey 1990). Earlier studies suggested that competition between intercropped species occurs first for the mobile resources of water and N since the depletion zones around roots for these

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resources would occur most rapidly, be the largest, and overlap first (Kurtz, Melsted & Bray 1952; Bray 1954). Biological efficiency is likely to result when the intercrop either explores a larger soil mass or explores the same soil mass more completely, compared to sole planting of the same species. There is also a possibility of differences in time of peak demand for different nutrients by the components in the mixture (Willey 1979; Francis 1989). Nutrient competition can be minimized in intercropping systems by selecting species with different rooting patterns (Chang, Chang & Ho 1969), nutrient requirements, timing of peak demand for nutrients (Willey 1979), or by proper plant spacing (Dalal 1974). Nutrient competition is reflected by lower nutrient concentrations in plant parts (Dalal 1974). An advantage of intercropping systems is greater total uptake of nutrients from the soil (Dalal 1974), although this may be reflected on the greater dry matter production due to better use of light or water rather than better nutrient use. However there is no information on nutrient uptake of turmeric under various intercropping systems. The objectives of this study were (i) to determine uptake of nutrients as influenced by intercropping systems with turmeric and maize, and (ii) to study N uptake pattern by various plant parts of turmeric in intercropping situations.

Materials and methods

The field design and materials used were as described previously (Sivaraman & Palaniappan 1994; 1995). Therefore, only the facets relevant to this paper are presented here. The treatments consisted of five intercropping systems and four levels of nitrogen with one of the treatments involving a biofertilizer (*Azospirillum brasiliense*). A split plot design with three replications was adopted for the study. The treatment details are given below.

Main plots : Intercropping systems

T	-	Sole crop of turmeric
$T + M_1$	-	Turmeric (100) + Maize (100)
$T + M_2$	-	Turmeric (100) + Maize (100) + Alternate rows of maize cut for fodder on 60th day
$T + M_3$	-	Turmeric (100) + Maize (50)
$T + M_3 + O$	-	Turmeric (100) + Maize (50) + Aggregatum onion (23)

(Figures in parentheses indicate percentage of the recommended sole crop population)

Sub plots : Nitrogen levels

N_{125}	-	125 kg N/ha (recommended dose of N for turmeric)
$N_{187.5}$	-	187.5 kg N/ha (recommended dose of N + 50 per cent of N recommended for maize)
$N_{187.5} + A$	-	187.5 kg N/ha - *Azospirillum* to maize
N_{250}	-	250 kg N/ha (full dose of recommended N for turmeric and maize)

Maize and onion were also raised as sole crops at 100 per cent population adopting recommended package of practices for comparison. Small plots (6 x 4 m) in

the respective experimental plots were used for sequential dry matter harvest. Dry matter sampling in various treatments were made at monthly intervals from 30 days after planting (DAP) for maize and 60 DAP for turmeric. For dry matter sampling, five plants each of turmeric and maize were uprooted at each stage with minimum damage to roots. In the case of maize, whole plants were chopped into manageable pieces and oven dried at 60°C till a constant weight was reached. In turmeric, sampling was done similarly by uprooting five plants from the demarcated area from the plot and separating them into shoots, rhizomes and roots, and oven dried at 60°C till a constant weight was reached. Dry matter weights of individual components were added to arrive at total dry matter accumulation. These samples were used for nutrient analysis and calculating nutrient uptake. The samples were dried at 60°C, ground in a Wiley mill to pass through 60-mesh screen, and analysed for N, P and K concentrations. Nitrogen concentration was measured by micro-Kjeldahl procedures (Bremner & Mulvaney 1982), P concentration by molybdenum blue colorimetric technique (Murphey & Riley 1963) and K concentration by emission spectrophotometry; N, P and K uptake was calculated by multiplying the quantity of dry matter for plant parts by the nutrient concentrations. In the case of P and K, uptake was calculated for maize and turmeric at the time of harvest only. In turmeric, uptake of N was calculated from 60 DAP at an interval of 30 days till harvest at 270 DAP.

Results and discussion

Nitrogen uptake

Intercropping systems and N levels showed significant influence on the uptake of N by maize both at Bhavanisagar and Coimbatore (Tables 1 and 2). Maximum N uptake was recorded in higher population of maize ($T + M_1$) and the lowest uptake in $T + M_3$. Application of stipulated fertilizer doses both for maize and turmeric in the intercropping systems (N_{250}) resulted in increased uptake of N than in other N levels. Values recorded for N uptake were slighly lower in Bhavanisagar. Uptake of N by the sole crop was lower by 6 per cent in Bhavanisagar and 16 per cent in Coimbatore as compared to the N uptake by maize in $T + M_1$.

N uptake by turmeric was maximum in the sole crop of turmeric during all the stages at both the locations. The reduction in uptake of N by turmeric between sole cropping and other intercropping systems varied from 12 to 22 per cent at Bhavanisagar and 8 to 16 per cent at Coimbatore during harvest (270 DAP). Uptake values were higher at Coimbatore than at Bhavanisagar. Nitrogen levels also showed significant effect on the uptake of nutrients; higher uptake of N was recorded in N_{250}. The differences between N_{125} and N_{250} were 6 per cent at Bhavanisagar and 10 per cent at Coimbatore. Mean N uptake pattern over intercropping systems and N levels showed that N uptake by shoots reached a peak by 150 DAP and then declined (Fig 1). Root and rhizome uptake of N showed an increasing trend up to harvest; this trend was observed at both the locations. At the time of harvest (270 DAP), maximum N accumulation was observed in rhizomes (83 and 85 per cent at Bhavanisagar and Coimbatore, respectively) followed by shoots (10 and 9 per cent) and roots (6.6 and 6.2 per cent).

Table 1. Nitrogen uptake by component crops in different intercropping systems and nitrogen levels (Bhavanisagar 1989-90)

Treatment	Turmeric (Days after planting)								Maize	Onion	Total uptake	Per cent increase over sole turmeric	Per cent increase over sole maize
	60	90	120	150	180	210	240	270					
T	8.31	15.4	51.7	120.4	132.5	150.1	164.0	166.2	-	-	166.2	-	13.4
$T+M_1$	7.60	13.1	39.7	91.1	103.4	116.9	134.4	136.3	155.9	-	292.2	75.8	99.3
$T+M_2$	7.81	13.3	40.1	94.7	111.5	118.0	140.5	140.5	138.0	-	278.5	67.6	89.9
$T+M_3$	8.10	13.8	42.6	101.4	112.8	121.2	144.2	146.2	120.9	-	267.1	60.7	82.2
$T+M_3+O$	7.90	14.0	43.0	105.3	113.1	123.1	147.3	148.6	132.6	17.6	298.8	79.8	103.8
SE_d	0.15	0.1	0.2	1.4	2.4	0.5	0.6	0.7	1.0	-	3.6	-	-
$CD_{(0.05)}$	NS	0.2	0.5	3.0	5.3	1.2	0.15	0.15	2.1	-	8.3	-	-
N_{125}	7.50	13.6	40.6	95.7	107.2	121.4	141.3	143.8	125.1	17.0	285.9	72.0	95.0
$N_{187.5}$	7.90	13.8	43.3	102.4	115.1	124.9	144.4	146.6	137.8	17.3	301.4	81.3	105.6
$N_{187.5}+A$	7.81	14.1	43.4	102.0	115.3	125.3	145.4	146.9	137.5	17.2	301.8	81.6	105.9
N_{250}	8.51	14.2	46.4	110.4	120.9	131.9	153.5	152.9	147.0	18.8	318.7	91.8	117.4
SE_d	0.27	0.1	0.2	2.1	1.3	1.2	1.3	1.2	0.8	-	5.2	-	-
$CD_{(0.05)}$	NS	0.3	0.5	4.9	2.8	2.5	2.8	2.8	1.7	-	12.2	-	-
Sole crop	-	-	-	-	-	-	-	-	146.6	37.8	-	-	-

Values indicate N uptake in kg/ha
*Includes uptake of N by turmeric + maize + onion

Table 2. Nitrogen uptake by component crops in different intercropping systems and nitrogen levels (Coimbatore 1990-92)

Treatment	Turmeric (Days after planting)								Maize	Onion	Total uptake	Percent increase over sole turmeric	Per cent increase over sole maize
	60	90	120	150	180	210	240	270					
T	8.0	16.6	77.0	125.8	150.7	160.9	170.6	188.6	-	-	188.6	-	15.8
$T+M_1$	7.7	14.2	57.6	97.1	125.7	140.5	152.7	163.2	169.8	-	333.0	76.6	104.0
$T+M_2$	7.7	14.3	56.4	98.5	130.1	145.4	152.4	169.2	140.1	-	309.3	64.0	89.9
$T+M_3$	7.7	15.3	58.5	101.6	131.8	147.8	154.6	172.7	122.7	-	295.4	56.6	81.3
$T+M_3+O$	7.7	15.3	59.8	106.1	131.0	147.9	162.4	174.4	123.7	14.4	312.5	65.7	91.8
SE_d	0.1	0.1	1.0	1.1	0.8	1.1	1.4	1.0	1.1	-	4.7	-	-
$CD_{(0.05)}$	NS	0.2	2.6	2.3	2.1	2.5	2.8	2.3	2.7	-	11.1	-	-
N_{125}	7.1	14.7	59.2	100.9	129.2	145.0	155.1	169.0	128.6	13.2	297.6	57.8	82.7
$N_{187.5}$	7.7	15.1	60.9	105.0	134.4	148.0	158.6	173.6	139.1	14.6	312.6	65.7	91.9
$N_{187.5}+A$	7.8	15.0	62.1	106.8	134.2	148.0	158.1	173.6	138.6	14.2	312.2	65.5	91.7
N_{250}	8.3	15.7	65.2	112.0	138.7	154.1	160.8	173.5	150.0	15.6	328.5	74.2	101.7
SE_d	0.1	0.1	0.7	0.9	0.7	0.9	0.7	0.7	0.8	-	6.2	-	-
$CD_{(0.05)}$	0.2	0.2	1.5	1.8	1.5	1.9	1.4	1.4	1.6	-	14.6	-	-
Sole crop	-	-	-	-	-	-	-	-	162.9	24.7	-	-	-

Values indicate N uptake in kg/ha
*Includes uptake of N by turmeric + maize + onion

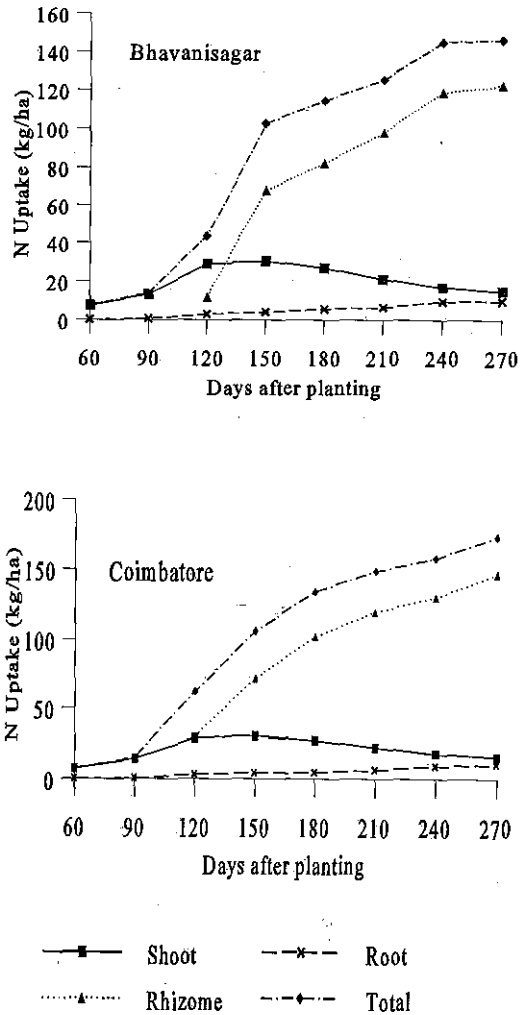

Fig. 1. Nitrogen uptake pattern at Bhavanisagar (1989-90) and Coimbatore (1990-91)

Nitrogen uptake by the intercropped onion was less by 115 and 72 per cent at Bhavanisagar and Coimbatore respectively, as compared to sole crop of onion. There was an increasing trend in N uptake with increasing levels of N, but the increase was 11 per cent at Bhavanisagar and 18 per cent at Coimbatore in the treatment N_{250} over N_{125}. No marked effect of addition of biofertilizer was observed in terms of N uptake by onion.

The differences in the values of N uptake between sole crop of turmeric and intercropping systems were significant at both the locations. The increase in uptake of N due to intercropping systems was significant over sole cropping of turmeric and it varied from 61 per cent in T + M_3 to 80 per cent in T+M_3+O at Bhavanisagar, and 57 per cent in T+M_3 to 77 per cent in T + M_1 at Coimbatore. The greater nutrient uptake by intercropping systems is attributed to higher total dry matter production in the system (Sivaraman & Palaniappan 1995). Increasing N levels showed a significant and positive influence on uptake of N at both the locations. The increase due to N_{250} over N_{125} varied from 12 per cent at Bhavanisagar and 10 per cent at Coimbatore. Addition of biofertilizer ($N_{187.5}$ + A) did not influence the uptake of N over $N_{187.5}$. A similar trend was also observed at Coimbatore.

Phophorus uptake

There was an increased uptake of P_2O_5 (10.3 and 9.4 per cent at Bhavanisagar and Coimbatore, respectively) by maize in the treatment T + M_1 (Table 3). However, P_2O_5 uptake in the other intercropping systems was less than P_2O_5 uptake observed in the sole cropping of maize at both the locations. Nitrogen levels did not show significant effect on P_2O_5 uptake by maize. Phosphorus uptake by intercropped onion was less by 72 per cent at Bhavanisagar and 49 per cent at Coimbatore as compared to sole cropping. Nitrogen levels did not show marked effect on the

Table 3. Phosphorous and potassium uptake at harvest by component crops in various intercropping systems and nitrogen levels

Treatment	Bhavanisagar (1989-90)								Coimbatore (1990-91)							
	Onion		Maize		Turmeric		Total		Onion		Maize		Turmeric		Total	
	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O
T	-	-	-	-	36.5	285.3	36.5	285.3	-	-	-	-	39.2	327.2	39.2	327.8
$T+M_1$	-	-	56.9	197.3	30.1	266.4	87.0	463.7	-	-	57.0	207.4	31.6	269.4	88.6	476.8
$T+M_2$	-	-	42.6	174.6	31.9	271.5	74.5	446.1	-	-	38.6	170.7	32.4	278.8	71.0	449.5
$T+M_3$	-	-	38.3	167.3	31.5	281.1	69.8	448.4	-	-	40.1	172.5	32.1	283.7	72.2	456.2
$T+M_3+O$	7.4	22.6	38.5	168.7	31.3	282.9	77.2	474.2	6.8	18.4	40.2	173.9	32.2	284.0	79.2	476.9
SE_d	-	-	0.8	1.2	0.4	2.3	3.2	6.9	-	-	1.4	1.1	0.54	0.8	2.3	12.5
$CD_{(0.05)}$	-	-	1.8	3.0	0.9	5.2	7.5	16.2	-	-	3.7	2.6	1.24	1.8	5.6	31.5
N_{125}	7.4	21.8	44.1	175.3	31.4	281.2	82.9	478.3	6.7	18.1	45.0	177.7	33.1	285.8	84.8	481.6
$N_{187.5}$	7.2	22.6	44.3	177.2	31.9	286.5	83.4	486.3	6.9	18.3	43.9	181.5	33.8	288.3	84.6	488.1
$N_{187.5}+A$	7.4	22.7	44.4	178.3	32.1	268.1	83.9	469.1	6.8	18.6	43.1	181.8	33.5	288.8	83.4	489.2
N_{250}	7.6	23.3	44.5	179.0	32.8	273.9	84.9	476.2	6.8	18.4	43.8	183.5	33.7	292.0	84.3	493.9
SE_d	-	-	0.5	0.7	0.2	1.5	0.7	1.1	-	-	1.3	0.8	0.3	0.5	1.3	1.2
$CD_{(0.05)}$	-	-	NS	1.5	0.5	3.1	NS	2.6	-	-	NS	1.6	NS	1.1	NS	2.8
Sole crop	12.7	36.9	51.6	186.4	-	-	-	-	10.1	24.4	52.1	195.6	-	-	-	-

Values indicate P_2O_5 uptake in kg/ha

uptake of P_2O_5 by onion. Sole cropped turmeric recorded the highest uptake of P_2O_5 as compared to intercropped turmeric. The effect of N levels on P_2O_5 uptake by turmeric though significant at Bhavanisagar, the differences were marginal. Raising 100 per cent of the recommended population of maize as an intercrop in turmeric ($T+M_1$) resulted in the highest uptake of P_2O_5 at both the locations compared to other intercropping systems. The combined uptake of P_2O_5 by turmeric and maize in $T + M_1$ was higher by 130 and 69 per cent than the sole crop of turmeric and maize respectively, at Bhavanisagar; it was 126 and 70 per cent more than that of sole crop of turmeric and maize respectively, at Coimbatore. Nitrogen levels did not have a significant effect on the total uptake of P_2O_5 at both the locations.

Potassium uptake

Potassium uptake by maize was influenced by intercropping systems and N levels (Table 3). Maximum uptake of K_2O by maize was recorded when 100 per cent of the sole crop population was planted with turmeric ($T+M_1$) and this was about 6 per cent higher than the sole cropped maize at both the locations. Higher levels of N showed significant effect in the increased uptake of K_2O by maize. Addition of biofertilizer to maize did not increase the uptake of K_2O.

Sole cropping of turmeric recorded maximum uptake of K_2O at both the locations as compared to the uptake of K_2O by turmeric in the intercropping systems. However the differences between the values of K_2O uptake recorded in sole crop of turmeric (T), $T+M_3$ and $T+M_3+O$ were on par. The interaction effect of intercropping systems and N levels was significant at Bhavanisagar and this exhibited a similar trend as that of main effects.

Potassium uptake by onion was lower by 63 per cent at Bhavanisagar and 33 per cent at Coimbatore when onion was grown as intercrop with turmeric and maize than grown as a sole crop. Nitrogen levels did not have a marked effect on the uptake of K_2O by onion in both the locations.

Total uptake of K_2O by the component crops in the intercropping systems was highest in $T+M_3+O$ followed by $T+M_1$ at both the locations. But the differences between the above treatments were not significant.

In general, nutrient uptake in intercropping systems was higher than either of the sole crops of turmeric, maize or onion. The total uptake of N by the various intercropping systems varied from 61 to 80 per cent more than the uptake of N by the sole crop of turmeric at Bhavanisagar and 57 to 77 per cent at Coimbatore. Similarly, it varied from 82 to 104 per cent more than the sole crop of maize at both the locations. A maximum uptake of 279 kg/ha of N in $T+M_3+O$ at Bhavanisagar and 333 kg/ha at Coimbatore ($T+M_1$) was recorded. Similar trends were also observed with P_2O_5 and K_2O uptake in the intercropping systems. The greater uptake probably represents efficient use of the same resources that is available to sole crops. This clearly shows that for sustainable production of intercropping systems meeting the combined nutritional requirement of the component crops is essential. Therefore turmeric-maize and onion intercropping systems often lead to more rapid mining of natural soil fertility and require higher nutrient application rates than the corresponding sole crops.

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