varieties had remained the same during 1984-'85 to what it was during 1975-'76. Consequent on the decrease in area under the crop production had come down to the extent of 8 per cent for the State as a whole. A 10 per cent increase in the productivity of the crop is noticed during the period 1975-'76 to 1984-'85 for the State. At present only a low percentage of area comes under high yielding varieties. Steps must be taken to bring more areas under high yielding varieties especially in those taluks where the yield is reasonably good. Any step to increase the productivity of the crop must be location oriented.

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STUDIES ON CRITICAL LEVELS OF MAJOR NUTRIENTS FOR SOLANACEOUS VEGETABLE CROPS THROUGH MITCHERLICH MATHEMATICAL MODELS, DRIS AND INDUCTIVE APPROACHES

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ABSTRACT

Field experiments were conducted at the Tamil Nadu Agricultural University, Coimbatore to investigate the critical levels of N P K DRIS indices, fertilizer prescription for specified yield targets and for a cropping sequence in vegetable crop like brinjal (CO2) and tomato (CO3).

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The Diagnosis and Recommendation integrated system (DRIS) approach clearly indicated the nutrient status of brinjal and tomato crops. The reference values of NPK in 5th leaf, changes in fruit yield and soil nutrient availability due to an unit change in respect of leaf nutrients NP and K differed. Brinjal (CO2) required roughly double the dose of N P and K of tomato (CO3) to produce one tonne of fruits. Possibilities of making fertilizer recommendation for a cropping sequence were brought out based on the multiple regression analysis to predict post harvest soil available NP and K.

Although, soil test is a good diagnostic tool in fertilization practices, aberrant weather conditions in the early stages of vegetable crop growth or managerial inadequacies may diminish crop growth. To remedy such effects by midterm corrections, the critical leaf/soil nutrient content, DRIS indices could be made use of. Fertilizer application for varying levels of vegetable production also needed to meet the increasing demands of the growing population, the targetted yield approach has been reported to be the best. Information regarding the DRIS indices and critical levels of N,P and K for leaf and soil fertilizer prescription for targetted vegetable production and a cropping sequence is lacking. Hence, an attempt was made to find out the above aspects in respect of brinjal (CO2) and tomato (CO3).

MATERIALS AND METHODS

Experiment - 1

Field experiments were conducted in a clay textured soil (Inceptisol with brinjal and tomato during June-July 1984 and 1985 seasons respectively). The treatments for brinjal were 5 levels of N(0, 50, 100, 150 and 200 kg N/ha) 2 levels of P (0 and 50 kg P_2O_5/ha) and 2 levels of K_2(O and 30 kg K_2O/ha), for tomato (CO.3), the treatments consisted of 5 levels of N (0, 50, 100, 150 and 200 kg N/ha) and 4 levels of P (0, 50, 100 and 150 kg P_2O_5/ha) besides a common dose of 37 kg K_2O/ha as soil test recommendation. The treatments in respect of brinjal and tomato were imposed in a Randomised Block Design with 2 replications. The normal package of practices of above crops were followed. The representative soil and 5th leaf samples (Vonuxkull, 1978) at 50th and 70th day after transplanting brinjal seedlings and 30th and 50th day after transplanting tomato seedlings were collected, processed and analysed for the contents of N, P and K in leaf and KM_nO4-N, Olsen's-P and NH_40 AC-K in soil samples (Jackson, 1967) besides recording the fruit yield.

The scatter diagram on fruit yield and nutrient content/ratios for both the crops of brinjal and tomato showed Mitcherlich's form (ware et al., 1982).

$$Y = A\ (1 - e^{-bx})$$

The marginal change in the yield of fruit (Y) due to unit change in a leaf nutrient content/ratios were obtained by

the relation, $dy/dx=be^{-bx}$, were Y = fruit yield X = the nutrient content/ratio in 5th leaf.

The leaf nutrient content mainly depends on the soil nutrient availability. The scatter diagram of leaf nutrient content and corresponding soil nutrient (N,P & K) availability also followed the Mitcherlich's curve of the form, LN = A (1 - e^{-bx}). Where LN = leaf nutrient content/ratio x=soil available nutrient (N,P and K). The unit change in the availability of soil nutrient is obtained by $DLN/dx=be^{-bx}$.

The nutrient ratios such as N/P, K/P and N/K in respect of brinjal and tomato were computed and subjected to the computation of norms of DRIS (Jones, et al., 1986; Walworth and Somner, 1987).

Experiment 2.

Experiments were conducted in Fd. No. 54 (Inceptisol) of orchard, Faculty of Horticulture, Tamil Nadu Agricultural University, Coimbatore. The experiment approach followed was the Inductive Methodology adopted in the All India Coordinated Project on Soil Test crop response correlation studies (Velayutham et al., 1985) by which fertility gradients with respect to N, P and K were created in the experimental soil by applying different amount of these nutrients by growing gradient/exhaust crop of maize (UCM. 6) Brinjal and Tomato were raised during June-July, 1984 and 1985 seasons respectively with 24 fertilizer treatments as in Table 6 and 7.

The treatments were superimposed over the fertility gradients. The normal package of practices of above crops were followed. The fruit and plant yield in respect of brinjal and tomato were recorded. Pre and post harvest soil samples were analysed for $KMnO_4$-H, Organic Carbon, Olsen's P NH_4OAC-K. The fruit and plant samples were analysed for the contents of N, P and K (Piper, 1966) and uptake computed from the data collected, the targetted yield equations for brinjal and tomato were computed by adopting the procedures prescribed in Table 8. To predict the post harvest soil test values from the pre-sowing soil test values CO2, the respective post harvest soil test values were regressed with the respectively pre sowing soil test values, added doses of N, P and K through fertilizer/manure

TABLE : 6 Levels of N P K & F Y M

Level	FYM (t/ha)	Fertilizer P_2O_5		K_2O
		N(kg/ha)	(kg/ha)	(kg/ha)
0	0	0	0	0
1	10	50	50	50
2	20	100	100	100
3	30	150	150	-
4	-	200	-	-

TABLE 1 : Critical limits of nutrients in leaf and soil vegetables

(a) Nutrient content in 5th leaf (%).

Nutrient in leaf	Lower C.L. (Early stage)		Upper C.L. (Early stage)		Marginal changes in fruit yield (t/ha)		Lower C.L. (Later stage)		Upper C.L. (Later stage)		Marginal changes in fruit yield (t/ha)	
	B	T	B	T	B	T	B	T	B	T	B	T
N	2.81	3.73	7.36	5.64	18.34	13.24	2.66	2.68	6.98	4.17	10.00	11.30
P	0.43	0.41	0.90	1.33	28.22	0.71	0.42	0.28	0.94	0.41	33.76	34.74
K	4.21	3.87	9.55	6.10	22.72	12.97	3.60	3.15	8.59	4.83	21.03	12.46
N/P	14.64	20.44	29.08	28.09	29.81	18.50	14.46	20.99	29.08	28.76	29.44	10.60
K/P	7.92	7.41	16.45	10.32	27.09	18.10	6.90	8.87	14.78	12.08	25.92	18.30
N/K	1.86	2.68	6.25	4.33	13.15	15.60	2.11	2.37	6.41	4.21	15.08	14.40
(b) Soil available nutrients (kg/ha)												
N	117.30	109.0	438.02	130.6	119.87	113.93	111.00	138.1	431.85	214.6	113.19	140.38
P	7.00	7.6	24.16	16.9	6.72	7.26	6.20	3.3	24.48	10.3	5.93	2.90
K	807.80	770.0	5078.67	1966.1	811.04	772.70	816.20	663.6	5195.00	2302.6	819.06	665.36

B = Brinjal (CO.2) T = Tomato (Co.5)

Table - 8 Targetted yield equations

1. Nutrient requirement to produce one tone of fruit (NP) = $\frac{\text{Total uptake of nutrients (kg/ha)}}{\text{Fruit yield (t/ha)}}$

2. Per cent contribution from soil (CS) = $\frac{\text{Total uptake of nutrient}}{\text{Soil text value}} \times 100$

3. Per cent contribution from fertilizer (CF) = $\frac{\text{Total uptake} - (\text{STV} \times \text{CS}) \text{ of nutrient (kg/ha)}}{\text{Fertilizer dose (kg/ha)}} \times 100$

4. Per cent contribution from FYM(CO) = $\frac{\text{Total uptake of nutrient in FYM plot (kg/ha} - \text{CS} \times \text{FYM)}}{\text{Nutrient FYM (kg/ha)}} \times 100$

5. $Fd = \frac{NR}{CF} \times T - \frac{CS}{CF} \times O \text{ (FYM)}$

Fd = Fertilizer dose (kg/ha)
NR = Nutrient requirement per ton of fruit production (kg/ha)
CF = Contribution from fertilizer/FYM (%)
T = Targetted yield (t/ha)
CO = Organic manure efficiency (%)
CS = Soil efficiency (%)
S = Soil test value (kg/ha) for available nutrient
O = Nutrient addes through organic matter (kg/ha)

and fruit yield/total dry matter yield by using HCL/1800 computer available at Tamil Nadu Agricultural University.

RESULTS AND DISCUSSION

Mitcherlich's Mathematical Model approach

It could be seen from Table 1a and b that the lower and upper critical levels of N, P and K, their ratios in 5th leaf decreased with advancement in age of the crop growth. However, the ratios such as N/K in brinjal N/P and K/P in Tomato increased with the age of the crop growth.

An unit change in N, P, K, N/P and K/P in 5th leaf of brinjal and the N, K and N/K in tomato had more in marginal changes in fruit yield at early stage of crop growth indicating the importance of maintenance of plant nutrients at early stage of crop growth to achieve the maximum yield potential in solanaceous vegetable crops.

It is also seen that the marginal changes in fruit yield due to an unit change in N/K ratio in 5th leaf was maximum at later stage of brinjal and at early stage of tomato. This findings clearly indicated the importance of

TABLE 3 : Relationship between fertilizer treatments, DRIS indices and fruit yield - Tomato (CO.3)

N & P_2O_5 (kg/ha)	DRIS indices at 30th day			Total indices	DRIS indices at 50th day			Total indices	Fruits yield (t/ha)
	N	P	K		N	P	K		
0-0	3.78	-8.15	-2.91	14.84	0.21	-7.00	-6.70	13.91	12.1
0-50	-2.41	4.79	2.51	9.71	3.14	-3.34	-0.20	6.68	11.8
0-100	-0.39	7.59	4.32	12.30	0.37	3.39	3.76	7.52	15.8
0-150	26.06	-7.88	18.19	52.13	-1.80	1.33	-0.13	3.267	15.7
50-0	3.25	0.95	1.06	5.26	-3.47	-3.67	-3.47	10.61	11.3
50-50	-8.89	-7.00	-6.71	22.60	21.26	-15.02	6.25	42.53	17.0
50-100	-7.82	-11.32	-7.81	26.95	-15.15	-11.58	-8.37	35.10	15.3
50-150	0.67	-9.31	-9.97	19.95	-15.17	-9.35	-6.15	30.67	14.1
100.0	14.06	-12.00	2.10	28.16	11.99	-0.53	8.20	20.72	12.0
100-50	-6.56	-3.40	-3.50	13.46	-5.06	9.66	4.94	19.66	18.6
100-100	-2.64	-10.65	-8.00	21.29	2.55	-5.33	-2.45	10.33	16.5
100-150	-0.45	1.44	1.11	3.00	5.31	-6.67	-1.36	13.44	21.1
150-0	1.18	3.28	4.46	8.92	-7.39	-7.07	-5.12	19.58	16.4
150-50	0.31	-2.40	-0.86	-3.57	-4.89	-0.67	1.22	6.78	16.4
150-100	6.46	0.03	-0.58	7.07	-2.88	5.22	2.67	10.77	11.7
150-150	-1.89	0.34	1.45	3.68	-13.40	-13.68	-10.00	37.14	11.6
200-0	-2.34	-8.15	-2.91	13.40	11.99	20.19	8.20	40.38	13.4
200-50	-2.34	-13.56	-8.08	23.98	11.99	20.19	8.20	40.38	15.1
200-100	8.43	-6.59	1.84	16.86	27.95	13.32	-3.85	45.12	12.3
200-150	-1.32	-1.65	-1.12	4.09	3.72	-1.12	1.51	6.35	17.7

+ 37 KG k_2O/ha as ST recommendation

TABLE 4 : Relationship between fertilizer treatments, DRIS indices and fruit yield - Brinjal (CO.2).

N & P_2O_5 (kg/ha)	DRIS indices at 50th day			Total indices	DRIS indices at 70th day			Total indices	Fruits yield (t/ha)
	N	P	K		N	P	K		
0-0-0-	2.67	-3.00	0.17	5.84	-12.15	21.51	14.05	47.71	21.5
0-0-30	-7.14	1.56	-2.14	10.84	-4.57	8.02	3.81	16.40	23.2
0-50-0	-2.73	3.28	0.54	6.55	-11.61	1.72	0.95	14.28	22.5
0-50-30	3.69	-10.17	0.32	14.18	1.26	-4.69	-3.43	-9.38	27.2
50-0-0	-5.91	-8.75	-5.34	20.00	3.67	-1.46	0.79	5.92	31.0
50-0-30	13.78	-5.50	-3.44	22.72	-7.25	-2.99	-2.47	12.71	31.6
50-50-0	29.66	-12.64	-10.06	52.36	-3.73	-4.51	-3.43	11.67	30.4
50-50-0	-5.06	-1.45	-3.07	9.58	-19.46	-17.13	-12.55	49.14	29.5
100-0-0	-6.32	-2.71	-3.07	12.10	-2.25	-0.03	-0.43	2.71	32.0
100-0-30	-1.53	-9.88	-2.51	13.92	-12.63	4.72	2.45	19.80	34.9
100-50-0	7.29	-3.43	3.86	14.58	20.53	-12.56	7.98	41.07	31.7
100-50-30	7.29	-7.24	2.41	16.94	-9.20	-3.31	-2.89	15.40	3.61
1550-0-0	-9.26	-9.26	-5.75	24.27	-8.73	-17.30	-8.57	34.60	30.7
150-0-30	-4.01	1.94	-4.01	9.96	-1.68	-22.98	-11.71	36.37	30.5
150-50-0	-0.86	1.81	0.95	3.62	3.58	-3.95	-0.73	8.26	33.4
150-50-30	-7.38	-11.22	-6.34	24.94	1.27	-2.66	-1.39	5.32	30.6
200-0-0	13.10	-2.03	9.48	24.69	-7.25	-13.42	-8.83	29.50	28.9
200-0-30	1.03	1.60	2.62	5.25	-11.05	-8.76	-6.49	26.30	27.7
200-50-0	2.08	1.21	3.29	6.58	-4.75	-3.31	-1.45	9.51	30.7
200-50-30	-8.18	5.29	-1.54	15.01	7.02	7.02	-10.69	-3.67	21.38

maintaining optimum N/K ratio at early stage of tomato and at later stage of long duration crop like brinjal by adopting proper fertilizer N and K management to achieve their full yield potential.

Diagnosis and recommendation integrated system (DRIS) approach (Tables 2, 3, 4 & 5).

TABLE 2 : Index Equations for DRIS Analysis

$$N\ Index = \frac{(f(N/P) + f(N/K))}{2}$$

$$P\ Index = \frac{(f(N/P) + f(K/P))}{2}$$

$$K\ Index = \frac{(f(K/P) - f(N/K))}{2}$$

$$f\ (N/P) = (N/P) - n/p) \times 10SD$$

Where N/P is the natural value of ratio of % N and %P in leaf being diagonised. n/p is value of reference norms, No. 10 is the arbitrary multiplier to make index a whole. SD is standard deviation for high yield population.

The effect of added N, P and K on the N, P and K contents in 5th leaf, DRIS indices and fruit yield of brinjal and tomato indicated that the individual as well as combined application of N, P and K fertilizers altered the nutrient content, DRIS indices and fruit yield of solanaceous vegetables.

The DRIS indices clearly indicated the N demand during the later periods of crop growth by indicating most negative index of N, mostly in the case of long duration crop like brinjal compared to the short duration crop like tomato.

Based on the DRIS indices and fruit yield, the appropriate fertilizer schedule not only to maintain the N, P and K nutrients in well balanced condition in the plant system but also to improve fruit yield of brinjal was found to be 100-50-30 kg/ha of N P_2O_5 and N P_2O respectively while in the case of tomato the best N and P combination was found to be 100-150 kg/ha of N and P_2O respectively.

Table 3(b) DRIS Foliar Diagnosis Reference norms in Brinjal CO_2

Parameter	Norms value at 50th day	S.D.	Norms value at 70th day	S.D.
N/P	14.12	2.38	15.90	2.67
K/P	7.62	2.38	15.90	2.67
N/K	1.86	0.24	2.23	0.49

Table - 5 DRIS Foliar Diagnosis Referance norms for Tomato CO_3

Parameter	Norms value at 30th day	S.D.	Norms value at 50th day	S.D.
N/P	20.06	5.200	20.10	2.99
K/P	7.73	0.896	8.63	0.90
N/K	2.54	0.510	2.35	0.46

TARGETTED YIELD APPROACH (Table 9)

Though the brinjal and tomato were classified under solanaceous family, the fertilizer requirements to produce one ton of fruits per hectare and response ratios were found to differ.

The N, P and K requirements to produce one ton of tomato fruits were found to be 3.6 kg 0.7 kg and 5.8 kg/ha respectively. Its response ratio was 48.92. For the production of one ton of brinjal fruits, the N, P and K requirements were found to be 7.6 kg, 1.4 kg and 17.3 kg/ha respectively. Its response ratio was found to be 89.85. In general, the brinjal crop requires double the dose of N, P and K nutrients of tomato (CO.3) for the production of one ton of fruits.

Prediction of post harvest soil (Table 10) test values from the pre transplanting/sowing soil test values and other associated parameters can be done in the case of $KMn0_4$-N, per cent organic carbon, Olsen's-P and NH_4OAC-K with family high degree of accuracy indicating the possibility of making fertilizer recommendation for a cropping sequence.

Table 9. Targetted yield equations - Solanaceous vegetables

(a) Tomato - CO.3

(i) For inorganic fetilizer (NPK) alone

FN = 11.11 T - 3.92 SN

FP = 2.59 T - 10.81 SP

PK = 6.74 T - 0.28 SK

(ii) For conjoint use of inorganic (NPK) and organic (FYM) fetilizers

FN = 11.11 T - 3.92 SN - 0.65 ON

FP = 2.59 T - 10.81 SP - 0.69 OP

FK = 6.74 T - 0.28 SK - 0.31 OK

(b) Brinjal - CO2 - For inorganic fertilizer (NPK) alone

(i) FN = 6.64 T - 9.46 SN

FP = 1.89 T - 28.86 SP

FK = 2.60 T - 0.35 SK

(ii) For inorganic (NPK) and organic (FYM) fertilizers.

FN = 6.64 T - 9.46 SN - 0.92 ON

FP = 1.89 T - 28.86 SP - 1.00 OP

PK = 2.60 T - 0.35 SK - 1.35 OK

Where FN, FP, FK=Fertilizer N,P and K(kg/ha) SN,SP,SK=KMn04, Olsen's-P and N, NH_4O. AC-K (kg/ha) T = Targetted yield (t/ha),

ON,OP,OK = N,P and K contents in the added FYM (kg/ha)

Table - 10 Multiple regression analysis to predict post harvest soil available NP and K

(a) Crop-Tomato-CO.3

Post harvest available N (kg/ha) ($KMnO_4$-N)	=	527.71 + 9.31 * SN -0.004 SN2 + 1.46 FN+0.004 FN2-1.57 ON-0.001 ON2 + 1.82 DMY+0.03 DMY2-0.009 SNON-0.08 SNDMY - 0.03 FNDMY + 0.04 ONDMY R2 = 0.8481*
Post harvest organic carbon content soil (per cent)	=	13.22+ 80.42 OC -74.16 OC2 - 0.13 FN - 0.0002 FN2 + 0.1 ON + 0.00000 8 ON2 - 0.39 Fruit + 0.006* Fruit 2 + 0.31* OC.FN - 0.12 OC.ON + 0.0002 FN ON + 0.04 OC. Fruit - 0.001 FN Fruit - 0.003 ON. Fruit R2 = 0.8766*
Post harvest available P(kg/ha) (Olsen's-P)	=	9.18 - 0.04 SP+ 0.01 SP2+ 0.19 FP + 0.0008 FP2 + 0.02 OP + 0.0008 OP2 + 0.17 Fruits + 0.01 Fruit 2 + 0.007 SPFP - 0.02 SP. Fruit - 0.008 FP2 + 0.02 OP + 0.0008 OP2 + 0.17 Fruits + 0.01 Fruit 2 + 0.0007 FPOP - 0.02 SP. Fruit - 0.009 Fp. Fruit - 0.004 OP.Fruit R2 = 0.8464*
Post harvest available K(kg/ha) (N.NH4OAC.K)	=	9188.33-16.78 SK + 0.007 SK2+28.77 FK + 0.005 FK2 + 6.83 LK-0.00002 OK2 - 104.81 Fruit + 0.26 Fruit2 - 0.02 SK.FK-0.0009 SK, OK-0, Fruit-0.12 OK, Fruit R2 = 0.8553*

(b) Crop-Brinjal (CO.2)

Post harvest soil available N KMn04-N (kg/ha)	=	126.57-0.31 SN-0.006 SN2+1.70 FN+0.0006 FN2-0.91 ON-0.00004 ON 2-1.77 Fruit-0.004 Fruits2-0.001 SN ON-0.03 SN.FRUIT-0.01 FN Fruit + 0.01 ON.Fruit. R2 = 0.8249*
Post harvest soil organic carbon content (%)	=	-4.79+7.65 OC-4.05 OC2 + 0.0007 FN-0.0002 FN2 + 0.01* ON-0.000006 ON2+0.07 Fruit-0.0002 Fruit2 + 0.007 OC.FN-0.01+0C.ON-0.0000001 FN ON Fruit-0.0000** ON Fruit. R2 = 0.8609*
Post harvest soil available P(kg/ha) (Olsen's-P)	=	42.70-3.26 SP+0.02 SP2-0.10 P+0.001 OP2 - 0.16 Fruit-0.0009 Fruit2 +0.001 SP.liP+ 0.0009 SP.OP+0.0009 Fp.OP+0.02 SP. Fruit. R2 = 0.8822*
Post harvest soil available K(kg/ha) (N.NH40A C-K)	=	540.79-3.68 SK+0.006 SK2-8.02 FK-.006*FK2-4.68 OK+0.009 OK2+26.64 Fruit-0.007 Fruit2 + 0.001 SK.FK + 0.01 SK.OK+0.01 FK.OK-0.04 SK. Fruit+0.02 FK. Fruit - 0.05 OK.Fruit

Where R2 = 0.9928**
SN = Presowing soil available N (kg/ha)
FN = Fertilizer -N (kg/ha)
ON = N content in added FYM (kg/ha)
DMY = Total dry matter yield (t/ha) (Fruit+Stalk)
Fruit = Fruit yield (t/ha)
OC = Per cent pre soil organic carbon content
OP = P content in added FYM (kg/ha)
PP = Fertilizer P (kg/ha)
OK = K content in added FYM (kg/ha)
FK = Fertilizer-K (kg/ha)

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INFLUENCE OF SEASON ON THE RATE OF IMBIBITION AND SPEED OF GERMINATION OF SEEDS OF CHILLI

C.P. THIAGARAJAN

ABSTRACT

The differences in the rate of imbibition was more in larger seeds from rabi than kharif seasons. The difference in the rate of imbibition between grades was comparatively more in kharif season than rabi. In both the seasons, seeds from earlier pickings recorded higher rate of imbibition than those from later pickings.

Seeds from rabi season germinated faster than kharif. Smaller seeds germinated faster than medium and larger seeds and seeds obtained from earlier pickings germinated faster than those from later pickings.

Season of the place of production of seeds differentially influences the development of various parts of seed. In a developing seed, the organisation