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Impact of Organic and Inorganic Sources of Nitrogen and Water Management on Tomato-French Bean by Radish Cropping System

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A B S T R A C T

Experiment was done to study the integration of different sources of nitrogen and water management under vegetable based cropping system during rabi season of 2007 – 08 and 2008 – 09 at the Horticultural Research Station, Mondouri of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. The treatments consisted of three levels of irrigation as main plot *viz*., 15, 30 and 45 CPE, two cropping systems as subplot *viz*., sole crop and intercrop and three levels of fertility as sub-subplot *viz*., fertility level consisted of 100% N/ha from inorganic source, fertility level consisted of 75% N/ha from inorganic and 25% N/ha from organic sources and fertility level consisted of 50% N/ha from inorganic and 50% N/ha from organic sources. Tomato was grown as a main crop intercropped with French bean and radish. The recommended doses of fertilizer (RDF) were 120: 80: 80: N: P_2O_5: K_2O kg/ha. Sole crop of tomato with 30 CPE level of irrigation and fertility level consisted of 75% N from inorganic and 25% N from organic sources was found to be the best combination with the production of 28.22 tonnes fruit per hectare. Irrigation at 45 CPE with fertility level containing of equal amount of inorganic and organic N produced highest yield of French bean (intercrop) with 8.04 t/ha. Treatment combination of 15 CPE level of irrigation along with fertility level consisted of 75% N from inorganic and 25% N from organic sources produced highest root yield (36.10 t/ha) of radish (intercrop). It was clear from the experiment that tomato as a sole crop together with application of irrigation of water at 30 CPE and fertility level consisted of 120 kg N (90 kg from inorganic source and 30 kg from organic source + 80 kg P_2O_5 + 80 kg K_2O/ha had beneficial effect to boost up the yield.

Introduction

Vegetables occupy an important place in crop diversification and play a key role in economic security of our country. The share of vegetables in area and production was 0.39% and 60.84%, respectively. In vegetable production, India secured second position in the world after China with an annual production of 115.01 million tonnes from an area of 7.58 million hectare during 2007-2008 with the productivity of 15.2 metric tonnes per hectare (NHB, 2008). Though West Bengal continues to be the leading state in area and production, the productivity is higher in Tamil Nadu followed by U.P. and Bihar. The vegetable production is around 1 billion tonnes with an average productivity of 15.1

tonnes per hectare. However, this is much lesser than the recommended requirement of 300g/capita/day of vegetables for a balanced diet. Therefore, productivity of vegetables needs to be raised to 25 tonnes per hectare, as there is a tremendous pressure on land and renewable energy sources to meet ever-increasing demand of quality vegetables (Anon., 2006). In India, fertilizer being relatively cheap in relation to the value of the crop, farmers tend to apply too much fertilizer. This is particularly true for vegetables, since they are a high-value crop. For the farmer, this represents a type of insurance against crop losses due to nutrient deficiencies. However, overuse of fertilizer is not only wasteful, but is damaging crop quality and soil health in particular and the environment in general. Application of required amount of nutrients is one of the best methods for gaining higher yield of any crop.

Most of the vegetable crops are annuals and short duration in nature. Growths of vegetable crops are rapid and they are harvested in immature stage. Therefore, fertilizers and manures in adequate quantities are required to promote proper growth with a view to achieve success in vegetable production. Similarly, plants need water continuously during their life. It profoundly influences photosynthesis, respiration, absorption, translocation and utilization of mineral nutrients, and cell division besides some other metabolic processes. In India, the irrigation source is scarce compared to cropped area. So, it is advisable to use irrigation water wisely and economically at proper time and in required quantity. It would, therefore, necessary to establish a balance between number of irrigations and yield in such a way that maximum yield per unit of water used by the crop is obtained i.e., maximum water use efficiency. Among the different farming practices, irrigation management is very important for proper growth and yield of any crop, but either excess or shortage of water seriously affects the same. The relationship between growth and yield of a crop and water use has been a major focus of agricultural research in the arid and semi- arid regions. Most vegetables are rather shallow rooted and even short periods of two to three days of stress can affect marketable yield. Irrigation is important to increase size and weight of individual fruit and to prevent defects such as toughness, strong flavor, poor pod filling, and cracking of edible parts, blossom - end rot and misshapen fruit. Considering the above in view, proper management of water is very much essential for good yields and high quality of any vegetable. Intercropping is a cropping system where two or more crops are grown simultaneously in alternate rows or otherwise in the same land showing significant amount of intercrop competition.

The crop may or may not be sown/planted and harvested at one time. Intercropping is the only possible way of increasing cropping intensity to utilize available resources efficiently. Recently intercropping has been recognized as a potential beneficial system of crop production. The main purpose of intercropping is to get more net return per unit area of land at the same time with saving of energy and water along with less expenditure involving cost of cultivation.

The technology of intercropping of vegetable crops in the same piece of land at the same time could give a new direction in increasing total production with available resources, thereby raising farm family income. Therefore, keeping the above discussions as guideline, the present study was undertaken with vegetable based cropping system (using vegetables like tomato, French bean, radish, as experimental crops) under different sources of nitrogen with adequate and limited supplies of water.

Materials and Methods

The experiments were conducted at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during the year 2007-08 and 2008-09. The experiment was laid out in split plot design with 18 treatments and 3 replications. The treatment comprised of Irrigation (I_1 – 15 CPE, I_2 – 30 CPE, I_3 – 45 CPE); Cropping system (C_1 – Sole crop, C_2 – Intercrops); Fertility level (F_1 –100% N / ha from inorganic source, F_2 –75% N / ha from inorganic source +25% N / ha from organic source, F_3 –50% N / ha from inorganic source +50% N / ha from organic source. Tomato seedlings were transplanted as a main crop at a spacing of 120 x 60 cm between and within rows. French bean seeds were sown as an intercrops at a distance of 30 cm in hills 60 cm apart and to a depth of 2.5-3.0 cm in the main field. Radish seeds were also sown continuously in line in the main field and after thinning a spacing of 10cm from plant to plant and 20cm between rows were maintained. Irrigations were given by using cumulative pan evaporation (CPE). The water level in every irrigation was maintained till saturated (i.e. 5 cm). Earthing up was done at 30 days after planting and ridges were made by manually with the help of a spade. This operation also kept the field weed free by helping the crop to attain a good crop canopy. In order to keep the crops free from diseases and insect pests, adequate plant protection measures were taken in time. Observation was recorded on yield and its attributes from each treatment.

Results and Discussion

Effect of levels of irrigation, cropping system and fertility level of tomato

Data presented in Table 1 reveal that effect of interactions of irrigation, cropping system and fertility had significant influence on the results of plant height. Maximum plant height of 82.85 and 80.45 cm were obtained with $I_2C_1F_3$ combination respectively in 2007-08 and 2008-09. The pooled values of the two consecutive years show that, the highest plant height of 81.65 cm was obtained with $I_2C_1F_3$ combination. Effect of interactions of irrigation, cropping system and fertility was significant on number of fruits per plant (Table 1). Treatment combination $I_2C_1F_2$ produced maximum number of fruits per plant of 27.52 and 28.34 respectively in first and second year. This combination differed statistically from other interactions except $I_3C_1F_2$ in 2007 – 08. Minimum number of fruits per plant was recorded with $I_1C_2F_3$ in both the years. Pooled data indicate that number of fruits ranged between 17.69 in $I_1C_2F_3$ and 27.93 in $I_2C_1F_2$. Treatment combinations $I_2C_1F_1$, $I_2C_2F_2$ and $I_3C_1F_2$ were also found to be promising with the production of more than 25 fruits per plant. Interactions of irrigation, cropping system and fertility resulted significant effect on fruit weight (Table 1). Treatment combination $I_2C_1F_2$ was found to be the superior performer recording maximum fruit weight of 74.41 and 69.75 g respectively in 2007-08 and 2008-09 followed by $I_2C_2F_2$ where the same were 72.48 and 68.46 g. These two treatments were statistically at par for the results of fruit weight of tomato. Higher fruit weight of tomato under F_2 might be due to the fact that organic manures would have improved the soil physical conditions and increased nutrient availability resulting in a better vegetative frame (Rafi *et al.,* 2005). The increase in fruit weight of tomato due to integrated nutrient management was reported earlier by Shukla *et al.,* (2009). Beneficial effects of nitrogen in improvement of this character in tomato were also reported by Gupta and Sengar, (2000), Sahoo *et al.,* (2002) and Kaur *et al.,* (2003). Minimum fruit weight of 42.51 and 38.67 g were obtained with $I_1C_2F_3$ combination in the

respective years. Pooled data show that highest (72.08 g) and lowest (40.59 g) fruit weight were obtained respectively with $I_2C_1F_2$ and $I_1C_2F_3$ combinations. Interactions of irrigation, cropping system and fertility rendered their significant effect on fruit yield per hectare (Table 1). Treatment combination $I_2C_1F_2$ was found to be significantly superior recording fruit yield of 28.86 and 27.58 t/ha respectively in 2007-08 and 2008-09. The fruit yield decreased significantly at I_1 level of irrigation (15 CPE). This may be explained from the findings of Sharda *et al.*, (2006) in onion who reported that yield at higher level of irrigation decreased significantly and might be due to the fact that with increase water supply, the increase in evapotranspiration was proportionally higher than the increase in yield upto certain limits. Higher and lower proportions of inorganic N in the fertility treatments in this experiment were not effective for getting better fruit yield of tomato. Better results under F_2 were perhaps due to higher plant height, number, weight of fruit. Increase yield was also due to higher absorption of N, P, and K, this might have favourably affected the chlorophyll content of leaves resulting in increased synthesis of carbohydrates and buildup of new cells (Harikrishna *et al.*, 2002). Besides organic manures in terms of FYM in combination with inorganic fertilizers improved the soil physical conditions and increased nutrient availability resulting increased yield of tomato (Rafi *et al.*, 2005). Improved biometric characters namely plant height, number of branches, number and weight of fruit, possibly contributed to the higher fruit yield per hectare under the said combination.

Pooled data indicate that fruit yield ranged between 12.56 t/ha in $I_1C_2F_3$ and 28.22 t/ha in $I_2C_1F_2$. Yield of tomato under intercropping was less than sole crop. Lower yield of tomato under intercropping was possibly due to competition for space, light, water and nutrients created by intercrops namely French bean and radish. Prakash *et al.*, (2004) recorded higher yield of sole crop (tomato) than intercrop. Treatment combinations *viz*., $I_2C_2F_2$ and $I_3C_1F_2$ were also found to be promising recording more than 25.00 tonnes fruit yield per hectare. Data presented in Table 2 reveal that ascorbic acid content in fruit of tomato significantly varied due to different treatments. The significant impact on the ascorbic acid content in fruit in both the years with combined influence of different treatments was observed. The pooled data showed that significantly highest amount of ascorbic acid content was exerted in $I_2C_2F_3$ combination with a value of 24.35 mg / 100 g. Treatment combinations rendered significant influence on lycopene content in fruits of tomato (Table 2). Revelation of the results indicates that significantly highest amount (3.37mg/100g) was noted in $I_2C_1F_3$ treatment combination during first year. However, in second year it was observed under $I_1C_2F_2$ with 3.26mg/100g. Nitrogen content in fruit significantly varied due to different treatment combinations (Table 2). Treatment combination $I_2C_1F_1$ showed significantly highest amount of 4.82 % Nitrogen accumulation in fruit in second year while in first year it was observed under $I_2C_2F_1$ combination with a value of 4.77 %. Like the Nitrogen content in fruit, the Nitrogen uptake produced more or less same trend (Table 2). Different treatment combinations produced significantly increased Nitrogen uptake by fruit of tomato. Revelation of the results indicates that significantly highest amount of N uptake by fruit (21.92 Kg/ha) was observed with $I_2C_1F_1$.

Effect of levels of irrigation and fertility level of French bean

Effect of interactions of irrigation and fertility level was statistically significant on plant height of French bean.

Table.1 Effect of levels of irrigation, cropping system and fertility level on plant height, no. of fruits/ plant, fruit weight, fruit yield of tomato

Treatment combinations	Plant height (cm)			No. of fruits / plant			Fruit weight (g)			Fruit yield (t / ha)		
	07-08	08-09	Pooled	07 – 08	08 – 09	Pooled	07 – 08	08 – 09	Pooled	07 – 08	08 – 09	Pooled
$I_1C_1F_1$	65.82	63.52	64.67	19.21	20.76	19.99	56.68	54.67	55.68	15.30	16.08	15.69
$I_1C_1F_2$	69.67	68.23	68.95	21.22	21.19	21.21	56.85	55.21	56.03	17.34	16.56	16.95
$I_1C_1F_3$	59.25	60.52	59.89	18.07	19.25	18.66	51.72	49.62	50.67	13.28	13.67	13.47
$I_1C_2F_1$	63.21	61.03	62.12	20.34	22.32	21.33	49.37	45.75	47.56	14.13	14.28	14.21
$I_1C_2F_2$	69.13	67.52	68.33	22.27	24.54	23.40	64.27	59.69	61.98	20.25	20.71	20.48
$I_1C_2F_3$	59.62	58.46	59.04	17.16	18.21	17.69	42.51	38.67	40.59	12.64	12.47	12.56
$I_2C_1F_1$	79.36	78.38	78.87	24.15	26.43	25.29	70.21	67.42	68.82	23.65	24.98	24.32
$I_2C_1F_2$	82.85	80.45	81.65	27.52	28.34	27.93	74.41	69.75	72.08	28.86	27.58	28.22
$I_2C_1F_3$	59.48	57.61	58.55	22.87	24.52	23.70	63.32	59.38	61.35	20.43	20.61	20.52
$I_2C_2F_1$	63.41	61.22	62.32	24.32	23.82	24.07	65.52	61.42	63.47	22.39	20.98	21.69
$I_2C_2F_2$	82.67	78.02	80.35	26.53	27.16	26.85	72.48	68.46	70.47	27.10	26.76	26.93
$I_2C_2F_3$	58.61	56.75	57.68	20.34	22.31	21.33	62.38	57.76	60.07	17.90	18.11	18.01
$I_3C_1F_1$	63.48	61.47	62.48	22.46	23.16	22.81	63.22	59.31	61.26	20.22	19.67	19.95
$I_3C_1F_2$	75.08	71.46	73.27	27.45	26.98	27.22	68.19	63.47	65.83	26.40	24.41	25.41
$I_3C_1F_3$	58.43	58.42	58.43	20.71	21.15	20.93	58.25	55.17	56.71	17.27	16.63	16.95
$I_3C_2F_1$	63.47	61.48	62.48	21.32	22.32	21.82	64.72	60.72	62.72	19.39	19.14	19.27
$I_3C_2F_2$	73.72	70.22	71.97	23.39	24.43	23.91	66.38	63.18	64.78	21.93	21.58	21.75
$I_3C_2F_3$	55.72	53.35	54.54	18.21	19.33	18.77	56.72	52.67	54.70	14.62	14.47	14.55
S.E(m) ±	0.88	0.85	0.61	0.29	0.30	0.21	0.80	0.75	0.55	0.25	0.25	0.18
C.D. (0.05)	2.54	2.45	1.73	0.84	0.87	0.59	2.31	2.17	1.56	0.72	0.72	0.51

I_1 = 15 CPE; I_2 = 30 CPE; I_3 = 45 CPE; F_1 = 100% N/ha from inorganic source; F_2 = 75% N/ha from inorganic source + 25% N/ha from organic source; F_3 = 50% N/ha from inorganic source + 50% N/ha from organic source; C_1 = Sole crop; C_2 = Intercrop.

Table.2 Effect of levels of irrigation, cropping system and fertility level on ascorbic acid, lycopene content, Nitrogen content and Nitrogen uptake in tomato

Treatment combinations	Ascorbic acid (mg / 100 g)			Lycopene (mg / 100 g)			Nitrogen content in fruit (%)			Nitrogen uptake by fruit (kg / ha)		
	07-08	08-09	Pooled	07-08	08-09	Pooled	07-08	08-09	Pooled	07-08	08-09	Pooled
$I_1C_1F_1$	17.68	18.82	18.25	2.42	2.41	2.42	4.72	4.69	4.70	9.42	9.34	9.38
$I_1C_1F_2$	25.62	20.31	22.97	2.36	2.35	2.36	4.64	4.61	4.62	9.74	9.67	9.71
$I_1C_1F_3$	17.71	14.67	16.19	2.31	2.25	2.28	4.59	4.42	4.50	9.91	9.56	9.73
$I_1C_2F_1$	20.23	18.17	19.20	3.25	3.21	3.23	4.80	4.77	4.79	12.58	12.45	12.52
$I_1C_2F_2$	22.74	23.40	23.07	3.31	3.26	3.29	4.69	4.53	4.60	13.24	12.81	13.03
$I_1C_2F_3$	20.98	16.17	18.57	3.34	3.21	3.28	3.62	3.67	3.64	6.34	6.43	6.38
$I_2C_1F_1$	22.56	18.72	20.74	2.45	2.44	2.45	4.77	4.82	4.80	21.78	22.06	21.92
$I_2C_1F_2$	24.28	22.04	23.16	2.31	2.34	2.33	4.62	4.67	4.64	18.80	18.96	18.88
$I_2C_1F_3$	17.85	15.00	16.23	3.37	2.35	2.86	4.60	4.63	4.61	11.26	11.33	11.30
$I_2C_2F_1$	19.01	18.62	18.82	3.32	2.23	2.78	4.82	4.80	4.81	13.37	13.29	13.33
$I_2C_2F_2$	20.21	16.17	18.19	2.22	2.17	2.20	4.64	4.61	4.62	14.77	14.67	14.72
$I_2C_2F_3$	25.37	23.34	24.35	2.18	2.12	2.15	3.59	3.60	3.60	7.38	7.42	7.40
$I_3C_1F_1$	22.72	18.67	20.69	2.16	3.12	2.64	4.74	4.68	4.70	15.31	15.08	15.19
$I_3C_1F_2$	20.26	18.26	19.26	2.26	3.18	2.72	4.48	4.51	4.50	18.92	19.09	19.00
$I_3C_1F_3$	22.75	25.52	24.13	3.22	3.14	3.18	4.38	4.41	4.40	8.31	8.39	8.35
$I_3C_2F_1$	17.68	16.90	17.29	2.16	2.15	2.15	4.62	4.58	4.60	11.68	11.58	11.63
$I_3C_2F_2$	20.24	17.45	18.84	2.12	2.24	2.18	3.85	3.47	3.65	18.22	16.42	17.32
$I_3C_2F_3$	17.82	15.82	16.82	2.18	2.13	2.16	3.24	3.31	3.28	5.34	5.46	5.40
S.E(m) ±	0.28	0.25	0.18	0.03	0.03	0.02	0.06	0.06	0.04	0.17	0.17	0.12
C.D. (0.05)	0.80	0.72	0.51	0.09	NS	0.06	0.17	0.17	0.11	0.49	0.49	0.34

I_1 = 15 CPE; I_2 = 30 CPE; I_3 = 45 CPE; F_1 = 100% N/ha from inorganic source; F_2 = 75% N/ha from inorganic source + 25% N/ha from organic source; F_3 = 50% N/ha from inorganic source + 50% N/ha from organic source; C_1 = Sole crop; C_2 = Intercrop.

Table.3 Effect of levels of irrigation and fertility on plant height, number of pods per plant, pod weight and pod yield of French bean

Treatment combinations	Plant height (cm)			Number of pods per plant			Pod weight (g)			Pod yield (t/ha)		
	07-08	08-09	Pooled	07-08	08-09	Pooled	07-08	08-09	Pooled	07-08	08-09	Pooled
I_1F_1	106.85	108.18	107.52	15.32	15.58	15.45	7.43	7.69	7.56	3.90	4.05	3.98
I_1F_2	114.68	115.58	115.13	16.82	17.52	17.17	8.39	8.72	8.56	4.07	4.71	4.39
I_1F_3	141.68	140.02	140.85	17.62	17.82	17.72	8.74	8.97	8.85	4.84	4.89	4.86
I_2F_1	112.68	109.25	110.96	17.42	16.76	17.09	0.12	0.12	0.08	4.78	4.77	4.77
I_2F_2	136.21	135.28	135.75	17.43	19.51	18.47	0.39	0.39	0.26	4.87	5.59	5.23
I_2F_3	148.58	142.65	145.62	22.76	23.18	22.97	7.83	7.92	7.87	6.76	7.39	7.07
I_3F_1	111.24	127.52	119.38	18.56	18.79	18.68	8.01	8.32	8.17	5.31	5.34	5.32
I_3F_2	135.58	144.78	140.18	19.16	19.21	19.19	8.71	9.14	8.93	5.64	5.78	5.71
I_3F_3	174.88	165.23	170.06	24.38	25.23	24.81	0.06	0.06	0.04	7.73	8.34	8.04
S.E(m) ±	1.50	1.54	1.07	0.22	0.22	0.15	0.18	0.18	0.12	0.06	0.06	0.04
C.D.(0.05)	4.62	4.74	3.30	0.68	0.68	0.46	7.43	7.69	7.56	0.18	0.18	0.12

NS = Non significant; I_1 = 15 CPE; I_2 = 30 CPE; I_3 = 45 CPE; F_1 = 100% N/ha from inorganic source; F_2 = 75% N/ha from inorganic source + 25% N/ha from organic source; F_3 = 50% N/ha from inorganic source + 50% N/ha from organic source

Table.4 Effect of interactions of levels of irrigation and fertility on number of leaves per plant, root length, root weight and root yield of radish

Treatment combinations	number of leaves per plant			Root length (cm)			Root weight (g)			Root yield (t/ha)		
	07-08	08-09	Pooled	07-08	08-09	Pooled	07-08	08-09	Pooled	2007-08	2008-09	Pooled
I_1F_1	11.02	11.48	11.25	22.48	22.64	22.56	184.02	185.42	184.72	34.60	34.85	34.72
I_1F_2	11.21	11.61	11.41	24.48	23.52	24.00	226.35	230.80	228.57	35.75	36.46	36.10
I_1F_3	10.43	10.56	10.50	21.41	21.64	21.53	178.56	182.73	180.65	33.85	34.21	34.03
I_2F_1	10.21	10.37	10.30	22.25	22.38	22.32	152.41	160.18	156.30	28.74	30.33	29.54
I_2F_2	10.68	10.82	10.75	22.49	24.31	23.40	164.52	176.30	170.41	31.06	33.24	32.15
I_2F_3	9.53	9.75	9.64	21.36	21.52	21.44	138.31	140.94	139.63	26.08	26.56	26.32
I_3F_1	9.94	10.14	10.04	21.02	21.84	21.43	106.28	110.60	108.44	20.06	20.79	20.43
I_3F_2	10.34	10.42	10.38	22.38	23.62	23.00	123.35	125.43	124.39	23.05	23.28	23.16
I_3F_3	9.48	9.56	9.52	20.53	20.62	20.58	104.62	106.54	105.58	20.79	21.02	20.90
S.E(m) ±	0.13	0.13	0.09	0.27	0.28	0.19	1.88	1.93	1.35	0.35	0.36	0.25
C.D.(0.05)	NS	NS	NS	0.83	NS	NS	5.79	5.94	4.16	1.08	1.11	0.77

NS = Non significant; I_1 = 15 CPE; I_2 = 30 CPE; I_3 = 45 CPE; F_1 = 100% N/ha from inorganic source; F_2 = 75% N/ha from inorganic source + 25% N/ha from organic source; F_3 = 50% N/ha from inorganic source + 50% N/ha from organic source

Irrigation at 45 CPE along with application of 120kg N/ha (50% from inorganic and 50% from organic sources) was found to be best for getting maximum plant height of 170.06 cm in French bean plant. Effect of interactions of irrigation and fertility was found to be significant on the results of number of pods per plant (Table 3). Data of individual years as well as their pooled values point out that maximum number of pods per plant were obtained with I_3F_3 combination i.e. when the plots received 45 CPE level of irrigation along with 60kgN/ha from inorganic and 60kgN/ha from organic sources. Higher number of pods in French bean under integrated nutrient management had been reported earlier by Chaudhari *et al.,* (2001). Treatment combination I_3F_3 resulted significant differences from other interactions during both the years. Effect of interactions of different levels of irrigation and fertility was significant on the results of pod weight of French bean during 2008-09 only (Table 3). Maximum pod weight of 9.25 and 9.86 g were obtained with I_3F_3 combination. Influence of the said interaction was also reflected on the pooled values with the production of highest pod weight of 9.56 g. Band *et al.,* (2007) also established beneficial effects of integrated nutrient management on pod weight of French bean. It has been observed from the results of Table 4 that treatment combinations I_1F_2 recorded root weight of radish. Effect of

interactions of different levels of irrigation and fertility was found to be significant on pod yield per hectare in French bean when grown as an intercrop in the field of tomato (Table 3). Irrigation treatments associated with F_3 level of fertility resulted better performances. Treatment combination I_3F_3 recorded significantly highest pod yield of 7.73 and 8.34 t/ha respectively in 2007-08 and 2008-09. The present results are in conformity with the findings of Ahlawat and Sharma (1998) who reported that seed yield of French bean was proportionately higher with reduced water supply as compared to seed yield with frequent irrigations. Next best result was obtained under I_2F_3. Pooled data indicate that range of pod yield was between 3.98 and 8.04 t/ha. Higher pod yield might also be due to gradual and steady nutrient release during the growth period as well as enhanced biological activity and proper nutrition to the crop (Tripathy *et al.,* 2004). Besides better vegetative growth associated with development of yield attributes and increased availability of plant nutrients might have resulted higher pod yield under F_3 level of fertility. Similar results were also reported by Sharma and Arya (2001) in cabbage, Band *et al.,* (2007) in French bean and Rathore *et al.,* (2007) in cluster bean. The improvement in growth characters and yield attributes might have resulted enhanced pod yield under the promising combinations. During both the years of experiment minimum pod yield was recorded under I_1F_1.

Effect of levels of irrigation and fertility level of radish

Different treatment combinations of irrigation and fertility failed to influence significant effect on number of leaves per plant in both the years as well as on pooled data (Table 4). Maximum number of leaves of 11.21 and 11.61 were recorded with I_1F_2 combination during 2007 – 08 and 2008 – 09. Pooled data show that maximum average number of leaves of 11.41 was also observed under I_1F_2. The results are in conformity with the findings of Batra and Kalloo (1990) who also obtained increase root length of carrot with increase intensity of irrigation and Production of increased number of leaves of carrot at higher doses of inorganic N.

Treatment I_1F_2 combination produced maximum root length in both the years. Higher root length of radish at increasing level of nitrogen was reported earlier by Srinivas and Naik (1990). Treatment combinations namely, I_1F_1, I_2F_2 and I_3F_2 were found to be promising for production of higher root length of radish in this experiment.

Effect of different treatment combinations of irrigation and fertility was found to be significant on individual root weight (Table 4). Maximum individual root weight of 226.35 and 230.80 g were obtained with I_1F_2 combination in 2007-08 and 2008-09. Maximum root weight was 228.57 g in the pooled data. Treatment combination I_1F_2 differed significantly from other interactions for the results of this character in both the years and in case of pooled values also. Minimum individual root weight was obtained with I_3F_3. Effect of treatment combinations of irrigation and fertility was significant on root yield per hectare (Table 4). Maximum root yield of 35.75 and 36.46 t /ha were obtained with I_1F_2 combination in first and second year. Highest pooled values of root yield was 36.10 t /ha and obtained with I_1F_2 combination. Treatment combinations *viz*., I_1F_1, I_1F_3 and I_2F_2 were also found to be promising for production of better root yield of radish.

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