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CUCUMBER RESPONSE TO CATTLE MANURE LEVELS AND *N* AND *K* SPLIT APPLICATION FREQUENCIES IN THE SANDY REGOSOLS

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ABSTRACT

Cucumber (*Cucumis sativus*) has been introduced recently to the intensive and highly commercialized crop production system in sandy regosols of the Kalpitiya peninsula. The concentrated inorganic fertilizer nitrogen (N) and potassium (K) leaching losses in highly permeable sandy soil owing to frequent overhead irrigation and heavy *maha* rains impair its productivity. In order to address these issues, a field experiment was conducted during *maha*, 1999/2000 and *maha*, 2000/2001 at the Agricultural Research Station, Kalpitiya. In this experiment, the influence of three cattle manure levels (0, 05 and 10 t/ha) and four N and K split-application frequencies (3, 4, 6, and 8) on the productivity of slicing cucumber variety "LY-58" was examined. Increasing the cattle manure level significantly increased cucumber yields and highest yields recorded were 23.3 t/ha and 21.7 t/ ha at the 10 t/ ha level during *maha*, 1999/2000 and *maha*, 2000/2001, respectively. Cucumber yields showed a significantly increased (p=0.05) response to increasing N and K split application frequencies during *maha*, 2000/2001. The interaction between cattle manure levels and N and K split application frequencies for yield was significant (p=0.05) during *maha*, 2000/2001. The mean fruit weight was significantly increased (p=0.05) by the increased application of cattle manure during *maha*, 2000/2001. The mean fruit weight showed a significantly increasing response during *maha*, 2000/2001 to increased N and K application frequencies. The mean fruit number plant $^{-1}$ was significantly increased (p=0.05) by the increased cattle manure application during both seasons. The fruit number plant $^{-1}$ showed a significantly increasing response during *maha*, 2000/2001 to increased N and K application frequency. Overall, it appears that enhanced cucumber productivity could be realized in this agro-ecology at the highest cattle manure level and at the maximum N and K split-application frequency tested in this study

KEYWORDS: Cucumber, Leaching, Nitrogen, Potassium, Regosols, Split-application

INTRODUCTION

Cucumber (*Cucumis sativus*) is a popular market vegetable in the tropics grown throughout the year for both slicing and pickling purposes. It is assumed to be a native of north India (Purseglove, 1982). In Sri Lanka, cucumber is grown in almost all the dry zone districts year-round under both rain-fed and irrigated conditions. Cucumber has been introduced recently to the intensive and highly commercialized crop production system in sandy regosols of the Kalpitiya peninsula, situated in the north-western coastal belt of the country. The plausible causes for cultivating this crop in the area are a). ease in handling cultivation operations; b). generate continuous income; c). relatively low pest/disease incidence; d). availability of irrigation water with acceptable quality throughout the year over large area of the peninsula (table 1); e). good access to the primary market and f). no water-logging problems because of the permeable nature of the regosols.

Table 1. Chemistry of Kalpitiya ground water.

Major ions	*Concentration (mg/l)*
Sodium	33
Potassium	27
Calcium	100
Magnesium	17
Bicarbonate	116
Chloride	90
Sulphate	125
Total dissolved solids	512
Conductivity (µS/cm)	800
pH	7.3

Source: British Geological Society, 1992

The low nutrient retention capacity of the highly permeable sandy soil with inferior soil fertility status and the leaching of solutes, particularly, N and K derived from concentrated inorganic fertilizers owing to excess irrigation and heavy *maha* rains are some of the constraints associated with successful cucumber cultivation in this area. These constraints could be mitigated through incorporating organic manure to the soil and to improve nutrient retention capacity and split applying concentrated inorganic N and K fertilizers. Fertilization and irrigation contribute to high NO_3-N leaching in sandy soils (Hargert, 1986; Middlton *et al.*, 1975). Both irrigation management and the interaction between irrigation and N management can influence NO_3 leaching (Brinsfield *et al.*, 1991; MacMorran, 1994). The beneficial effect of split applying N was associated with an improvement in the recovery of N in the potato crop owing to a reduction in losses due to leaching (De Vaz and Gunasena, 1974). Frequent application of irrigation water in large quantities (20-25 mm/application) to crops grown in the regosols might leach down soluble nutrients beyond the extraction zone of the crop roots and results in the waste of valuable crop nutrients (Kuruppuarachchi, 1993). British Geological Survey, 1992 has suggested that research be undertaken to evaluate cultivation and irrigation practices necessary to minimize leaching losses of fertilizers to ground water in the Kalpitiya area. The shallow water table and highly permeable soils in the peninsula have produced a vulnerable aquifer with a simple flow system that is the only source of both potable water supply and irrigation (British Geological

Survey, 1992). The leaching of nutrients from intensively cultivated soils has been responsible for elevated concentrations of chloride, nitrate and potassium in many of the irrigation wells in the Kalpitiya area (Kuruppuarachchi and Fernando, 1999). Kenderagama *et al.*, (1998a) reported that the cultivated dry zone regosols are low in exchangeable K (<39 ppm). The organic matter was also found to be low in the dry zone regosols (0.54 %) resulting in low soil fertility (Kenderagama *et al.*, 1998b). The importance of soil organic matter in maintaining soil fertility status was highlighted by the FAO (1984). Fertilizer use efficiency (FUE) of added NPK increases when the soil organic matter percentage is over 2 % (Dissanayake *et al.*, 1992). Information on the response of cucumber to cattle manure levels and N and K split application frequencies in the sandy regosols is vital to device an appropriate nutrient management strategy to enhance yields and to sustain productivity. Consequently, a field investigation was conducted, over two seasons, to address these issues and the results are reported in this paper.

MATERIALS AND METHODS

A field experiment was conducted over two seasons (1999/2000 *maha* and 2000 / 2001 *maha*) at the Agricultural Research Station, Kalpitiya. The *maha*, 1999 / 2000 investigation was conducted during 09th November, 1999-30th January, 2000 period while *maha* 2000 / 2001 investigation was conducted during 07 October, 2000- 27th December, 2000 period. The climate at Kalpitiya is characterized by high temperature (>27 ° C) throughout the year with some cool nights (18-20 ° C) in December and January. Pan evaporation ranges from 3 mm / day (November) to 6.5 mm / day (August). The average annual rainfall is about 1000 mm, 80 % of which is received during *maha* season. The soil at Kalpitiya is characterized as a regosol (De Alwis and Panabokke, 1973) and is extremely permeable, consisting of 90-98 % fine and coarse sand (Kuruppuarachchi, 1993). The soil properties of the experimental site are presented in the table 2.

Table 2. Soil properties of the experimental site at the Agricultural Research Station, Kalpitiya.

Property	*Content*
pH (1:1) H_2O	6.5
Electrical conductivity at 25 ° C (EC-dS/m)	0.01
Available water capacity % (by volume)	7.0
Bulk density (g cm^{-3})	1.56
Organic matter content (%)	0.4
Olsen's P (mg/kg)	2.5
Exchangeable K (mg/kg)	0.04

Source: Kuruppuarachchi, (1993)

The weather conditions prevailed during the two cropping seasons where the experiment was conducted are shown in the tables 3a and 3b.

Table 3a- Mean monthly weather data recorded during cropping season maha, 1999 / 2000 at the Agriculture Research Station, Kalpitiya.

Month/ Year	*Air Temperature ^0C Max.*	*Min.*	*Soil Temperature ^0C 05 cm*	*10 cm*	*RH (%)*	*Total Monthly Rainfall (mm)*
Sep. 1999	31.1	27.0	35.6	34.2	72.1	62.5
Oct. 1999	31.4	26.4	32.1	31.6	76.5	214.5
Nov. 1999	30.6	24.9	31.8	31.6	75.2	149.0
Dec. 1999	30.0	24.4	30.7	30.9	75.8	131.0
Jan. 2000	30.6	23.6	30.4	30.3	78.2	149.5
Feb. 2000	31.4	24.6	32.7	32.0	71.7	35.5

Source: Agriculture Research Station, Kalpitiya.

Table 3b. Mean monthly weather data recorded during cropping season maha, 2000 / 2001 at the Agriculture Research Station, Kalpitiya..

Month/ Year	*Air Temperature ^0C Max.*	*Min.*	*Soil Temperature ^0C 05 cm*	*10 cm*	*RH (%)*	*Total Monthly Rainfall (mm)*
Sep. 2000	31.2	27.4	36.6	34.9	72.5	95.5
Oct. 2000	30.8	27.0	34.5	33.5	72.7	34.5
Nov. 2000	32.7	25.6	32.2	31.9	79.2	43.5
Dec. 2000	28.9	25.3	30.9	30.5	72.3	428.5
Jan. 2001	28.2	25.3	29.9	29.9	75.6	88.0
Feb. 2001	29.8	24.9	30.9	30.8	74.8	77.5

Source: Agriculture Research Station, Kalpitiya.

The treatments are detailed in table 4. The treatments were combined factorially and were arranged in a randomized complete block design, replicated three times during both seasons. The Department of Agriculture (DOA) recommended concentrated inorganic fertilizers of 225 kg / ha urea, 200 kg / ha triple super phosphate, and 195 kg/ha muriate of potash were used. The total triple super phosphate was applied as basal while the urea and muriate of potash were equally split-applied in accordance with the application frequencies. All fertilizers used for top-dressing were placed to the plant base as broadcasting would cause scorching. Cattle manure was incorporated into the planting holes about one month before planting in accordance with the treatments.

Table 4. Treatment details.

1. Cattle manure levels (t/ha)

C_0=0
C_1=05
C_2=10

2. N and K split-application frequencies:

S_1= Basal, 2 WAP and 5 WAP (control)- 03 equal split-applications
S_2 = Basal, 2WAP, 4 WAP, and 6 WAP – 04 equal split-applications
S_3 = Basal, 10 DAP, 20 DAP, 30 DAP, 40 DAP and 50 DAP– 06 equal split-applications
S_4 = Basal, 1WAP, 2 WAP, 3WAP, 4 WAP, 5WAP, 6, WAP, and 7 WAP- 08 equal split-applications

WAP = Weeks after planting; DAP = Days after planting

Basal concentrated inorganic fertilizer was applied to each planting hole about 2 days before dibbling the seeds. Each experimental unit measured 3m x 3m. Pre-soaked seeds of cucumber variety "LY-58" were planted at the rate of three seeds per hill dibbled to a depth of 2-3 cm at a spacing of 1m x 1m. The seedlings were thinned-out two weeks after emergence leaving two seedlings per hill. The crop was raised under both rain-fed and supplementary irrigation. Over-head irrigation was practiced where water was obtained from shallow open wells and applied by hand-held hose. The other crop management practices adopted were as per Department of Agriculture recommendations. The first fruit picking commenced on 09th January, 2000 and continued till 30th January, 2000 during *maha* 1999/ 2000 while that in *maha* 2000/2001 commenced on 07th December 2000 and continued till 27th December 2000. At each pick, the fruit yield, individual fruit weight, fruit number plant^{-1}, fruit diameter and fruit length were recorded.

RESULTS AND DISCUSSION

The study reported in this paper was conducted only during two consecutive rainy *maha* seasons and could address to certain degree the aforesaid issues that are prevailing in the study area. The productivity (fruit yield, fruit weight and fruit number plant $^{-1}$) response to cattle manure levels and N and K split-application frequencies during *maha*, 1999/2000 and *maha*, 2000 / 2001 is presented in table 5 and table 6, respectively. The fruit size (fruit length and fruit diameter) response to cattle manure levels and N and K split-application frequencies, over the two seasons, is presented in the table 7.

Table 5. Cucumber productivity under different cattle manure levels and N and K split-application frequencies during *maha*, 1999/2000 at the Agricultural Research Station, Kalpitiya.

Cattle manure levels (t/ha)	*N and K appl-freq.*	*Fruit yield (t/ha)*	*Fruit weight (g)*	*Fruit No. plant $^{-1}$*
0	3	3.5	470	1.2
	4	3.7	500	0.9
	6	4.7	560	0.6
	8	4.2	697	0.6
Mean		**4.03**	**557**	**0.8**
05	3	17.5	477	2.9
	4	14.0	703	2.6
	6	19.0	730	2.4
	8	17.0	727	2.0
Mean		**16.9**	**659**	**2.5**
10	3	18.3	792	3.0
	4	23.0	817	3.0
	6	24.3	716	2.6
	8	28.0	706	4.1
Mean		**18.3**	**758**	**4.2**
Means for N and K split-application frequencies	3	13.3	580	2.4
	4	13.6	673	2.2
	6	16.0	669	1.9
	8	16.4	710	2.2
LSD (P=0.05)				
Cattle manure levels		4.42	ns	ns
N and K split-application Frequencies		ns	ns	ns
Interaction		ns	ns	Ns

Response of productivity and fruit size to cattle manure levels

Increasing the cattle manure level significantly increased the fruit yield, fruit weight and fruit number plant $^{-1}$ and the highest values were recorded at the maximum cattle manure level during both seasons (tables 5 and 6). An increased fruit size response was also apparent in increased cattle manure levels over the two seasons though the trend was not significant. Enhanced fruit yield could be attributed to soil fertility improvement of the infertile sandy regosols through cattle manure incorporation. Organic matter holds the minerals against loss by leaching until they are released by the micro-organisms and increases water-holding capacity of sands and sandy soils (Lorenz and Maynard, 1980).

Table 6. Cucumber productivity under different cattle manure levels and N and K split-application frequencies during *maha*, 2000 /2001 at the Agricultural Research Station, Kalpitiya

Cattle manure levels (t/ha)	*N and K appl-freq.*	*Fruit yield (t/ha)*	*Fruit weight (g)*	*Fruit No. plant $^{-1}$*
0	3	7.5	302	2.5
	4	10.3	350	2.9
	6	13.6	315	4.2
	8	14.9	375	4.0
Mean		**11.6**	**355**	**3.4**
05	3	16.0	336	4.8
	4	15.6	371	4.2
	6	22.1	391	5.7
	8	12.1	353	4.2
Mean		**16.5**	**363**	**4.7**
10	3	15.6	454	3.6
	4	10.8	344	3.1
	6	22.4	372	5.8
	8	32.4	452	5.5
Mean		**20.3**	**406**	**5.2**
Means for N and K application freq.	3	13.0	364	3.6
	4	12.2	355	3.4
	6	19.4	359	5.2
	8	19.8	393	5.5
LSD (P=0.05)				
Cattle manure levels		0.49	38.8	1.16
N and K application freq.		0.56	44.8	1.34
Interaction		1.37	ns	3.28

The cucumber crop responds well to organic manure (Purseglove, 1982). Organic matter plays a major role in maintaining soil fertility status especially in sandy soils (Weerasinghe and Latiff, 1999). Animal manure applied as soil amendment can improve soil organic matter content (Kononowa, 1966), water holding capacity (Salter and Williams, 1965) and nutrient retention (Johnston, 1976). Wijewardena (2000) reported that enhanced vegetable crop yields could be achieved through incorporating animal manure. The importance of soil organic matter was highlighted by the FAO (1984). Dissanayake *et al.*, (1992) have shown that fertilizer use efficiency (FUE) of added NPK increases when the soil organic matter percentage is over 2 %. It has been reported (Williams *et al.*, 1972.) that cucumbers can be grown on almost any soil, but for good yields, in the tropics, they require a deep soil with high organic matter content.

Table 7. Cucumber fruit-size (fruit length and fruit diameter) response to different cattle manure levels and N and K split-application frequencies during *maha*, 1999 / 2000 and *maha*, 2000 /2001 at the Agricultural Research Station, Kalpitiya.

Cattle manure Levels (t/ha)	*N and K Apli. Freq.*	*Maha 199/2000*		*Maha 2000/2001*	
		Fruit length (cm)	*Fruit diameter (cm)*	*Fruit length (cm)*	*Fruit diameter (cm)*
0	3	16.0	6.5	15.4	5.8
	4	17.5	7.2	17.0	6.8
	6	18.0	7.5	16.0	6.6
	8	18.2	7.6	16.1	6.7
Mean		17.4	7.2	16.1	6.5
05	3	17.2	7.0	15.6	6.7
	4	18.1	7.3	15.6	6.8
	6	19.0	8.0	15.3	6.9
	8	18.4	7.8	14.9	6.7
Mean		18.2	7.5	15.4	6.8
10	3	17.5	7.4	15.8	6.7
	4	17.2	7.0	16.1	6.8
	6	18.2	7.4	15.5	6.9
	8	18.5	8.0	17.0	7.2
Mean		17.9	7.5	16.1	6.9
Means for N and K application frequency	3	16.9	7.0	15.6	6.4
	4	17.6	7.2	16.2	6.8
	6	18.4	7.6	15.6	6.8
	8	18.4	7.8	16.0	6.9
LSD (P=0.05)					
Cattle manure levels	ns	ns	ns	ns	ns
N and K application freq.	ns	ns	ns	ns	ns
Interaction	ns	ns	ns	ns	ns

Cucumbers benefit well from rotten farmyard manure which should be applied whenever available (Doerfler, 1976). Generally, animal manures could increase the chemical, physical and biological properties of soils (Kononowa, 1966; Gaur *et al.*, 1971). The organic matter incorporation increases water and nutrient holding power and in this way many nutrients are protected from losses due to leaching; it increases available water in sandy soils (FAO, 1984). Both organic and chemical fertilizers are indispensable inputs in vegetable production systems, particularly, in today's high-technology oriented agriculture. This emphasizes the need to adopt integrated plant nutrient systems (IPNS) technology to enhance yields and to sustain productivity in intensive vegetable production systems. The FAO (1984) has made emphasis on this nutrient management system to enhance yields and to sustain productivity. This also minimizes nutrient losses through leaching in regosols where vegetable production is intensive. The combined use of organic manure and chemical fertilizer could narrow down the negative nutrient balance substantially while improving the overall soil fertility in many cropping systems (Singh and Yadev, 1994; Sharma, 1995). Further, combined application of organic manure and chemical fertilizer could increase the uptake efficiency of plant nutrients (Yeh, 1987). It is evident from the results of this study that concurrent application of organic and NPK concentrated chemical fertilizers resulted in higher yields than that from individual application of concentrated inorganic fertilizers

Response of productivity and fruit size to N and K split-application frequencies

Fruit yield showed an increasing trend during *maha*, 1999/2000 and a significant response in *maha*, 2000/2001 to increased N and K split-application frequencies (tables 5 and 6). However, the yield increase was not significant when N and K split-application frequency was increased from 6 to 8 during *maha*, 2000/2001. A similar trend was observed during *maha*, 1999/2000 as well although the yield response was not significant to increased N and K split-application frequencies. An increased fruit size response was also apparent for increased N and K split application frequencies, over the two seasons, though the trend was not significant. Adequate fertilization is central to high productivity in cucumbers and in the tropics, they respond well to split-application of fertilizers over the first 8-10 weeks; this also prolongs the productive life of the vines (Williams *et al*., 1972). The fruit weight and fruit number plant $^{-1}$ showed an inconsistent response during *maha*, 1999 / 2000 and a significantly increasing response during *maha*, 2000 / 2001 to increased N and K split-application frequencies. Timing of N application did not influence the dollar value significantly, although the treatment with 01 side-dress application tended to do best in Arkansas, USA (Bradley *et al.*, 1975). A previous study by them showed best results from applying all of N before planting, a usual recommendation in other production areas in the USA. Mixed results have been obtained from studies of split-application of N fertilizer compared to one time broadcast application (Evanylo, 1989; Locascio *et al.*, 1970; Smith, 1984; Westermann, 1988). According to them, the positive responses usually have occurred on sandy soils and in wet seasons. It has been reported (Kuruppuarachchi, 1993) that potato tuber yield showed no response to several top-dressings of N fertilizer under Kalpitiya conditions which may be due to the supply of N through irrigation water masking the effect of N fertilizer applied to the soil. The dry matter accumulation in groundnut vegetative parts was increased when N top-dressing was done in split doses in regosols (Thanaraj and Sandanam, 2000). According to Hochmuth (1992) single applications of large amounts of N at planting may save application time and expense but are more prone to leaching losses, because these amounts exceed the N requirement of young seedlings. On sandy soils where leaching is likely to occur, one-half of the N is applied close to planting and the remainder is side-dressed in several applications when vines start to fill the rows (Swiader, *et al.*, 1992). Split-applications of N would be preferable over single applications for minimizing potential negative effects to the environment due to N leaching, because split applications more closely match the plant N uptake function (Peterson and Frye, 1989; Scarbrook, 1965). This is appropriate to the situation in Kalpitiya where ground water contamination owing to N leaching can be minimized.

It has been reported (FAO, 1984) that limited leaching of K may occur, but normally with high rainfall and on sandy soils. Maintenance of adequate soil K status by the correct use of fertilizers and manure is important particularly on soils of low clay content. Usually the entire requirement for K may be applied as a basal dose but in sandy soils and high rainfall areas, a split application may be beneficial. Potassium is required by the crop over a longer period than phosphorus, but is seldom subjected to serious loss of availability once it is in the soil.

Agricultural production sites at the highest risk for groundwater contamination are those in humid, high-rainfall areas with highly permeable soils and shallow water tables (Hochmuth, 1992). According to Hochmuth, (1992), high-value intensively managed crops, e.g. vegetables and other horticultural crops, and irrigated agronomic crops to which large amounts of N fertilizer are applied have the highest potential for contributing to groundwater contamination. Vegetable production on sandy soils meets all of these conditions. The future of vegetable production in these areas depends on fertilizer management technologies that minimize the potential for groundwater contamination from N (Hochmuth, 1992).

Interaction

The interaction observed between cattle manure levels and N and K split-application frequencies for fruit yield and fruit number plant^{-1} was significant only during *maha*, 2000/2001. This indicates that highest fruit yield and maximum fruit number plant^{-1} could be obtained at the highest cattle manure level combined with maximum N and K split-application frequency.

CONCLUSIONS

It appears that integrating concentrated inorganic fertilizer with highest cattle manure level and split applying N and K at the frequency of either six or eight could, no doubt, enhance cucumber yields and sustain its productivity in the sandy regosols. However, further detailed investigations are suggested to ascertain cucumber productivity response to cattle manure levels higher than 10 t/ha that was used in this study combined with concentrated inorganic fertilizer higher than the level recommended by the Department of Agriculture (DOA) in order to arrive at an optimum integration that would be cost-effective and could minimize groundwater contamination as well.

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