Nutrient Uptake and Productivity as Affected by Nitrogen and Potassium Application Levels in Maize/Sweet Potato Intercropping System

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ABSTRACT: Field experiment was conducted during 1993-94 season to determine the pattern of nutrient uptake and productivity of maize/sweet potato intercropping system. Four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and four levels of potassium (0, 40, 80 and 120 kg K_20 ha^{-1}) formed treatment variables. Plants were sampled periodically to determine dry matter and tissue concentrations of N and K in the individual plant components of intercropped maize and sweet potato. Nitrogen and potassium fertilizer did not interact significantly to nutrient uptake by any plant parts of intercropped maize and sweet potato. But application of N fertilizer independently enhanced N uptake in all the plant parts of maize and sweet potato.The uptake of N in leaf, leaf sheath, stem, husk, and cob of maize increased upto 90 days after planting (DAP) but grain continued to accumulate N till its maturity. Sweet potato exhibited a wide variation in N uptake pattern. Sweet potato leaf shared the maximum uptake of N at 50 DAP which rapidly increased at 70 DAP and then declined. Declination of N uptake by petiole and stem were observed after 120 DAP whereas N uptake by tuber increased slowly upto 90 DAP and then rapidly till harvest. Rate of applied K had very little effect on the uptake patterns in different components of intercropped maize. Pattern of K uptake by leaf, petiole and stem of sweet potato showed almost similar trend to N uptake. But uptake of K by tuber increased almost linearly with the K application. Pattern of N and K uptake by grain and tuber paralleled the grain yield of maize and sweet potato respectively. Intercropped productivity of maize and sweet potato found to be better by the application of 100 kg N and 120 kg K_2O ha^{-1}.

Keywords : nitrogen, potassium, nutrient uptake, maize, sweet potato, intercropping.

Two high yield potential crops maize and sweet potato are widely grown in many parts of the world and becoming more popular for their diversified use. Production may be increased by several folds by growing these two crops in association as they possess different photosynthetic pathways, different growth habit and requirement for different growth resources (Ogunlela *et al.*, 1988). Despite different advantages of intercropping (Okigbo and Greenland), there is difficulty in quantifying and applying fertilizers for obtaining maximum benefit from the component crops of intercropping system. In maize/sweet potato intercropping system both the crops are responsive to nitrogen fertilizer (Moreno, 1982), but the degree of response varies greatly. Nitrogen had the largest effect on grain yield and nitrogen content of maize (Rabuffetti and Kamprath, 1977) and showed a linear response upto 180 kg N ha^{-1} and thereafter declined (Sharma *et al.*, 1979). On the contrary, response of sweet potato to nitrogen fertilizer is much lower than maize and excess nitrogen causes unusual vine growth and reduces the yield and quality of tuber (Constantin *et al.*, 1974). Conversely, maize is less responsive (Steele, 1985) but sweet potato is highly responsive to applied potassium for tuberous root yield (Nicholaides *et al.*, 1985). However excess in applied potassium to sweet potato may lead to luxury consumption of potassium (Maity and Arora, 1980). Inorganic fertilizers are both scarce and costly. It is therefore imperative that fertilizer should be applied only when plants require the nutrients. Such need-based fertilizer application is possible only when there is adequate information on the pattern of uptake of a particular nutrient (Singh and Randhawa, 1979). Information on the nitrogen and potassium uptake pattern of maize and sweet potato under intercropped condition is currently unavailable. This study therefore examines the pattern of nutrient uptake and productivity of maize and sweet potato under intercropping system.

MATERIALS AND METHODS

The experiment was carried out at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur, Bangladesh during winter season of 1993-94. The soil of the experimental plot is loamy and winter months range from November to February. The experiment consisted of four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and four levels of Potassium (0, 40, 80 and 120 kg K_20 ha^{-1}) applied in a maize sweet potato intercropping system. Sole maize was fertilized at the rate of 100-60-40 kg and sole sweet potato at the rate of 40-60-40 kg N, P_2O_5 and K_2O per hectare. In

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intercropped maize and sweet potato 60 kg P_2O_5 ha^{-1} was applied as general dose. The design of the experiment was factorial randomized complete block with three replications. The density of maize/sweet potato was 50 : 100 and maize was sown in pair rows as this showed the best performance in an earlier experiment (Basak *et al.*, 1993). The crops were established on December 2, 1993. The crops were managed properly through out the growing season. Plant samples were harvested from 1 m^{-2} area at 50, 70, 110 and 130 days after planting (DAP) and separated into different components. The samples were oven-dried at 70°C for at least 72 hours to a constant weight. Total nitrogen (N) concentration in different plant parts were determined by modified Kjeldahl digestion colorimetric method (Cataldo *et al.*, 1974) and for potassium (K), methods derived by Hunter (1984). Based on the nitrogen and potassium content of the plant components, N and K uptake were determined by multiplying with their respective dry matter weight. The component crop maize was harvested at 130 and sweet potato at 150 days after planting. The yield data of maize and sweet potato were statistically analysed and means were compared using Duncan's Multiple Range Test (DMRT). Sole crops were also grown out side the treatment structures for evaluating the intercropped productivity. The intercropped productivity of maize and sweet potato was determined in terms of total edible yield (Fukai and Trenbath, 1993), land equivalent ratio (LER) as Horst, 1995 and monetary return (Shah *et al.*, 1991). Gross return was calculated by multiplying the products to their respective market prices and gross margin was obtained by subtracting the variable fertilizer cost from gross return.

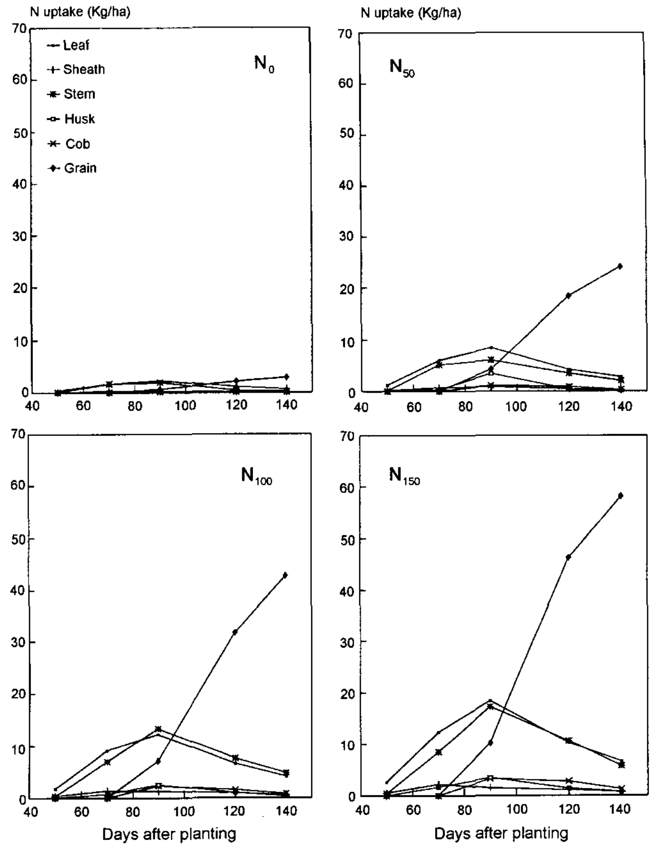

Fig. 1. Seasonal profile of nitrogen uptake by intercropped maize as affected by applied nitrogen fertilizer.

RESULTS AND DISCUSSION

Data relating pattern of N and K uptake and yield of maize and sweet potato did no interact significantly due to application of N and K fertilizers. So the independent effect of N and K to pertaining data were discussed here. Nitrogen is one of the key factor in regulating the growth and yield of crops and nitrogen uptake by plants components often has been used as an index of crops N requirement. The uptake of N by intercropped maize and its distribution in different parts during the growing season indicated that increased rates of applied N enhanced N uptake in all the plants parts (Fig. 1). The extremely low accumulation of N was apparent by maize of 0 Kg N ha^{-1} treatment and highest from 150 kg N ha^{-1}. The intermediate level of N fertility provided the intermediate amount of N accumulation in intercropped maize. Higher uptake of N by intercropped maize under higher applied N also reported by Chowdhury and Rosario (1992). However, the pattern of N distribution in different parts of maize did not appear to differ appreciably from the different treatments. The uptake of N in leaf, leaf sheath, stem, husk and cob of maize increased upto 90 DAP with the increase of plant growth and thereafter declined. Such decline of N uptake in vegetative parts after 90 DAP corresponded to the increase of N uptake in grain. The grain continued to accumulate N till its maturity and finally it accounted for the maximum proportion of N at harvest.

Nitrogen uptake by intercropped sweet potato significantly increased with the increasing rate of applied N and there was appreciable variation among the plant components in the pattern of N accumulation over time (Fig. 2). The higher level of applied N produced higher amount of biomass which accompanied with higher uptake of N (Singh and Arora, 1980). In comparison with different parts, the share of leaf in N uptake was maximum at 50 DAP which rapidly increased at 70 DAP with the increase of dry weight and N concentration in leaf. Afterwards, N uptake was sharply declined in plants treated with 0 and 50 kg N ha^{-1} and slowly declined in plants with 100 and 150 kg N ha^{-1}. The uptake of N by petiole was lowest and N uptake by stem continued to increase upto 120 DAP and then declined a lit-

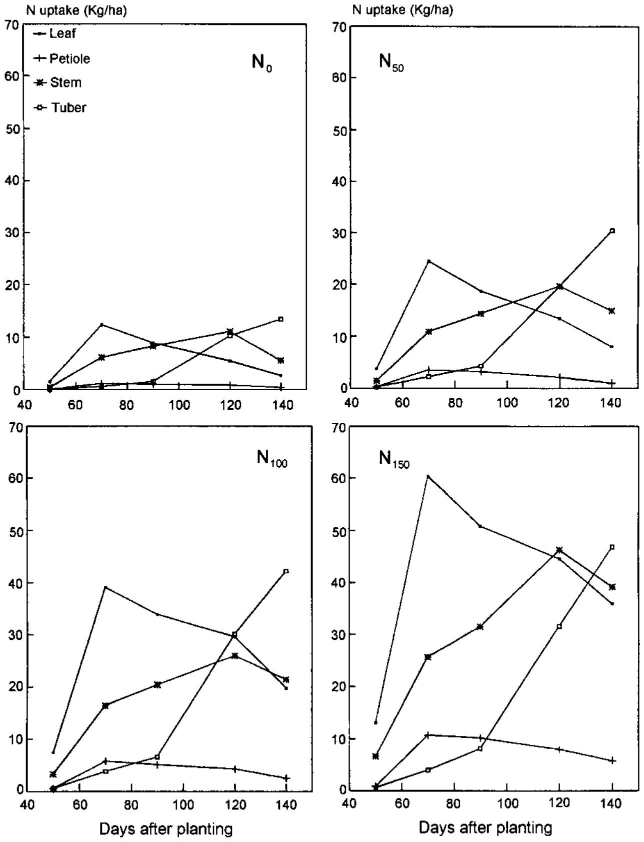

Fig. 2. Seasonal profile of nitrogen uptake by intercropped sweet potato as affected by applied nitrogen fertilizer.

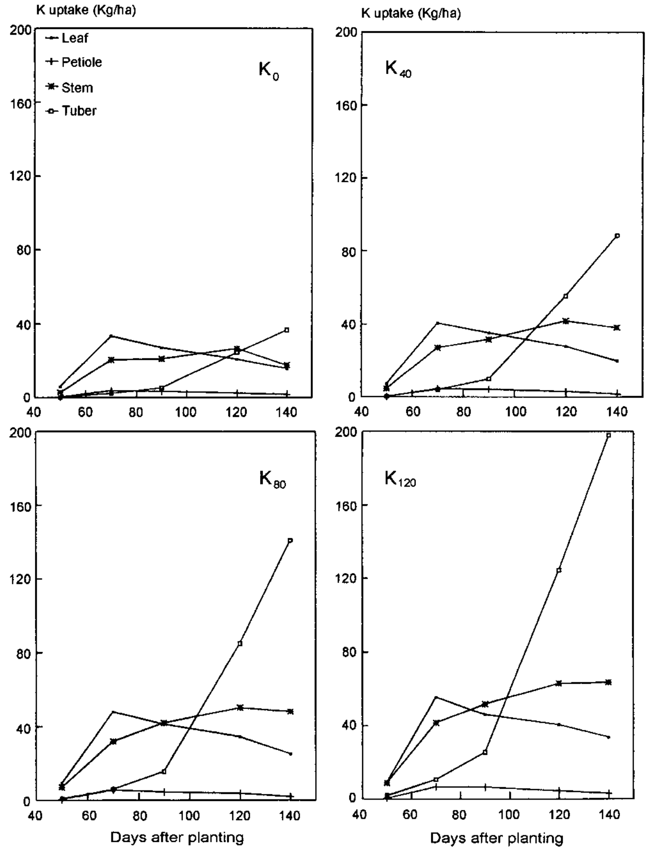

Fig. 3. Seasonal profile of potassium uptake by intercropped sweet potato as affected by applied potassium fertilizer.

tle. Uptake of N by sweet potato tuber was very slow upto 90 DAP due to its low amount of dry matter coupled with low N concentration. However, there was a sudden increase in N uptake at 120 and 140 DAP which exceeded the N uptake by any other parts of sweet potato. Although N concentration in tuber was consistently lower than the other segments of the plants, highest dry matter accumulation in tuber in later season peaked the N uptake by sweet potato tuber (Bruns and Bouwkamp, 1989).

Potassium uptake of intercropped maize was not profoundly affected by applied K and thus only uptake of K by intercropped sweet potato was discussed. Potassium uptake by different plant components of sweet potato under four levels of K showed the striking difference over the growing season (Fig. 3). Higher levels of K tended to show greater K uptake in all the components and uptake of K by leaf and petiole increased upto 70 DAP and declined afterwards in accordance with K levels. The lower levels of K showed rapid decrease in K uptake by leaf and petiole indicating the translocation of K to rapidly growing tuber at the later stage. The stem however showed a almost steady state increase in K uptake through out the growing season. The higher level of K exhibited tremendous effect on K uptake by sweet potato tuber. The K uptake by sweet potato tuber increased almost linearly with increase of K application. Sweet potato grown without applied K showed a uptake of only 36.53 kg and as much as 198.03 kg ha^{-1} by tuber treated with 120 kg K_2O fertilizer. The greater amount of K uptake by tuber in heavily fertilized crop was associated with increased dry matter together with higher K content as well as K remobilized from other vegetative organs of sweet potato.

The effect of N on the grain yield of maize was highly significant (Table 1). Grain yield of maize responded favourably to applied N and higher the rate of applied N higher was the yield of maize. The higher yield of maize seemed to be directly related to the greater availability of N as clearly demonstrated by greater amount of N uptake by the plants. The yield of intercropped sweet potato responded to levels of applied N much differently than it was observed in maize. Sweet potato at 100 kg N ha^{-1} showed the best performance in producing tuberous root yield (27.42 t ha^{-1}). The lowest tuberous root yield (11.10 t ha^{-1}) was recorded from the control treatment which was followed to the yield obtained by 150 Kg N ha^{-1} (20.10 t ha^{-1}). The result emphasized the

Table 1. Production, land use and monetary efficiency of intercropped maize and sweet potato under varying levels of nitrogen and potassium fertilizer.

Fertilizer levels (Kg ha^{-1})	Edible yield (t ha^{-1})			Partial LER		LER	Gross return ($ ha^{-1})	Fertilizer cost ($ ha^{-1})	Gross margin ($ ha^{-1})
	Maize	S.potato	Total	Maize	S. potato				
N									
0	0.27d†	11.10d	11.37b	0.06	0.36	0.42	221.88	0	221.88
50	1.47c	22.94b	24.41a	0.32	0.73	1.05	544.04	10.08	533.96
100	2.43b	27.42a	29.85a	0.53	0.88	1.41	713.38	20.17	693.21
150	3.38a	20.10c	23.48a	0.73	0.64	1.37	672.81	30.25	642.56
K_2O									
0	1.77a	16.83d	18.60a	0.38	0.54	0.92	643.98	0	463.98
40	1.81a	19.78c	21.59a	0.39	0.64	1.03	519.96	9.75	510.21
80	1.99a	21.72b	23.71a	0.43	0.70	1.13	571.19	19.48	551.71
120	1.97a	23.23a	25.20a	0.43	0.75	1.18	596.06	85.48	510.58
Sole Maize	4.60‡	-	4.60	-	-	1.00	431.25	34.77	396.48
Sole S. potato	-	31.14‡	31.14	-	-	1.00	551.44	29.98	521.46

†Means in a collum followed by same letter did not differ significantly at 0.05 level.
‡Yield of sole crops was considered for evaluating the intercropped productivity.

requirement of N fertilizer but higher rate was detrimental in sweet potato yield. The effect of applied K on the grain yield of maize was not significant. But applied K increased the sweet potato yield almost linearly with its increasing rates. The higher level of K in the improvement of tuberous root yield of sweet potato also observed by Ashokan *et al.* (1984).

Intercropped productivity of maize/sweet potato intercropping system was determined considering the independent effect of N and K because of their non significant interaction effect on the yields of two crops. Intercropped productivity in terms of total edible yields, the treatment 100 kg N ha^{-1} produced the highest (29.85 t ha^{-1}) yield which was followed by the treatment 50 kg N ha^{-1} and 150 kg N ha^{-1} (Table 1). The lowest total edible yield (11.37 t ha^{-1}) was obtained from the control treatment. The total edible yield increased with the increase of K levels and the highest yield (25.20 t ha^{-1}) was found from the highest treatment 120 kg K_2O ha^{-1}. Land use efficiency (LER) was highest (1.41) in treatment of 100 kg N ha^{-1} in maize/sweet potato intercropping system.In this treatment contribution of partial LER of intercropped sweet potato (0.88) was higher than the partial LER of intercropped maize (0.53). The second highest LER (1.37) was observed in case of 150 kg N ha^{-1} and lowest (0.42) from control treatment. The influence of K in LER showed that K had very little effect on partial LER of intercropped maize but it had great effect on partial LER of intercropped sweet potato. From applied K the highest LER (1.18) was found in the treatment 120 kg K_2O ha^{-1} and decreased gradually with the decrease of K levels and dropped below 1.00 under unfertilized treatment. The effect of nutrients on LER also reported by Chowdhury and Rosario (1992) in maize/mungbean intercropping system.

Monetary advantage is an important consideration in practicing intercropping system under subsistence farming. Highest monetary efficiency in terms of both gross return and gross margin were observed in the treatments 100 kg N ha^{-1} and 120 kg K_2O ha^{-1} in maize/sweet potato intercropping system. The highest gross margin ($ 693.21 ha^{-1})was obtained from the treatment 100 kg N ha^{-1}. From K application the highest gross margin ($ 510.56 ha^{-1}) was found from the treatment 120 kg K_2O ha^{-1}. The gross margin decreased with the further increase or decrease of N levels but it increased progressively with the increase of K levels.The monetary efficiency of maize/sweet potato intercropping system at 100 kg N and 120 kg K_2O ha^{-1} indicated the best intercropping combination.Monetary advantage in intercropping maize with different grain legumes was also reported by Shah *et al.* (1991).

The results discussed in this paper provide a good indication in better fertilizer management in maize/sweet potato intercropping system. Based on the nutrient uptake, total edible yield, better land use and monetary return, a moderate rate of nitrogenous fertilizer (100 kg N ha^{-1}) and higher rate of potash fertilizer (120 kg K_2O ha^{-1}) might be the most productive and economical intercropping system. However, further research combining with more levels of N and K may be undertaken to explore the most appropriate fertilizer requirement for maize/sweet potato intercropping system.

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