Indian Journal of Agricultural Sciences **86** (2): 267—72, February 2016/Article
https://doi.org/10.56093/ijas.v86i2.56002

Economic dynamics of tissue cultured strawberry (Fragaria × ananassa) under the influence of integrated plant nutrients in humid sub tropical hills of North Eastern India

T K HAZARIKA[1], ZOTHANKIMA RALTE[2] and B P NAUTIYAL[3]

Mizoram University, Aizawl 796 004

Received: 14 April 2015; Accepted: 22 September 2015

ABSTRACT

Satisfactory and sustainable level of agricultural production can be achieved by combined application of inorganic fertilizers with organic manures, bio-fertilizers, bio-regulators and vermicompost. A field experiment was conducted during 2010-12 at experimental farm, Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawl, India, to find out the profitability of tissue cultured strawberry (*Fragaria* × *ananassa* Duch.) (cv. Festival) cultivation by using various integrated plant nutrient system (IPNS) combining inorganic fertilizers with organic manures, bio-fertilizers and bio-regulators. The response of IPNS on economics of strawberry indicated that the overall cost of cultivation as well as economics of strawberry production was significantly influenced by integration of various components. Among the different treatments, the highest expenditure of ₹ 2 077 576.83/ha was incurred in 100% RDF + vermicompost as against the lowest in control. With respect to the income, the highest net income of ₹ 7 298 119.27/ha was obtained in 75 % RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+50 ppm BA. The same treatment also recorded the highest cost benefit ratio of 1: 3.51.

Key words: Bio-fertilizer, Bio-regulators, Cost benefit, Economics, Festival, IPNS, Organic manures, Strawberry

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most important soft fruits acclaimed for its refreshing characteristics, aroma, lucrative appearance and good nutritive values (Singh *et al.* 2012). It is a very popular berry and also good source of natural antioxidants including carotenoids, vitamins, phenols, flavonoids, dietary glutathionine and endogenous metabolites and exhibits a high level of antioxidant capacity against free radical species (Wang and Jiao 2000, Singh *et al.* 2008).

Among the various factors which contribute to the production, nutrition is the most important aspect (Bhat 1999, Nazir 2005). Although, chemical fertilizers contributes a lot in fulfilling the nutrients requirement of strawberry, but excessive and unbalanced use of chemical fertilizers may lead to health and ecological hazards, depletion of physico-chemical properties of the soil and ultimately results in poor crop yields (Singh and Singh 2009).

Uses of organic manures are environmentally safe and viable alternatives of chemical fertilizers and it increases microbial biomass in the soil (Selvamani *et al.* 2011). Organic and microbial sources of nutrients have advantage of consistent and slow release of nutrients, maintaining ideal C : N ratio, improvement of water holding capacity and microbial biomass of soil profile without having any residual effects (Yadav *et al.* 2010). The use of bio-fertilizers is being sought to maintain and improve soil quality and productivity levels at low input cost (Singh *et al.* 2010). Through better conservation of C, N and P, use of sole or co-inoculation of bio-inoculants, viz *Azotobacter*, *Azospirillum, Pseudomonas* and arbuscular mycorrhizal fungi (AMF) which are the components of organic farming regulate steady supply of nitrogen and phosphorus during plant growth (Singh and Singh 2006). Inoculation of these N-fixing microorganisms in the soil not only increases the yield but also save 20-40% nitrogen inputs. In addition to organic manures and bio-fertilizers, the bio-regulators also play an important role in growth and yield of fruit crops (Hazarika *et al.* 2015). Bio-fertilizers are known to exert indirect effects on soil microbiological activities which in turn help the plant to grow better, besides direct effect on nitrogen fixation and P mobilization (Rana and Chandel 2003). Plant bio-regulators, play important role in regulating the various physiological processes and balance the source and sink thereby increase the productivity of fruit crops (Purbey and Sen 2005). Some of the plant bio-regualtors are synthesized endogenously, but occasionally they are needed to be supplemented exogenously for additional

[1]Assistant Professor (e mail:triidp28@gmail.com), [2]Ph D Scholar (e mail:mama83ralte@gmail.com), Department of Horticulture, Aromatic and Medicinal Plants; [3] Dean, College of Horticulture, UUHF, Bharsar, Uttarakhand (e mail: bhagwatinautiyal@ gmail.com)

stimulus for short duration crops like strawberry, which require quick response for increased growth, fruit set and yield.

Integrated Plant Nutrient System (IPNS) is a recent approach for utilization of available resources such as organic, inorganic, and microbial inoculants with an integrated approach for sustainable economic yield for accelerating crop productivity by maintaining chemical, physical, and biological balance in the soil plant system (Hazarika *et al.* 2015). This system has already been receiving wide attention and is contributing substantially towards acceleration of crop productivity by maintaining chemical, physical and biological balance in soil-plant system. The combined application of chemical fertilizers with organic manures like farmyard manure (FYM), vermicompost, neem cake along with bioferlizers, viz. arbuscular mycorrhizal fungi (AMF), *Azospirillum*, phosphate solubilising bacteria (PSB) help to increase the organic matter content of soil and population of beneficial soil microorganisms which ultimately increase the growth, yield and productivity of the crop (Selvamani *et al.* 2011).

Keeping above points in view and the research gaps, the present experiment was conducted to find out the best suitable integrated plant nutrient system packages by combining inorganic fertilizers with organic manures, bio-fertilizers and bio-regulators with respect to economics with the production of micro-propagated strawberry cv. Festival for giving maximum profitability to the farmers of Mizoram, India.

MATERIALS AND METHODS

The present experiment was conducted at Experimental farm, Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawl, India during 2010 to 2012 with tissue cultured strawberry cv. Festival. The experimental field was situated at 23°44′45.6′′ N latitudes and 92°41′04.5′′ E longitudes and the elevation was 855 m above MSL. The soil of the experimental plot was sandy loam; the available N, P and K were 270.45 kg/ha, 28.76 kg/ha and 119.45 kg/ha with 0.57% organic carbon and the soil was acidic in reaction with soil pH 4.97. The experiment was laid out in a Randomized Block Design (RBD) with 12 treatments and 3 replications. Required quantity of vermicompost @ 5 tonnes/ha was applied before transplanting of strawberry runners in the respective plots as per scheduled treatments. *Azospirillum* and PSB culture were mixed in 10% molasses slurry and the roots of the runners were thoroughly dipped in the slurry before planting. After two months of planting, the soil was also inoculated with *Azospirillum* and PSB @ 2 kg/ha. The recommended N @120 kg/ha, in the form of urea was applied in two split doses, half after one month of planting and the second half after flowering. The recommended dose of P_2O_5 and K_2O @ 80 kg and 100 kg/ha in the form of single super phosphate and muriate of potash were applied at the time of field preparation.

The various treatments comprising of organic manures, chemical fertilizers, bio-fertilizers and bioregulators were as follows: T_1 = 100% recommended dose of fertilizer (RDF) + vermicompost, T_2 = 75% RDF + vermicompost + *Azospirillum,* T_3 = 75% RDF + vermicompost + PSB, T_4 = 50% RDF + vermicompost + PSB + *Azospirillum*, T_5 = 75% RDF + vermicompost + PSB + *Azospirillum,* T_6 = 50 % RDF + vermicompost + PSB + *Azospirillum* + 100 ppm GA_3, T_7 = 75 % RDF + vermicompost + PSB + *Azospirillum*+ 100 ppm GA_3, T_8= 50% RDF + vermicompost + *Azospirillum* + PSB + 100 ppm BA, T_9= 75 % RDF + vermicompost + *Azospirillum* + PSB + 100 ppm BA, T_{10} = 50% RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA, T_{11}= 75 % RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA, T_{12} = control,

Standard procedures were adopted for taking observations on various growth and yield characters. Plant growth characters of five plants from the middle of each plot were selected randomly for observation and tagged for subsequent record. The observations for growth and developmental characters were recorded after one months

Table 1 Comparative yield potentiality of different treatments and economics of cultivation

Treatment	Yield(q/ha)	Percentage yield increase over control	Runners/ha	Gross expenditure (₹)	Gross income (₹)	Net income (₹)	C:B ratio
T_1	88.60	2.46	462400	2077576.87	7282000.00	5204423.13	2.51
T_2	93.30	7.90	470400	2075153.68	7503000.00	5427846.32	2.62
T_3	94.36	9.12	477600	2075153.68	7606800.00	5531646.32	2.67
T_4	95.15	10.04	498400	2072730.48	7838500.00	5765769.52	2.78
T_5	94.76	9.59	528000	2075456.68	8122800.00	6047343.32	2.91
T_6	96.84	11.99	549600	2076408.90	8401200.00	6325743.32	3.05
T_7	97.70	12.99	557600	2063985.10	8507000.00	6443014.90	3.12
T_8	104.82	21.22	561600	2072630.16	8760600.00	6684973.84	3.22
T_9	106.11	22.71	577600	2075626.36	8959300.00	6883673.64	3.32
T_{10}	110.40	27.67	590400	2074654.53	9216000.00	7141345.47	3.44
T_{11}	113.85	31.66	596000	2077380.73	9375500.00	7298119.27	3.51
T_{12}	86.47		378400	2013899.60	6378100.00	4364200.40	2.17

Table 2 Details of economics of cultivation per hectare (In ₹)

Item	Treatment											
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
Preparatory cost												
Preparatory cultivation including land preparation, ploughing, harrowing and soil leveling	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Cost of fencing	59200	59200	59200	59200	59200	59200	59200	59200	59200	59200	59200	59200
Cost of plastic mulches	46290	46290	46290	46290	46290	46290	46290	46290	46290	46290	46290	46290
Cost of seedlings @₹ 20/seedling	1600000	1600000	1600000	1600000	1600000	1600000	1600000	1600000	1600000	1600000	1600000	1600000
Planting of seedlings (20 mandays)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Infrastructure												
Store and Pump House	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Agricultural equipments and implements	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Labour room	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Manuring												
Cost of vermicompost @ 5 t/ha	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Urea @ 260.4kg/ha	3124.80	2343.60	2343.60	1562.40	2343.60	1562.40	2343.60	1562.40	2343.60	1562.40	2343.60	
SSP @ 500 Kg/ha	5000	3750	3750	2500	3750	2500	3750	2500	3750	2500	3750	
MOP @ 167 Kg/ha	2672	2004	2004	1336	2004	1336	2004	1336	2004	1336	2004	
Biofertlizers @ 2 Kg/ha		300	300	600	600	600	600	600	600	600	600	
Bioregulators						3642	3642	168	168	1905	1905	
Application of fertilizer : basal and top dressing (15 md)	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	
Irrigation												
Tube-well/submersible pump	105000	105000	105000	105000	105000	105000	105000	105000	105000	105000	105000	105000
Cost of drip (Turboline) with Fertigation	85000	85000	85000	85000	85000	85000	85000	85000	85000	85000	85000	85000
II. Intercultural operations												
III. Earthing up, mulching, spray of chemicals (30 md)	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
Plant protection chemicals	1470	1470	1470	1470	1470	1470	1470	1470	1470	1470	1470	1470

Contd.

Table 2 *Cond.*

Item	Treatment											
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
IV. Harvesting (20 md)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
V. Packaging (10 md)	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Total expenditure	2057006.80	2054607.60	2054607.60	2052208.40	2054907.60	2055850.40	2043549.60	2052376.40	2055075.60	2054113.40	2056812.60	1993960
Miscellaneous cost (1% of total expenditure)	20570.07	20546.08	20546.08	20522.08	20549.08	20558.50	20435.50	20253.76	20550.76	20541.13	20568.13	19939.60
Gross expenditure	2077576.87	2075153.68	2075153.68	2072730.48	2075456.68	2076408.90	2063985.10	2072630.16	2075626.36	2074654.53	2077380.73	2013899.60
Yield (q/ha)	88.60	93.30	94.36	95.15	94.76	96.84	97.70	104.82	106.11	110.40	113.85	86.47
Return @₹ 30000/q	2658000	2799000	2830800	2854500	2842800	2905200	2931000	3144600	3183300	3312000	3415500	2594100
Runner production/hectare	462400	470400	477600	498400	528000	549600	557600	561600	577600	590400	596000	378400
Return @ ₹ 10/ runner	4624000	4704000	4776000	4984000	5280000	5496000	5576000	5616000	5776000	5904000	5960000	3784000
Gross income (₹)	7282000	7503000	7606800	7838500	8122800	8401200	8507000	8760600	8959300	9216000	9375500	6378100
Net income	5204423.13	5427846.32	5531646.32	5765769.52	6047343.32	6325743.32	6443014.90	6684973.84	6883673.64	7141345.47	7298119.27	4364200.40
Benefit : cost ratio	2.51	2.62	2.67	2.78	2.91	3.05	3.12	3.22	3.32	3.44	3.51	2.17

Cultivar: Festival Plant Population: 80000 Spacing: 0.5 × 0.25 m, wages: ₹ 150 per man-day.

of planting at monthly intervals. The matured fruits were harvested uniformly at 3/4th maturity stage when 75% of the fruit colour to pink. The yield/hectare was calculated by multiplying the weight of berries/plant with the total number of plants/ha and expressed in q/ha. Data were subjected to ANOVA (Gomez and Gomez 1984), where appropriate means were separated with least significant difference analysis. The economics of the individual treatment was calculated based on the total cost of cultivation and gross income and were expressed on per ha basis. The expenditures both recurring and non-recurring required during the cropping period were computed based on the investment on preparatory cost including planting materials. Net income was calculated by subtracting gross expenditure from the gross income on per ha basis. The cost benefit ratio was calculated from the value of total expenditure and gross return based on the benefit obtained on per rupee cost in different treatments separately.

RESULTS AND DISCUSSION

The cost-benefit ratio of an experiment is one of the most important factors that determine its usefulness and acceptance of it by the grower. A treatment should not only be effective in terms of yield and quality, but it also should be monetarily profitable proposition to the acceptance by a grower. In the present study, the different treatments showed clear impact on the comparative economics of the production of strawberry under the combined influence of inorganic fertilizers, organic manures, vermicompost, bio-fertilizers and bio-regulators. The details pertaining to costs and returns of IPNS of tissue cultured strawberry production are given in Table 1 and 2.

Yield analysis

The pooled data for the period of experimentation pertaining to the yield of strawberry under the influence of different combinations of inorganic fertilizers with organic manures, bio-fertilizers and bio-regulators are presented in Table 1. From the data, it is evident that the treatment 75 % RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA (T_{11}) recorded significantly highest yield (113.85 q/ha) as compared to other treatments. It was followed by 50 % RDF + vermicompost + *Azospirillum* +PSB + 50 ppm GA_3 + 50 ppm BA (T_{10}), whereas the lowest (88.60 q/ha) yield was recorded in control (T_{12}). Treatment with 75 % RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA recorded an increased yield of 31.66 % over control as against the lowest increase of 2.46 % in 100% RDF +vermicompost (T_1). This yield was taken into consideration for computing the economics as well as cost: benefit analysis under various treatments and are presented in Table 1.

Gross expenditure

Pooled data over the years of experimentation revealed that among all the treatments, the highest gross expenditure of ₹ 2 077 576.87 was incurred in 100% RDF + vermicompost followed by 75 % RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA (₹ 2 077 380.73) and lowest of ₹ 2 013 899.60 in control.

Gross income

IPNS package with 75 % RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA (T_{11}) recorded highest gross income in monetary terms (₹ 9 375 500.00) followed by 50 % RDF + vermicompost + *Azospirillum* +PSB + 50 ppm GA_3 +50 ppm BA(T_{10}) (₹ 9 216 000.00) and the lowest (₹ 6 378 100.00) was in control.

Net income

The net income is the main parameter for deciding the adoptability of a farming system. Among all the various IPNS treatments, the highest net income of ₹ 7 298 119.27/ha was obtained with 75% RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA (T_{11}) followed by ₹ 7 141 345.47/ha under 50% RDF + vermicompost + *Azospirillum* +PSB + 50 ppm GA_3+ 50 ppm BA(T_{10}). The lowest net income of ₹ 4 364 200.40 was recorded in control (T_0).

Cost- benefit analysis

The evaluation of relative merit of integration of inorganic fertilizers, organic manures, with bio-fertilizers, and bio-regulators in the present study in augmenting yield and thereby income are revealed from the data presented in Table 1. In our study, among the various IPNS package, the highest cost benefit ratio of 1: 3.51 was recorded in 75% RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3 +50 ppm BA (T_{11}) followed by 1: 3.44 in 50 % RDF + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA(T_{10}). The highest ratio in T_{11} might be due to the comparatively higher yield of 113.85 q/ha as well as highest number of runner production per ha (596 000) which ultimately increases the cost benefit ratio. Among all the treatments, the lowest of cost: benefit ratio of 1:2.17 was obtained in control. Although there was no involvement of inputs in this treatment, but the lowest cost: benefit ratio in this treatment was mainly due to lowest yield (86.47 q/ha) and lowest number of runner production per ha (462 400) which together brings the net income lowering down (₹ 4 364 200.40).

Different studies conducted in various parts of the globe proved that IPNS packages are superior to any other fertilizer management in respect of economics of cultivation in different crops. Marathe and Bharambe (2007) obtained complete supremacy in treatment using IPNS packages with 50% RDF +50% FYM over the inorganic fertilizers with a highest cost benefit ratio of 4.59 in sweet orange cv. Mosambi. Likewise, Hazarika *et al.* (2014) also reported the highest cost: benefit ratio of 1:4.22 and highest net income of ₹ 1 115 180.20 in IPNS package combining 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* in tissue cultured banana cv. Grand Naine. Our study is in the line of conformity with the findings of Chundawat *et al.* (1983), Borges *et al.* (1994), Kulkarni *et al.* (1996), Duraiswami *et al.* (1999), El Naby (2000) and Medhi *et al.* (2007), who reported IPNS packages including various combinations of organic manures and bio-fertilizers with inorganic fertilizers in getting the maximum returns per unit area as compared to the inorganic fertilizers alone.

The overall findings in terms of production and economic returns with eleven components of integrated nutrient management in the present study revealed that IPNS package having 75% recommended dose of NPK + vermicompost + *Azospirillum* + PSB + 50 ppm GA_3+ 50 ppm BA significantly increased the yield of tissue cultured strawberry cv. Festival with maximum economic returns and highest cost-benefit ratio to the farmers. Hence, it can be concluded that, this IPNS package is best, economically viable and sustainable, resource use efficient and an excellent approach for sustainable production, income generation and employment opportunity for the strawberry growers of Mizoram.

REFERENCES

Bhat N H. 1999. 'Response of strawberry cultivars to varied levels of organic manure'. M Sc thesis, S K University of Agricultural Sciences and Technology of Kashmir, Srinagar, J&K.

Borges A L. 1994. Liming and fertilizing banana. *CNPMF Report* (Musa Doc. 1999), pp 2

Chundawat B S, Dave S K and Patil N L. 1983. Effect of sources of nitrogen on yield and economics of banana cv. Basrai. *Haryana Journal of Horticultural Science* **12**: 156—9.

El- Naby S K M A. 2000. Effect of banana compost as organic on growth, nutrient status, yield and fruit quality of Magharabi banana. *Assiut Journal of Agricultural Science* **31**: 101—14.

Gomez A A and Gomez K A. 1984. *Statistical Procedures for Agricultural Research*, p 680. John Wiley and Sons Inc., New York.

Hazarika T K, Bhattacharyya R K and Nautiyal B P. 2015 Growth parameters, leaf characteristics and nutrient status of banana as influenced by organics, biofertilizers and bioagents. *Journal of Plant Nutrition* DOI: 10.1080/01904167.2014.957399

Hazarika T K, Nautiyal B P and Bhattacharyya R K 2014. Economic analysis of tissue cultured banana (*Musa × paradisiaca*) production under the influence of integrated nutrient management. *Indian Journal of Agricultural Science* **84**: 656—60.

Hazarika T K, Nautiyal B P and Bhattacharyya R K. 2011. Effect of INM on productivity and soil characteristics of tissue cultured banana cv. Grand Naine in Mizoram, India. *Progressive Horticulture* **43**: 30—5.

Hazarika T K, Zothankima R. Nautiyal B P and Shukla A C. 2015. Effect of biofertilizers and bioregulators on growth, yield and quality of strawberry cv. Festival. *Indian Journal of Agricultural Sciences* **85**: 1 201—5.

Kulkarni B S, Nalwadi U G and Giraddi R S. 1996. Effect of vermicompost and vermiculture on growth and yield of China aster (*Callistephus chinensis* Nees) cv. Ortrich Plume Mised. *South Indian Horticulture* **44**: 33—5.

Marathe R A and Bharambe P R. 2007. Growth, yield and quality of sweet orange cv. Mosambi in response to INM in vertisols of central India. *Indian Journal of Horticulture* **64**: 274—7.

Medhi B K, Saikia A J, Borah S C, Hazarika T K and Barbora A C. 2007. Integrated use of concentrated organic manure, biofertilizers and inorganic NPK on yield quality and nutrient content of Khasi Mandarin (*Citrus Reticulata* Blanco.). *Indian Journal of Agricultural Research* **41**: 235—41.

Nazir N. 2005. 'Studies on organic farming techniques for production of quality strawberry (*Fragaria* × *ananassa* Duch.)'. M Sc thesis, S K University of Agricultural Sciences and Technology of Kashmir, Srinagar, J&K.

Paramanick K K, Kishore D K and Sharma S K. 2005. Commercial strawberry cultivation in the nurseries as well as urban areas in India. *Advances in Horticultural Sciences* **19**: 34—41.

Patel V B, Singh S K, Ram Asrey, Lata Nain, Singh A K and Singh Laxman, 2009. Microbial and inorganic fertilizers application influenced vegetative growth, yield, leaf nutrient status and soil microbial biomass in sweet orange cv. Mosambi. *Indian Journal of Horticulture* **66**: 163—8.

Purbey S K and Sen N L. 2005. Effect of bioinocnlants and bioregulators on productivity and quality of fenugreek *(Trigonella foenum-graecum*). *Indian Journal of Agricultural Sciences* **75**: 608—11.

Rana R K and Chandel J S. 2003. Effect of biofertilizers and nitrogen on growth, yield and quality of strawberry. *Progressive Horticulture* **35**: 25—30.

Selvamani P, Manivannan K and Jagan Mohan 2011. Impact of Organic manures, inorganic fertilizers and biofertilizers on the nutrient concentration in soil at different growth stages of Banana cv. Poovan Mysore (AAB) (*Musa* sp. L.). *Plant Archives* **11**: 165—8

Sharma R R, Sharma V P and Pandey S N. 2004. Mulching influences plant growth and albinism disorder in strawberry under subtropical climate. *Acta Horticulturae* **662**: 187—91.

Singh A and Singh J N. 2006. Studies on influence of biofertilizers and bio-regulators on flowering, yield and fruit quality of strawberry cv. Sweet Charlie. *Annals of Agricultural Research* **27**: 261—4.

Singh A and Singh J N. 2009. Effect of biofertilizers and bioregulators on growth, yield and nutrient status of strawberry cv. Sweet Charlie. *Indian Journal of Horticulture* **66**: 220–4.

Singh A, Patel R K, De L C and Periera L S. 2008. Performance of strawberry cultivars under subtropics of Meghalaya. *Indian Journal of Agricultural Sciences* **78**: 1—4.

Singh S R, Srivastava K K, Sharma M K, Singh Lal And Sharma V K. 2012. Screening of strawberry (*Fragaria* × *ananassa*) varieties under organic production system for Kashmir valley. *Indian Journal of Agricultural Sciences* **82**: 538—42.

Singh S R, Zargar M Y, Singh Ummed And Ishaq M. 2010 Influence of bio-inoculants and inorganic fertilizers on yield, nutrient balance, microbial dynamics and quality of strawberry (*Fragaria* × *ananassa*) under rainfed conditions of Kashmir valley. *Indian Journal of Agricultural Sciences* **80**: 275—81.

Umar I, Wali V K, Kher R and Sharma A. 2008. Impact of integrated nutrient management on strawberry yield and soil nutrient status. *Applied Biological Research* **10**: 22–5.

Wang S Y and Jiao H. 2000. Scavenging capacity of berry crops on superoxide radicals, hydrogen peroxide, hydroxyl radicals, and singlet oxygen. *Journal of Agriculture and Food Chemistry* **48**: 5 677—86.

Yadav S K, Khokhar U U and Yadav R P. 2010. Integrated nutrient management for strawberry cultivation. *Indian Journal of Horticulture* **67**: 445—9.