Himachal Journal of Agricultural Research Vol. 33 (1): 40-46, 2007

Effect of integrated nutrient management on tomato production

Pardeep Kumar and S.K. Sharma*
CSK Himachal Pradesh Krishi Vishvavidyalaya
Mountain Agricultural Research and Extension Centre, Sangla (Kinnaur).

Abstract

A field experiment to study the effect of integrated nutrient management on growth, yield, and quality of tomato and on physico-chemical parameters of the soil was conducted during 2001 and 2002 at Vegetable Research Farm of Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni-Solan (H.P.), India. Seedlings were transplanted on 21 April 2001 and 15 April 2002. Plant height, number of main branches per plant, days to 50% flowering, days to first harvest, number of fruits per plant, fruit yield, fruit firmness, total soluble solids and vitamin C contents of fruits were determined. Soil water holding capacity, organic carbon, nutrient uptake and available NPK in plants at harvest were recorded It was found that application of farmyard manure at 25 t/ha + NPK at 150:112.5:82.5 kg·ha^{-1} was best for obtaining higher values with respect to growth, yield, quality and available nutrients.

Key words: *Lycopersicon esculentum,* bio-fertilizer, fertilizer, integrated nutrient management, integrated plant nutrient system.

Introduction

Tomato (*Lycopersicon esculentum* Mill) is an important vegetable crop because of its nutritive value with wide spread production. It is one of the most popular salad vegetables and is also used in large volumes in soups, preserves, pickles, ketchups, sauces and other products. It is world's largest produced vegetable crop after potato and sweet potato, and is produced on 0.45 million ha with an annual production of 6.8 million metric tones. It occupies an area of 321,000 ha with a total production of 4,603,446 metric tones in India (Anonymous, 1997). In Himachal Pradesh it covers an area of 2,240 ha with annual production of 65437 metric tons (Anonymous, 1998). Total average yield per unit area for tomato is still low in Himachal Pradesh as compared to international standards. An adequate supply of nutrients, and appropriate management practices have the potential to increase the productivity of tomato to that of national and international levels. Chemical fertilizers are formulated to supply one or two nutrient elements to the crop. The integrated use of chemical fertilizers, farm yard manure (FYM), organic manures, bio-fertilizers and other organics have promise in securing high levels of crop productivity and in protecting soil health from deterioration and pollution hazards. This complementary is important to sustain a higher level of soil fertility and crop productivity. FYM supplies organic matter, improves the soil physical and biological environment, and acts as a storehouse of nutrients. However, when used alone it has the drawbacks of low nutrient content and slow release. Organic mulches improve hydrothermal regimes of the soil, provide favorable conditions for the availability of the nutrients, better crop growth, control soil erosion, and maintain the soil health.

Azotobactor a nitrogen-fixing bacterium is also capable of producing small quantities of plant growth promoting substances like B vitamins, phytohormones like IAA, GA and cytokinins. It produces antifungal, antibiotic, and fungistatic compounds against pathogens like *Fusarium* and *Alternaria*. Since it fixes about 15 to 20 kg·ha^{-1} of N in a year, it may provide only a part of the nitrogen requirement of crop plants. There is a need to apply an external source of nitrogen, which may be in the form of organic manures or chemical fertilizers used alone or in combinations.

Bio-fertilizers like dry grass and pine needles are organic materials used by producers to modify biological activity of soil microorganisms and to improve plant growth and yield by stimulating production of bioactive compounds in the soil. Bio-fertilizers are non-bulky and cheap

* Dean, College of Horticulture & Forestry, Jhalawar, MPUA&T-Rajasthan.

sources of nutrients and may prove cost effective and eco-friendly supplementation in hill farming. This study was undertaken to evaluate the efficacy of the integrated use of chemical fertilizers, bio-fertilizers and organic materials on the development and yield of tomato and on soil factors.

Material and Methods

The experiment was carried out at the Vegetable Research Farm of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan, India during 2001 and 2002. The experimental farm is located at 30° 51`N latitude and 76° 11`E longitude and at an elevation of 1,270 m above mean sea level. The climate of the area ranges from sub-tropical to sub- is located at 30° 51`N latitude and 76° 11`E longitude temperate with the maximum temperature rising up to 34°C during summer. The area experiences 110 to 130 cm of rainfall with mostly occurring during monsoon (mid-June to mid-Sept.). The fertility status of the sandy loam experimental site was 0.99% organic carbon, 323 kg·ha^{-1}N, 47.5 kg·ha^{-1}P and 289 kg·ha^{-1}K. Soil pH was 7.37. This comprised the control (T_0) for the study. The recommended additional rate of fertilizer for tomato is 100:75:55 kg ha^{-1} of N, P and K, respectively. The nitrogen, phosphorus, potassium in the appropriate treatment combinations were broadcast applied before transplanting and thoroughly mixed with the surface layer of the soil.

The cultivar used in the study was Solan Vajr. Eighteen treatments, complete in a randomized block design included: T_0, T_1 (pine needles at 10t/ha), T_2 (dry grass at 10t/ha), T_3 FYM 25 t/ha, T_4 (*Azotobactor*), T_5 (T_1+50% NPK), T_6 (T_1+100% NPK), T_7 (T_1+150% NPK), T_8 (T_2+50% NPK), T_9 (T_2+100% NPK), T_{10} (T_2+150% NPK), T_{11} (T_3+50% NPK), T_{12} (+100 T_3% NPK), T_{13} (T_3+150% NPK), T_{14} (T_4+50% NPK), T_{15} (T_4+100% NPK), T_{16} (T_4+150% NPK) and T_{17} (T_{1+} T_{2+} T_{3+} T_4).

The chemical fertilizers used for nitrogen, phosphorus and potassium were calcium ammonium nitrate (25% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. The remaining dose of nitrogen was side-dressed as calcium ammonium nitrate five weeks after transplanting. *Azotobactor*, as a carrier based inoculant, was applied to the seed, seedlings and soil. Seeds were treated with *Azotobactor* @ 0.5kg·ha^{-1}. The bio-fertilizer slurry was prepared by mixing *Azotobactor* cultures @ 1 kg·ha^{-1} in 5 l of water. Roots of seedlings were dipped in the slurry for 30 min before transplanting. *Azotobactor* @ 5 kg·ha^{-1} was applied to the soil and its volume was increased with 50 kg of FYM and applied evenly before transplanting. FYM was incorporated in the soil one week prior to transplanting. Pine needle and dry grass were applied as mulch materials 15 days after transplanting. The crop was sprayed with ridomil MZ (Metalaxyl; 0.25 g·l^{-1} + Mancozeb 64%) just before the onset of the monsoon followed by Blitox-50 (copper oxychloride, 0.3 g·l^{-1}) for the control of fruit rot twice at 15 day intervals.

Data on plant height, number of main branches per plant, days to 50% flowering, days to 1st harvest, number of fruit per plant, fruit yield, fruit firmness, total soluble solids (TSS) and Vitamin C content. There were 5 harvests which occurred days apart. Soil temperature and soil moisture were determined at 15 days after transplanting and application of mulch materials during both the years using soil thermometers placed at 0-15 cm depth and oven dry basis method, respectively. Soil samples from the top 15 cm of the soil were collected from all plots, air dried, crushed, passed through a 2 mm sieve and stored in cloth bags for chemical analysis. Available nitrogen was determined by alkaline potassium permanganate method (Subhiah and Asija, 1956) and available phosphorus by the method of Olsen *et al.* (1954) with spectrophotometer Available potassium was determined by the ammonium acetate method with a flame photometer using the methods of Jackson (1973). For plant analysis 5 plants were taken at random from each plot at harvest.

The plants were washed with tap water and sterilized with HCL 0.1N and finally with distilled water. The samples were air dried and then placed in an oven at 60± 5°C till constant weight was obtained. Dried samples were ground and analyzed for nutrient concentrations. For nitrogen a 0.2 g of sample was digested in concentrated H_2SO_4 in the presence of a digestion mixture. After digestion, a Kjeldahl auto analyzer was used to determine the nitrogen concentration. For the determination of P and K, 1 g of plant sample was digested in a HNO_3: HCL (4:1 v/v) mixture. In order to have complete transfer of the digested material, the digestion flasks were washed 3 times with distilled water and the volume made to 50 ml. Phosphorus in the extract was determined by the

vandomolybdate yellow color method (Jackson, 1973) while potassium was determined using the same flame photometer.

Other soil parameters recorded were water holding capacity, nutrient uptake and available soil NPK at harvest. Data relating to plant growth, fruit yield and quality, nutrient uptake and available nutrients in the soil were statistically analyzed with the procedures of Gomez and Gomez (1984).

Results and Discussion

Since, there were no significant differences in results between years the data were pooled over two years.

A. Growth parameters

Plant height, and the days to 50% flowering and 1st harvest were greatest for the T_{13} (Table 1). The treatments, which included FYM, measured plant development values at least 14% higher than the control. There were 50% more main branches on plants treated with FYM than on controls. Days to 50% flowering (~50 days) were increased, as was the time to 1st harvest (~115 days). The possible reasons for higher values in T_{13} might be due to the increase in the microbial population due to decomposition of organic matter with the subsequent release of available nutrients to the plants for growth. Organic manures applied with inorganic fertilizers improved the effectiveness of chemical fertilizers. FYM has pronounced effect on availability of nutrients due to solubilization of different nitrogenous compounds into simpler and available forms (Madhu *et al.*, 1997). These findings conform to those of Abusaleha and Shanmugavelu (1988) and Singh *et al.* (1998) for okra, Minhas and Sood (1994) and Shelke *et al.* (2001) for brinjal.

B. Yield and yield contributing parameters

The number of fruits per plant was greatest for T_{13} (Table 2), which was 67% more than the control. This treatment also had the greatest fruit yield, 1,730 g/plant, i.e. 86.7% higher than control, the highest fruit yield per plot (31.2 kg) and per hectare (5192.0 kg). Combining farmyard manure and inorganic fertilizers increased yield over the other treatments. This increase in yield with NPK and FYM may be attributed to increased vegetative growth, and better availability of nutrients when most needed during plant development. Moreover, FYM likely also supplied additional nutrients and improved soil physical properties, which could lead to better soil physical health. Among the treatments T_{13} proved to be superior, and this was likely due to difference in mineralization, availability and utilization of nutrients by the plants (Selvi and Perumal, 2000). Sharma (2000) studying broccoli concluded that NPK (175:75:60 $kg \cdot ha^{-1}$) +FYM at 12.5 $Mt \cdot ha^{-1}$ was best for obtaining higher yields. Others similar findings were reported by Abusaleha and Shanmugavelu (1988) and Singh *et al.* (1998) for okra, Sharma and Singh (1991) for potato and radish, Kumaran *et al.* (1993) for tomato, Rumpel (1997) for tomato, carrot and onion, Parmar *et al.* (1998) for pea, and Shelke *et al.* (2001) for brinjal.

C. Quality parameters

Quality and quantity are important in the marketing of a crop. For T_{13} fruit firmness was 611.7g/0.503cm^2, which was similar to T_{12} and this value was 11.72% higher than control (Table 2). Maximum Vitamin C content in T_{13} was 38.28 mg/100g, which was 44.18% higher than for control. The TSS observed was 4.90^0B in T_{13} was which was similar to T_{12} and 56.54% higher than controls. Fruit firmness, Vitamin C content and TSS were higher in plants grown with the combined FYM and NPK. This might be due to physiological influence on the activity of a number of enzymes, increased vegetative growth, balanced C/N ratio, solubilization of nutrients and their subsequent uptake (Pachauri and Singh, 2000). Similar effects with combined use of organic sources and chemical fertilizers were also reported by Abusaleha and Shanmugavelu (1988) for okra, Kumaran *et al.* (1993) for tomato, Malewar *et al.* (1998) for pepper and Shelke *et al.* (2001) for brinjal.

D. Available nutrients and their uptake

The highest available NPK in the soil at harvest was recorded for T_{13} (Table 2). Uptake of these nutrients by the tomato plants was studied at harvest. Results indicated that uptake of these nutrients was maximum for T_{13}. Increase in the uptake of nitrogen, phosphorus and potassium, with the application of higher levels of NPK, may be due to better availability of these nutrients a more extensive root system due to a balanced nutrient load, and improved absorption of nutrientsand water. The effect of FYM application was beneficial in enhancing the uptake of three major nutrients by tomato. Moreover, FYM after decomposition, releases macronutrients and micronutrients, which become available to the plants thus, increasing the uptake (Sharma, 2000). Similar observations have also been recorded by

Table 1. Effect of integrated nutrient management on growth, fruit yield, fruit firmness, vitamin C, TSS and B: C ratio of tomato (data pooled over two years)

Treatments	Plant height (cm)	Number of main branches/plant	Days to 50% flowering	Days to first harvest	Number of fruit/plant	Fruit yield/plant (g)	Fruit yield/plot (kg)	Fruit yield (kg/ha)	Benefit cost ratio	Fruit firmness (g/0.503cm^2)	Vitamin-C (mg/100g)	TSS (^{0}B)
T_0 Control	156	4.3	38	96	16.05	926.6	16.7	277.96	1.65	547.5	26.55	3.13
T_1 Pine needles at 10 t/ha	161	4.8	42	99	15.03	1030.0	18.6	309.31	1.69	558.2	29.50	3.73
T_2 Dry grass at 10 t/ha	161	5.2	44	100	17.07	1056.0	19.0	316.90	1.54	557.9	30.81	3.55
T_3 FYM 25 t/ha	173	5.8	46	103	19.20	1328.0	23.9	398.40	2.19	569.8	33.30	4.37
T_4 *Azotobactor*	162	4.6	42	100	16.62	1174.0	21.1	352.21	2.32	562.9	26.46	3.87
T_5 Pine needles (10t/ha)+50% NPK	166	5.0	42	101	17.05	1244.0	22.4	373.38	2.11	563.2	30.16	3.86
T_6 Pine needles (10t/ha)+100% NPK	169	5.3	45	104	18.03	1314.0	23.7	394.15	2.15	568.0	31.31	4.01
T_7 Pine needles (10 t/ha)+150% NPK	170	5.7	46	109	18.46	1316.0	23.7	394.80	2.03	568.5	32.66	4.18
T_8 Dry grass (10 t/ha) +50% NPK	162	5.7	41	103	17.51	1143.0	20.6	343.05	1.64	564.0	32.79	3.73
T_9 Dry grass (10 t/ha) +100% NPK	166	5.7	43	106	18.13	1162.0	20.9	348.66	1.58	566.0	33.50	3.82
T_{10} Dry grass (10 t/ha) +150% NPK	166	5.9	45	112	18.51	1237.0	22.3	371.11	1.65	568.5	34.70	3.87
T_{11} FYM (25 t/ha) + 50%NPK	174	6.0	47	108	20.53	1491.0	27.7	462.00	2.56	586.1	35.61	4.48
T_{12} FYM (25 t/ha) +100%NPK	177	6.2	48	110	23.13	1547.0	28.8	479.25	2.55	607.2	37.56	4.75
T_{13} FYM (25 t/ha) + 150%NPK	178	6.4	50	116	26.78	1730.0	31.2	519.16	2.70	611.7	38.28	4.90
T_{14} *Azotobactor*+50%NPK	164	4.8	43	103	19.42	1512.5	27.2	453.75	3.08	575.8	27.28	3.93
T_{15} *Azotobactor*+100%NPK	166	5.0	44	106	19.60	1542.5	27.8	462.75	2.98	576.1	28.21	4.05
T_{16} *Azotobactor*+150%NPK	169	5.1	45	108	20.83	1587.5	28.6	475.83	2.92	579.0	29.49	4.12
T_{17} Pine needles (10 t/ha) +dry grass (10 t/ha) +FYM (25 t/ha)	164	4.8	39	100	18.63	1179.0	21.2	352.08	1.25	559.7	29.18	3.69
SE (±)	1.87	0.13	0.82	1.07	0.32	12.15	1.02	7.20		2.38	0.38	0.07
CD (P=0.05)	3.80	0.28	1.66	2.18	0.65	24.70	2.12	14.50		4.83	0.78	0.15

Table 2. Effect of integrated nutrient management on N-P-K availability and uptake, water holding capacity and organic carbon in soil (data pooled over two years)

Treatments	Nutrients Availability			Nutrients Uptake			Water holding capacity (%)	Organic carbon (%)
	Available N(kg/ha)	Available P (kg/ha)	Available K(kg/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)		
T_0 Control	269.4	34.02	256.7	54.67	14.35	55.17	37.52	0.90
T_1 Pine needles 10 t/ha	274.6	34.39	270.5	59.50	16.35	57.83	38.56	0.96
T_2 Dry grass 10 t/ha	276.3	36.88	269.5	62.17	16.83	62.00	38.76	0.95
T_3 FYM 25t/ha	331.7	42.88	294.6	73.33	18.17	73.67	41.23	1.08
T_4 *Azotobactor*	303.7	38.89	278.2	62.50	15.50	61.33	39.15	0.92
T_5 Pine needles (10 t/ha)+50% NPK	323.3	43.90	289.5	65.83	18.67	61.00	39.38	0.93
T_6 Pine needles (10 t/ha)+100% NPK	340.0	46.80	293.0	68.83	20.60	64.50	40.17	0.99
T_7 Pine needles (10 t/ha)+150% NPK	350.8	48.29	291.8	74.17	20.50	67.33	40.18	1.05
T_8 Dry grass (10 t/ha) +50% NPK	307.8	44.06	291.5	67.50	18.00	66.83	40.23	0.98
T_9 Dry grass (10 t/ha) +100% NPK	313.2	47.54	295.5	71.67	19.67	69.50	40.65	1.00
T_{10} Dry grass (10 t/ha) +150% NPK	330.2	48.94	297.7	74.33	21.17	70.50	41.58	1.02
T_{11} FYM (25 t/ha) + 50%NPK	363.6	52.76	307.7	83.67	22.33	81.17	41.98	1.21
T_{12} FYM (25 t/ha) +100%NPK	368.7	53.97	319.3	89.33	24.00	82.65	43.12	1.27
T_{13} FYM (25 t/ha) + 150%NPK	382.8	57.24	334.5	97.17	25.50	87.15	44.42	1.39
T_{14} *Azotobactor* + 50%NPK	318.0	44.28	295.0	64.67	16.17	65.67	39.76	0.95
T_{15} *Azotobactor* + 100% NPK	352.8	45.13	299.2	69.83	17.33	70.50	38.58	1.00
T_{16} *Azotobactor* + 150% NPK	366.0	43.74	299.0	72.83	18.83	73.00	40.57	1.02
T_{17} Pine needles (10 t/ha) +dry grass (10 t/ha) +FYM (25 t/ha) + *Azotobactor*	345.0	45.97	288.0	65.50	16.32	64.00	39.37	0.98
SE (±)	4.54	0.51	2.99	2.77	1.12	1.02	1.09	0.02
CD (P=0.05)	9.24	1.05	6.08	5.63	1.59	2.56	2.22	0.04

Minhas and Sood (1994) for Jaggi *et al.* (1995) for potato and Malewar *et al.* (1998) for pepper.

E. Soil physico-chemical properties

Water holding capacity (WHC) was highest (44.42%) in plots receiving T_{13}, and it was similar to T_{12} (Table 3). Organic carbon was also highest in T_{13}. The highest WHC in treatments receiving FYM application may be due to soil aggregation, increased pore spaces, and enhancement in microbial activity.

The highest available organic carbon was for the combined FYM and chemical fertilizer treatments, which on decomposition released organic acids that increased solubilization of available nutrients (Sharma and Singh, 1991). These results are similar to those of Minhas and Sood (1994), Malewar *et al.* (1998) for pepper and Parmar *et al.* (1998) for pea.

F. Soil temperature and soil moisture

Maximum soil temperature (17.76 °C in 2000-2001 and 18.58 °C in 2001-2002) was found in T_{13} which was similar to the other treatments except T_0, T_{14}, T_{15}, T_{16} and T_{17} (Fig. 1). Maximum soil moisture (23.32%) was in treatment T_{17} (pine needles at 10t/ha+dry grass at 10 t/ha+FYM at 10 t/ha+*Azotobactor*). The T_{17} treatment had a soil moisture content that was 6.19% higher than the control. The highest soil temperature under FYM, pine needles and dry grass may be due to the prevention of daytime heating of the soil and by

retention of heat during the nocturnal hours. Whereas, maximum soil moisture found in T_{17} may be due to reduced evaporation with the use of dry grass, pine needles and FYM on the surface soil. Similar results have been reported by Moitra and Ghosh (1998) for rapeseed.

G. Economics of tomato production

The maximum benefit cost ratio (1:3.08) was found in T_{14} (*Azotobactor* + 50% NPK). This is likely due to a lower cost of cultivation as *Azotobactor* is a cheaper bio-fertilizer. The yield on a hectare basis was higher in T_{13} but the benefit cost ratio was lower (1:2.7) which may be due to high cost of FYM).

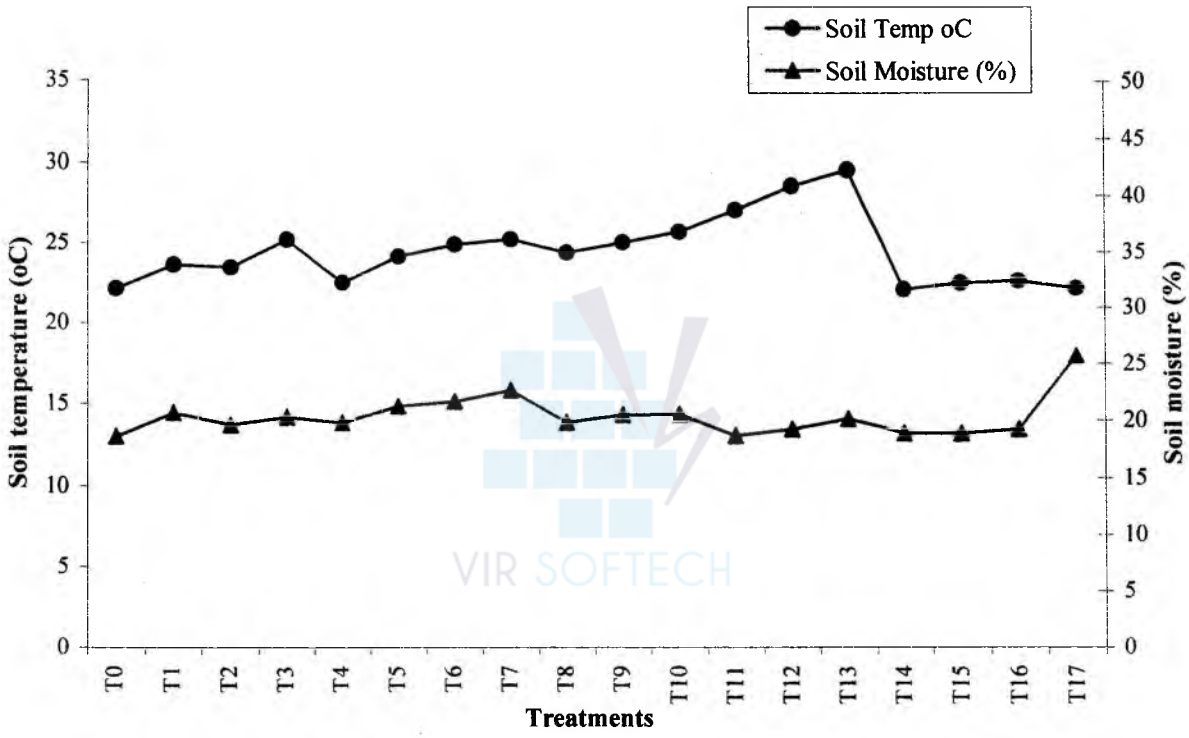


Fig. 1. Effect of nutrient management on soil temperature and moisture

References

Abusaleha and Shanmugavelu K G 1988. Studies on the effect of organic versus inorganic sources of N on growth, yield and quality of okra (*Abelmoschus esculentus* (L.) Moench). Indian J. Hort. **45**:312-318.

Anonymous 1997. Quarterly Bulletin of Statistics, FAO, Rome.

Anonymous 1998. State Department of Agriculture Estimate. HP Govt., Shimla, India.

Gomez A A and Gomez K A 1984. *Statistical Procedures for Agricultural Research*. John Wiley and Sons, New York.

Jaggi R C, Dixit S P and Bhardwaj S K 1995. Nutrient uptake and tuber yield of potato as influenced by phosphate and FYM in an acid alfisol. J. Indian Soc. Soil Sci. **43**:391-394.

Kumaran S S, Natrajan S and Thamburaj S 1993. Effect of organic and inorganic fertilizers on growth yield and quality of tomato. South Indian Hort. **46**:203-225.

Madhu M, Sersachalem N, Naladwadmatch K and Nimje P M 1997. Effect of organic and inorganic fertilizers on yield of crops and physio-chemical properties of soils in high hills of Nilgiri. Indian J. Soil Cons. **25** (3): 241-245.

Malewar G U, Ismail S and Rudraksha G B 1998. Integrated nitrogen management in chili (*Capsicum annum* L.). Bull. Indian Inst. Soil Sci. **2**:156-163.

Minhas R S and Sood A 1994. Effect of inorganics and organics on the yield and nutrient uptake by three crops in a rotation on an acid alfisol. J. Indian Soc. Soil Sci. **42**:257-260.

Moitra R and Ghosh D C 1998. Effect of tillage on soil physical properties, crop productivity and water use efficiency of rapeseed (*Brassica rapa* var. *glauca*) in West Bengal. Indian J. Soil Cons. **26**:86-90.

Pachauri S P and Singh V 2001. Effect of integrated use of FYM and chemical fertilizers on fertility of onion soils. Annals Plant Soil Res. **3** (2):304-306.

Parmar D K, Sharma P K and Sharma T R 1998. Integrated nutrient supply system for 'DPP68' vegetable pea (*Pisum sativum* var. *arvense*) in dry temperate zone of Himachal Pradesh. Indian J.Agric. Sci. **68** (2):84-86.

Rumpel J 1997. Effect of long-term organic and mineral fertilization on soil properties and development of tomato, carrot and onion. In: Ecological aspects of nutrition and alternatives for herbicides in horticulture. International Seminar, Warszawa, Poland. p. 96-100.

Sharma K C 2000. Influence of integrated nutrient management on yield and economics in broccoli under cold temperate conditions. Veg. Sci. **27** (1):62-63.

Singh D, Balyan D S and Rana M K 1998. effect of integrated nutreint management on growth, yield and economics of okra (*Abelmoschus esculentus* (L.) Moench). Haryana J. Hortic. Sci. **26**:254-257.

Sharma U C and Singh K 1991. Integrated management of phosphate and farmyard manure in potato-radish cropping sequence on acidic soil. J. Indian Soc. Soil Sci. **39**:468-471.

Shelke S R, Adsule R N and Amrutsagar V M 2001. Effect of conjunctive use of organic sources with urea fertilizer on soil chemical properties, yield and quality of brinjal. J.Indian Soc. Soil Sci. **49**:506-508.

VIR SOFTECH