Indian Journal of Agricultural Sciences **83** (11): 1159–64, November 2013/Article

Yield and quality of apple (*Malus domestica*) cv Red Delicious as affected by bio-inoculants

S R SINGH[1], A H DAR[2], A S SUNDOURI[3] and M K SHARMA[4]

Sher-e-Kashmir University of Agriculture Science and Technology of Kashmir, Shalimar, J&K 191 121

Received : 24 April 2011; Revised accepted : 20 September 2013

ABSTRACT

Four different fertilizer regimes, viz. F_1 (75 % NPK as chemical fertilizer + 25% NPK as organic manure), F_2 (50% NPK as chemical fertilizer + 25% NPK as organic manure), F_3 (25% NPK as chemical fertilizer + 75% NPK as organic manure) and F_4 (25% NPK as chemical fertilizer + 50% NPK as organic manure) were tested on apple (*Malus domestica* Borkh.) along with two phosphate solublizing inoculants, viz. PSB (P_1) and VAM (P_2) and two nitrogen fixing inoculants, viz. *Azotobacter* (N_1) and *Azospirillum* (N_2). Maximum fruit yield (77.67 kg/tree) and fruit set (49.63%) were recorded in treatment $F_1P_2N_1$ whereas, highest fruit retention (29.87%) was recorded in treatment $F_1P_2N_1$. Maximum TSS (14.27%) and total sugars (4.30%) were observed in treatment $F_3P_2N_1$. Among all treatments, treatment $F_3P_2N_1$ showed highest increase in physical characteristics of fruits, viz. fruit weight (180.03g), fruit length (7.17 cm), fruit breadth (7.14 cm) and fruit volume (193.21 cm^3). Amongst nitrogen fixing inoculants, *Azotobacter* was more effective and amongst phosphate solublizing inoculants, VAM proved to be more effective. With respect to different fertilizer regimes used, F_1 (75% NPK as chemical fertilizer + 25% NPK as organic manure) was more effective in enhancing yield, quality and nutrient use efficiency. However, among different treatment combinations, $F_1P_2N_1$ was most effective and desirable treatment combination for higher yield and better quality of fruit.

Key words: Apple, Bio-inoculants, Fruit quality, Red Delicious, Yield

In India apple (*Malus domestica* Borkh.) accounts for 52% of total area and 75% of total of temperate fruits production. The productivity of apple in India has increased from 4.12 to 10.28 tonnes/ha over the last 25 years (Anonymous 2010), with average productivity of 10.35 tonnes/ha in Jammu and Kashmir state though highest at national level, but at global level this position is deplorable.

Among various factors which affect the productivity and cost of production, nutrition is the most important, which shares 30 per cent of total cost of production. In view of the above fact, it becomes imperative to make fruit production a more cost effective enterprise by switching on to the non-conventional sources of nutrients to meet the nutrient need of plants while at the same time helping to lower the cost of production and maintaining healthy edaphic environment. Use of bio-inoculants along with the chemical fertilizers have proven beneficial for increasing the fertilizer use efficiency and also increasing their cost effectiveness by decreasing the need of inorganic fertilizers thus contributing towards the betterment and maintenance of healthy environment. The goal is to find out model which strikes on acceptance balance between production benefits and ecological conservation with reduced use of chemical fertilizers. The use of bio-inoculants will be of prime importance. Thus, the evaluation of different bio-inoculants under different fertilization regimes is urgently required in apple, for improving fertilizer use efficiency, yield, and quality under a cost effective sustainable production system. Keeping in view the above facts, the present investigation was carried out with objectives to evaluate the effect of bio-inoculants on fruit yield and quality.

MATERIALS AND METHODS

Present investigation was conducted at the experimental farm of Division of Pomology, SKUAST-K, Shalimar Srinagar. Four bio-inoculants out of which two were phosphate solublizing inoculants [Phosphate solublizing bacteria (P_1) and vesicular arbuscular mycorrhizae (P_2), i e *Glomus fasciculatum* and two Nitrogen fixing inoculants [*Azotobacter chroococcum* (N_1) and *Azospirillum brasilense* (N_2)] were tested under four fertilizer regimes [75% NPK through chemical fertilizers + 25% NPK through organic manures (F_1), 50% NPK through chemical fertilizers + 25%

[1]Senior Scientist (email:srajparmar@gmail.com; [2]Horticulture Development Officer (email:hadar@rediffmail.com); [3,4]Assistant Professor (email:drsharma_mk@rediff.mail.com), Division of Pomology

NPK through organic manures (F_2), 25% NPK through chemical fertilizers + 75% NPK through organic manures (F_3) and 25% NPK through chemical fertilizers + 50% NPK through organic manures (F_4) and control (i.e. recommended dose of NPK) on one of the most popular variety of apple, i e Red Delicious. Bio-inoculants (lignite based) were obtained from Microbiology Centre, Division of Environmental Sciences, SKUAST-K, Shalimar. The experiment was conducted under randomized block design with three replications. The soil of experimental field was loam with normal soil reaction.

15 year old trees of uniform size and vigour grafted on seedling rootstock were selected and effect of various treatment combinations were tested. The experimental trees were inoculated with bio inoculants in the 1st week of April by placing to the root zone. FYM was applied to the trees according to the treatment combination during the month of February. Nitrogen was applied as urea, phosphorus as di-ammonium phosphate (DAP) and potassium as muriate of potash (MOP). Full dose of DAP and MOP and half dose of urea was applied during March, whereas, remaining urea was split into two equal doses and were applied fifteen days after fruit set and in July. Fifteen fruits were picked randomly from the tagged plants. Length and diameter of the fruit nm was measured with the help of Vernier callipers. For determining the fruit volume formula as suggested by Westwood (1993) was used "4.189 $ab^{2"}$ Where, a is ½ of major axis (long axis) and b is ½ of minor axis (shorter axis) and expressed in cubic centimeter. Weight of 15 randomly selected fruits from each treatment under each replication was taken using the sensitive balance and average weight per fruit was calculated. Fruit set was estimated from the examination of three uniform limb units per tree evenly spaced around the tree. Very low, weak and shaded limbs were avoided.

The fruit set was obtained by counting the number of fruits of each tagged limb and calculated by using formula suggested by Westwood (1993) and expressed as:

$$\text{Per cent fruit set} = \frac{\text{Number of fruits at pea stage}}{\text{Number of flower}} \times 100$$

Fruit retention was calculated by formula:

$$\text{Per cent fruit retention} = \frac{\text{Number of mature fruits}}{\text{Number of fruit lets}} \times 100$$

A random sample of fifteen fruits from each treatment was taken for measuring colour percentage on skin of fruit. Total sugars were estimated by titrating boiling mixture containing 5 ml, each of Fehling's A and B solutions against a hydrolyzed aliquot using methylene blue dye as indicator (Lane and Eynon 1932). Total soluble solids were observed directly on "Zeise" Hand Refractometer in °Brix. The readings were corrected at 20°C (AOAC 1984). The readings obtained were then converted into per cent. The acidity was determined by diluting known volume of pulp and titrating the same against standard N/10 solution of NaOH using phenolphthalein as indicator, and expressed in percentage.

RESULTS AND DISCUSSION

The effect of different bio-inoculants and fertilizer on physical, yield and bio-chemical traits in apple cv. Red delicious presented in Table 1 revealed that nitrogen-fixing inoculants showed significant increase in physical characters of fruit which non–significant with phosphate solublizing inoculants, whereas it was significant with fertilizers regimes. However, effect of different treatments on bio-chemical traits was non-significant . The treatment F_3 (25% NPK through chemical fertilizer+75% NPK through organic manures) resulted in highest fruit weight (160.09 g), fruit length (6.78 g), fruit breadth (6.91 cm), fruit volume (168.38 cm^3), TSS (13.67 ° Brix) and fruit colour (66.81%), but lowest fruit set (46.73%), fruit retention (26.68%) and finally yield (67.92 kg/tree). The treatment F_4 (25% NPK through chemical fertilizer+50%NPK through organic manures) recorded lowest fruit weight (137.47 g), fruit length (6.35 cm), fruit breadth (6.66 cm and fruit volume (141.01 cm^3). The treatments N_1 and N_2, P_1 and P_2 were non-significant and at par with each other for fruit yield and biochemical traits, respectively. However, treatment F1 (75% NPK through chemical fertilizer+25%NPK through organic manures) recorded maximum yield and its attributing traits, viz. fruit set (49.41%), fruit retention (29.54%) and fruit yield (72.75 kg/tree), however, treatment N_1 (*Azotobacter)* recorded maximum values for biochemical traits, viz. acidity (0.48 5) and total sugars (7.12%).

The interaction effect of nitrogen fixing inoculants and phosphate solublizing inoculants on physical yield and bio-chemical traits of fruit was found to be significantly higher than other treatments (Fig 1). Treatment N_1P_2 (*Azotobacter* + VAM) recorded maximum fruit weight (160.92 g), fruit length (6.82 cm), fruit breadth (6.99 cm), fruit volume (169.84 cm^3), fruit set (48.07%), fruit retention (27.72%), fruit yield (70.51 kg/tree), TSS (13.43 ° Brix), fruit colour (64.54%) and total sugars (7.12%), followed by P_1N_1 (PSB + *Azotobacter*), and P_2N_2 (VAM + *Azospirillum*) respectively. Minimum fruit weight (133.51 g), fruit length (6.37 cm), fruit breadth (6.53 cm) and fruit volume (137.33 cm^3) was recorded in P_1N_2. However, treatments N_2P_1, N_2P_2 and N_1P_1 were statistically at par. On the other hand, the interaction effect of nitrogen fixing inoculants and fertilizer regimes on physical characters of fruit differ non-significantly. However, treatment N_1F_3 recorded maximum fruit weight (168.28 g), fruit length (6.87 cm), fruit breadth (6.98 cm) and fruit volume (172.35 cm^3). Similarly non-significant results were recorded for interaction effects of phosphate solublizing inoculants and fertilizer regimes. However, maximum fruit weight (167.18 g), fruit length (6.94 cm), fruit breadth (6.99 cm) and fruit volume (175.32 cm^3) was recorded in treatment P_2F_3. Treatment P_2F_1 (75% NPK through chemical Fertilizer

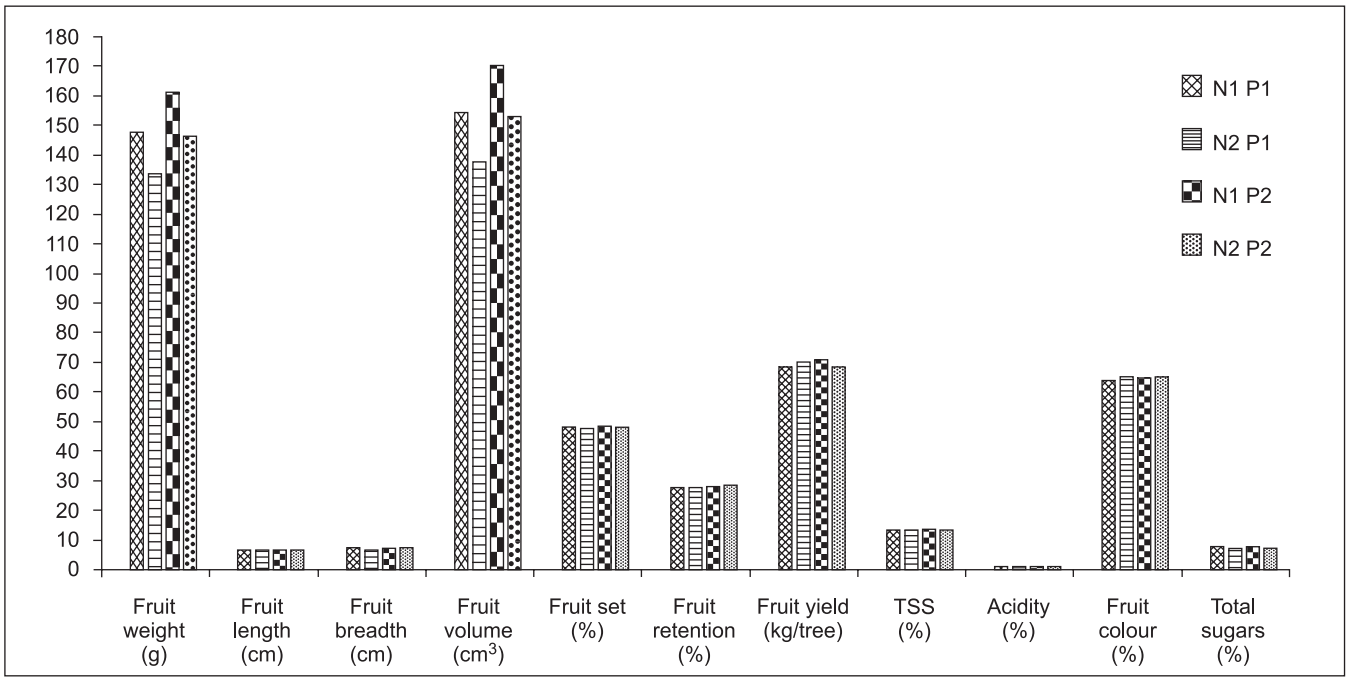

Fig 1 Interaction effect of nitrogen fixing inoculants and phosphate solublizing inoculants on fruit and yield attributing traits in apple cv. Red Delicious.

+25% NPK through organic manures + VAM) recorded the maximum value of 49.53%, 29.83% and 73.17 kg/tree for fruit set, fruit retention and fruit yield, respectively and also for biochemical traits.

Significant increase in fruit physical characteristics was recorded with interaction effect of nitrogen fixing inoculants, phosphate solublizing inoculants and fertilizer regimes (Table 1). Treatment $F_3P_2N_1$ resulted highest fruit weight (180.03 g), followed by $F_2P_2N_1$ (177.83 g), $F_2P_1N_1$ (159.43 g), $F_4P_2N_1$ (156.53 g), whereas, lowest fruit weight was recorded in treatment $F_4P_1N_1$ (114.41 g). However, treatments, $F_1P_1N_2$, $F_1P_2N_1$, $F_1P_2N_2$, $F_3P_2N_2$, $F_4P_1N_1$, $F_4P_1N_2$, F_5 were found to be statistically at par with each other.Effect of treatments $F_1P_1N_1$, $F_2P_1N_1$, $F_2P_1N_2$, $F_2P_2N_2$, $F_3P_1N_1$, $F_3P_1N_2$, $F_4P_2N_1$ and $F_4P_2N_2$ were also at par with each other. Treatment $F_3P_2N_1$ recorded highest fruit length (7.17 cm), whereas, treatment $F_1P_1N_2$ recorded lowest fruit length (5.86 cm). Treatment $F_3P_2N_1$ recorded greater fruit breadth (7.14 cm), followed by treatments $F_4P_1N_1$ (7.13 cm), $F_2P_1N_1$ (7.11 cm), $F_1P_1N_1$ (6.94 cm). Whereas, treatment $F_4P_2N_2$ resulted lower fruit breadth (6.25 cm). However, treatments $F_1P_1N_2$, $F_1P_2N_1$, $F_1P_2N_2$, $F_2P_1N_2$, $F_3P_1N_2$, $F_4P_1N_2$, $F_4P_2N_2$ and F_5 were statistically at par with each other. Treatment $F_3P_2N_1$ recorded maximum fruit volume (193.21 cm^3), followed by $F_4P_1N_1$ (187.27 cm^3), $F_2P_1N_1$ (169.27 cm^3), $F_1P_1N_1$ (166.63 cm^3). Whereas, treatment $F_4P_2N_2$ recorded minimum value (114.63 cm^3). However, treatments $F_1P_1N_2$, $F_1P_2N_1$, $F_1P_2N_2$, $F_3P_2N_2$, $F_4P_1N_2$, $F_4P_2N_2$ were statistically at par with each other.

Treatment $F_1P_2N_1$ recorded maximum fruit set (49.63%), fruit retention (29.87%) and high fruit yield (77.67 kg/tree). Treatment $F_3P_1N_1$ recorded minimum fruit set (45.81%) and fruit retention (26.51%), whereas treatment $F_4P_2N_1$ recorded minimum fruit yield (63.01 kg). In case of fruit set, treatments $F_2P_1N_1$, $F_2P_1N_2$, $F_2P_2N_1$, $F_2P_2N_2$, $F_3P_1N_1$, $F_3P_1N_2$, $F_3P_2N_1$, $F_3P_2N_2$, $F_4P_1N_1$, $F_4P_1N_2$, $F_4P_2N_1$, $F_4P_2N_2$ and F_5 were found to be statistically at par with each other. Whereas, treatments $F_3P_1N_1$, $F_4P_2N_2$, $F_3P_1N_2$, $F_3P_2N_1$, $F_3P_2N_2$, $F_2P_2N_2$, $F_4P_2N_1$, $F_4P_1N_1$, $F_2P_2N_1$, $F_2P_1N_1$, $F_4P_1N_2$ were statistically at par in respect to fruit retention and treatments $F_4P_2N_1$, $F_4P_2N_2$, $F_4P_1N_2$, $F_3P_2N_1$ and $F_2P_2N_1$ were statistically at par for yield. Treatment $F_1P_2N_1$ recorded maximum acidity (0.65%) followed by F_5 (0.60%), $F_3P_1N_1$ (0.57%), $F_2P_2N_2$ (0.54%), whereas, treatment $F_3P_1N_2$ recorded minimum value (0.23%). However, treatments $F_3P_1N_2$, $F_1P_1N_2$, $F_1P_2N_2$, $F_2P_1N_2$, $F_4P_1N_2$ and $F_4P_2N_1$ were found to be statistically at par with each other. Treatment $F_3P_2N_1$ had maximum total sugars content of 7.30% followed by $F_1P_2N_2$ (7.17%), $F_1P_1N_1$ and $F_2P_1N_1$ both (7.16%), $F_2P_2N_2$ (7.10%), whereas, minimum value was recorded in treatment $F_4P_2N_1$ (7.01%). However, treatments $F_4P_2N_2$, $F_4P_2N_1$, F_5, $F_4P_1N_2$, $F_3P_2N_1$, $F_3P_1N_2$, $F_3P_1N_1$, $F_2P_2N_2$, $F_2P_1N_2$ and $F_1P_1N_2$ were found to be statistically at par. Fruit colour showed a significant increase in response to interaction effect of nitrogen fixing and phosphate solublizing inoculants and fertilizer regimes (Table 2). Treatment $F_1P_2N_1$ recorded maximum fruit colour (68.33%) followed by $F_2P_2N_1$ (67.67%), $F_2P_2N_2$ (67.58%). Treatment $F_4P_1N_1$ recorded minimum fruit colour (61.01%). However, treatments $F_1P_1N_2$, $F_3P_1N_1$, $F_3P_1N_2$, $F_3P_2N_1$, $F_4P_1N_1$, $F_4P_1N_2$, $F_4P_2N_1$ and $F_4P_2N_2$ were found to be statistically at par with each other.

Table 1 Effect of different bio-inoculants and fertilizers (chemical + organic) on fruit and yield attributing traits in apple cv. Red Delicious

Treatment	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Fruit volume (cm^3)	Fruit set (%)	Fruit retention (%)	Fruit yield (kg/tree)	TSS (%)	Acidity (%)	Fruit colour (%)	Total sugars (%)
N_1	154.2	6.69	6.89	161.94	47.89	27.61	69.37	13.66	0.48	64.15	7.12
N_2	139.8	6.51	6.68	145.01	47.58	27.71	68.79	12.89	0.39	64.69	7.07
P_1	146.84	6.59	6.76	153.36	47.54	27.61	68.01	12.84	0.43	64.21	7.07
P_2	147.21	6.61	6.82	153.59	47.94	27.72	70.17	13.22	0.45	64.63	7.11
F_1	153.07	6.74	6.86	162.41	49.41	29.54	72.75	13.01	0.46	66.79	7.12
F_2	137.48	6.56	6.74	142.11	47.15	27.42	69.01	12.81	0.43	62.54	7.06
F_3	160.09	6.78	6.91	168.38	46.73	26.68	67.92	13.67	0.44	66.81	7.14
F_4	137.47	6.35	6.66	141.01	47.67	27.01	66.67	12.65	0.42	61.44	7.05
LSD(0.05)	13.25	0.35	0.20	15.64	1.33	0.64	1.61	0.01	0.07	1.49	0.02
±SED	6.43	0.17	0.09	7.66	0.65	0.31	0.79	0.00	0.03	0.73	0.01

75% NPK through chemical Fertilizer +25% NPK through organic manures - F_1; 50% NPK through chemical fertilizer + 25% NPK through organic manures - F_2; 25% NPK through chemical fertilizer +75% NPK through organic manures - F_3; 25% NPK through chemical fertilizer +50% NPK through organic manures - F_4. PSB - P_1; VAM - P_2; *Azotobacter* - N_1; *Azospirillum* - N_2

Table 2 Interaction effect of nitrogen fixing inoculants, phosphorus solublizing inoculants and fertilizer regimes on apple cv. Red Delicious

Treatment	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Fruit volume (cm^3)	Fruit set (%)	Fruit retention (%)	Fruit yield (kg/tree)	TSS (%)	Acidity (%)	Fruit colour (%)	Total sugars (%)
$F_1P_1N_1$	154.11	6.88	6.94	166.63	49.57	29.13	73.67	13.91	0.50	65.42	7.16
$F_1P_1N_2$	115.77	5.86	6.52	116.11	48.93	29.37	71.01	11.67	0.26	63.17	7.03
$F_1P_2N_1$	139.61	6.47	6.78	143.43	49.63	29.87	77.67	12.83	0.65	68.33	7.10
$F_1P_2N_2$	141.77	6.18	6.72	142.27	49.51	29.81	68.67	13.53	0.34	66.25	7.17
$F_2P_1N_1$	159.43	6.89	7.11	169.27	47.33	27.31	69.67	12.71	0.45	66.51	7.16
$F_2P_1N_2$	150.53	6.72	6.63	156.81	47.27	28.17	71.67	13.71	0.40	65.51	7.06
$F_2P_2N_1$	177.83	6.49	6.86	162.43	47.13	27.27	66.33	13.17	0.45	67.67	7.07
$F_2P_2N_2$	154.77	6.85	6.84	161.11	46.87	26.93	68.33	13.81	0.54	67.58	7.06
$F_3P_1N_1$	150.11	6.49	6.81	156.21	45.81	26.51	67.01	13.13	0.57	62.08	7.02
$F_3P_1N_2$	146.71	6.38	6.71	152.87	46.53	26.63	71.01	12.51	0.23	62.92	7.03
$F_3P_2N_1$	180.03	7.17	7.14	193.21	47.21	26.77	66.01	14.27	0.43	62.01	7.30
$F_3P_2N_2$	137.33	6.74	6.86	140.33	47.41	26.83	67.67	11.27	0.50	67.51	7.10
$F_4P_1N_1$	114.41	7.03	7.13	187.27	48.07	27.03	71.67	12.61	0.45	61.01	7.10
$F_4P_1N_2$	125.97	6.21	6.53	135.63	46.77	27.61	65.67	12.71	0.40	61.92	7.03
$F_4P_2N_1$	156.53	6.71	6.85	157.43	48.41	27.01	63.01	13.37	0.37	61.21	7.01
$F_4P_2N_2$	147.53	6.61	6.25	114.63	47.43	26.37	66.33	13.33	0.45	61.83	7.08
F_5 (Control)	143.77	6.66	6.69	159.63	46.45	29.73	67.01	13.50	0.60	66.08	7.02
LSD(P=0.05)	30.87	0.41	0.55	35.28	2.62	1.35	3.79	0.04.	0.18	2.98	0.07
±SED	15.12	0.19	0.27	17.34	1.28	0.66	1.86	0.01	0.08	1.46	0.03

75% NPK through chemical fertilizer+25%NPK through organic manures - F_1; 50% NPK through chemical fertilizer+25%NPK through organic manures - F_2; 25% NPK through chemical fertilizer + 75% NPK through organic manures - F_3; 25% NPK through chemical fertilizer + 50% NPK through organic manures - F_4. PSB - P_1; VAM - P_2; *Azotobacter* -N_1; *Azospirillum* - N_2.

The increase in various fruit physical parameters might be due to contribution of organic manures on more balanced C/N ratio, balanced availability of macro- and micro-nutrients and growth promoting substances produced by different bioinoculants applied under different treatment combinations. This may have lead to better metabolic activities in the plants which ultimately lead to high protein and carbohydrate synthesis (Singh *et al.* 1970). Mahendra *et al.* (1988) also observed increase in yield components apparently from improved soil chemical and physical properties which were induced by organic matter application. The results are also in line with the findings of Rathi and Bist (2004) who found maximum fruit length, breadth, weight and volume with application of poultry manures alongwith inorganic fertilizers.

The improvement in fruit TSS may be due to balanced and enhanced supply of macro- and micro-nutrients and hormonal secretion by different bio-inoculants. The results obtained are in line with the findings of Pereira and Mitra (1999) who have found TSS, vitamin C superior with organic manure application as compared to inorganic fertilizer. Rathi and Bist (2004) reported maximum TSS with application of FYM, poultry manures, neem cake along with *Azotobacter* and PSB. Singh *et al.* (2000) reported maximum acidity with the application of 75% inorganic nitrogenous fertilizer full phosphatic fertilizer along with biofertilizers. Increased sugar content might have resulted due to absorption of balanced macro- and micro-nutrients and growth regulators produced by bio-inoculants. Rathi and Bist (2004) observed maximum sugar content in treatments receiving FYM, poultry manure, neem cake along with *Azotobater* and PSB. The sugar content of fruits was recorded fairly high in plants inoculated with *Azotobacter* (Tiwary *et al.* 1998). The pigments causing red colouration in apple skin are mainly anthocyanins, i.e. glycosides of anthocyanidins (Van Bunen 1970). K appeared to favour the development of colour in some apple cultivars and improved anthocyanin formation by high K supply (Walter 1967).

The increase in fruit set may be attributed to the balanced nutrient supply to the plant. More fruit set with the help of optimum levels of N and K is supported by results of Baxter (1974). Analogous findings were recorded by Singh (1982) while working on Floradasun peach. Higher fertilizer doses of nitrogen and potassium were recorded to increase fruit set is different fruit crops (Sharma and Chauhan 1996, Ahlawat and Yamdagni 1988). Effect of nutrient levels is thought to bear a marked effect on fruit retention as recorded by various workers. Singh *et al.* (1991) recorded a significant increase in fruit retention by foliar application of urea in mango. Dutta *et al.* (2000) recorded significant increase in fruit retention with application of boron in litchi. The increase in fruit retention may be due to increased level of nitrogen which may increase the supply of some hormones to the fruit that tend to reduce abscission, probably auxins (Addicoot 1970, Rajput and Singh 1977).

The increase in yield with treatment $F_1P_2N_1$ might have been due to steady and balanced nutrient availability to the plant and secretion of growth promoting hormones by applied bio-inoculants. The results are in line with the observations made by Rathi and Bist (2004) who found maximum yield with application of poultry manures and inorganic fertilizers. The present results are also in accordance with the findings of Aslantas *et al.* (2007) who found higher apple fruit yields with growth promoting rhizobacteria inoculated trees than in non-inoculated ones.

From the foregoing discussion, it may be concluded that amongst nitrogen fixing inoculants, *Azotobacter* was more effective and amongst phosphate solublizing inoculants, VAM proved to be more effective. With respect to different fertilizer regimes used, F_1 (75% NPK as chemical fertilizer + 25% NPK as organic manure) was more effective in enhancing yield, quality and nutrient use efficiency. However, among different treatment combinations, $F_1P_2N_1$ was most desirable and effective treatment combination.

REFERENCES

AOAC. 1984. *Official Analytical Methods*, 14th edition, pp 22–4. Association of Analytical Agriculture Chemists, Washington DC.

Addicoot F T. 1970. Plant hormones in the control of abscission. *Bio. Review* **45**: 485–524.

Ahlawat V P and Yamdagni R. 1988. Effect of nitrogen and potassium application on berry set, berry drop and quality of grapes cv. Perlette. *Progressive Horticulture* **20**(1-2): 53–7.

Anonymous. 2010. Statements showing district-wise area and production of fruits in Jammu and Kashmir State. Directorate of Horticulture, J&K Government, Srinagar, Jammu and Kashmir.

Aslantas R, Cakmakci R and Sahin F. 2007. Effect of plant growth promoting rhizobacteria on young apple tree growth and fruit yield under orchard conditions. *Scientia Horticulturae* **111**: 371–7.

Baxter P. 1974. Young peach trees and phosphate and nitrogen. *Victorian Horticulture Digest* **61**: 11–7.

Dutta P, Banik A and Ohua R S. 2000. Effect of boron on fruit set, fruit retention and fruit quality of litchi cv. Bombai. *Indian Journal of Horticulture* **57**(4): 287–90.

Lane J H and Eynon L. 1932. Determination of sugars by means of Fehlings solution with methylene blue as an internal indicator. *Journal of Society of Chemical Industry* **42**: 301–6

Mahendra S B, Kenneth S D, Venkateshwara, R S and Veincent E P. 1988. Application of poultry manure influence Thompson Seedless grape production and soil properties. *HortScience* **23**: 1010–2.

Pereira L S and Mitra S K. 1999. Studies on organic along with inorganic nutrition in guava. *Indian Agriculturist* **43**(3&4): 155–60.

Rajput C B S and Singh J. 1977. Effect of urea spray on chemical composition of ber fruits (*Zizyphus mauritiana* Lam.). *Journal of Horticulture Science* **52**: 371–2.

Rathi D S and Bist LD. 2004. Inorganic fertilization through the use of organic supplements in low chill pear cv. Pant Pear-18. *Indian Journal of Horticulture* **61**(3): 223–5.

Sharma D P and Chauhan J S. 1996. Effect of pruning intensities under different levels of nitrogen and potassium on fruit set, yield and quality of peach cv. July Elberta. *Indian Journal of Horticulture* **53**(3): 175–80.

Singh C, Saxena S K, Goswami A M and Sharma R R. 2000. Effect of fertilizers on growth, yield and quality of sweet orange (*Citrus sinensis*) cv. Mosambi. *Indian Journal of Horticulture* **57**(2): 114–7.

Singh J N, Rajput, C B S and Prakash S. 1991. Effect of urea spray on fruit retention and physico-chemical composition of mango (*Mangifera indica* L.) cv. Amrapali. *Haryana Journal of Horticultural Science* **20**(1-2): 35–8.

Singh K, Gill I S and Verma O P 1970. Studies on poultry manure in relation to vegetable production, I-Cauliflower. *Indian Journal of Horticulture* **27**: 42–7.

Tiwary D K, Hasan M A and Chattopadhyay P K. 1998. Studies on the effect of inoculation with *Azotobacter* and *Azospirillum* on growth, yield and quality of banana. *Indian Agriculturist* **42**(4): 235–40.

Van Bunen J. 1970. Fruit phenolics. *(In:) The Biochemistry of Fruits and their Products,* Vol 1, pp 269-304. Hulme A C (Ed). Academic Press, London.

Walter T E. 1967. Factors affecting fruit colour in apples : a review of world literature. Report of East Malling Research Station for 1966, pp 70–82.

Westwood M N. 1993.*Temperate Zone Pomology*, p 223. W H Freeman and Company, San Francisco.