Indian J. Hort. 67(3), September 2010: 311-314

Pre-bearing behaviour of some fruit crops under horti-silviculture system

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ABSTRACT

The present study was conducted to investigate the impact of poplar inter-cropping on pre- bearing behaviour of four fruit crops namely, peach, Kinnow, plum and guava. Per cent increment for stock diameter and height was observed in Kinnow and for scion it was in plum inter-cultivated with poplar. There was no significant effect of poplar canopy on growth of fruit trees, except in guava where height and tree spread were significantly higher. Photosynthesis rate was higher in the shade than in the open was maximum recorded in the guava (7.57 µmol $m^{-2}s^{-1}$) and minimum in Kinnow (3.04 µmol $m^{-2}s^{-1}$). The rate of photosynthesis was more during morning hours and least during afternoon in all the fruit crops.

Key words: Diversification, fruit trees, photosynthesis, poplar, water use efficiency.

INTRODUCTION

In the present scenario, concept of sustainable integrated production system has emerged as a solution to the problem of shrinking agricultural land coupled with shortage of water, high cost of production, labour shortage and other abiotic stresses. The integrated farming involves more than one component of agriculture result in maximum output in terms of biomass and economic returns. The interaction between the components *viz.,* trees and fruit crops are complex to comprehend and can be classified as above-ground and below-ground interface. The complementarities among light, space, water and nutrients are the key for success of a horti-silviculture system/model. Intercropping or mixed cropping has potential to increase total yields above those of mono-cropping using the same resource base (Bellow, 1). The emphasis on diversification has focused to bring more and more area under pure horticultural crops, or mixing in spatial and temporal arrangement with short rotation timber species. Fruit crops like guava, peach, plum, citrus, etc. can be integrated with the timber trees. The micro- environmental changes due to intercropping are known to effect growth and performance of trees through regulating various vital physiological processes. (Tang, 11; Prado and Morases, 8; Radogdon and Teskey, 9). The physiological processes of these crops like photosynthesis, water use efficiency and carboxylation efficiency under shade conditions are important factors affecting growth parameters and ultimately fruit yield. The present study has been initiated to understand the pre-bearing behaviour of fruit crops grown under poplar canopy. The poplar trees grown in the blank inter-space between two fruit plants are harvested after five years age to enhance farmer's income during pre-bearing period and fruit crops is them retained as sole crop thereafter.

MATERIALS AND METHODS

The present studies were conducted in the Experimental Area of the Department of Horticulture, PAU, Ludhiana. All the experimental plants received uniform cultural practices during the course of studies. The layout was prepared to accommodate poplar plants between the recommended spacing of fruit plants (6 m × 6 m) to make use of inter-spaces. The total area of experiment was 4,608 m^2 (3,168 m^2 for intercropping and 1,440 m^2 for control conditions) accommodating 88 plants of poplar and 20 plants of each fruit crop in intercropping with poplar and 10 of each fruit crop under control conditions. Three replications for each plot with three plants per replication were selected. Fruit plants include peach cv. Shan-i-Punjab, plum cv. Satluj Purple, guava cv. Allahabad Safeda and Kinnow mandarin. One-year-old poplar ETPs (Entire Trans Plants) were planted in between two fruit plants in a row such that distance between fruit and poplar tree is 3 m within row. This experiment was laid out with the objective to evaluate interaction between fruit crops and poplar trees. Control plots of each fruit crop were also raised simultaneously for comparison. The statistical analysis was done with simple RBD design.

The data on vegetative growth attributes of poplar trees and fruit crops were recorded 33 months after planting (MAP) in December. The plants were planted during February and March in 2006. Per cent increments with reference to initial values (15 DAP) were calculated to assess the growth after 33 months of planting. In poplar, the vegetative growth parameters recorded include basal girth at 5 cm above ground level, girth

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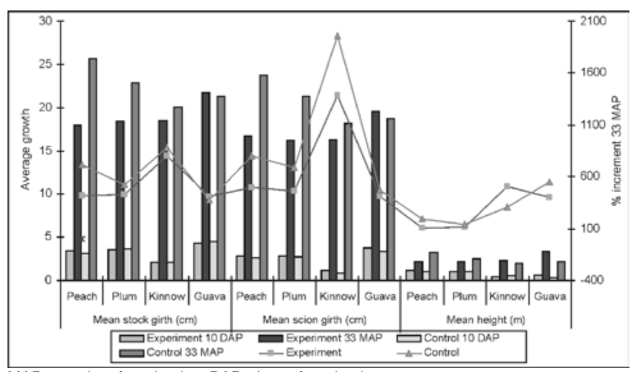
at breast height (GBH-1.37 above ground level) and height. In fruit crops, the vegetative growth parameters such as stock girth, scion girth and height of the plants and physiological parameters *viz.,* photosynthetic active radiation (PAR), stomata conductance, inter-cellular CO_2 and transpiration rate, using portable photosynthesis system (CID 340, CID Inc., USA) on fully expanded leaves of the fruit crops were recorded at 10.0 am, 1.0 pm and 4.0 pm for both experimental as well as control plants. Physiological parameters for plum have not been recorded because of small leaf size as compared to chamber size of photosynthesis system. Water use efficiency was measured as ratio of net photosynthesis to transpiration with same units.

RESULTS AND DISCUSSION

The maximum increment in basal girth (734.89%), GBH (758.33%) and total height (166.51%) was recorded in poplar intercropped with fruit trees; however, the incremental was less in the control poplar trees (Fig. 1). Poplar plants attained sufficient height than different fruit crops, hence above ground bio-physical characteristics of the poplar trees were not affected much by the fruit crops. Under ground root competition of poplar trees with that of fruit crops for nutrient and water might have influenced these growth characters of the poplar trees. Kumar (5) also tested eight intercrops to study the interaction for growth, yield and fruit quality of Santa Rosa plum plants and concluded that all these parameters were affected by the intercrops.

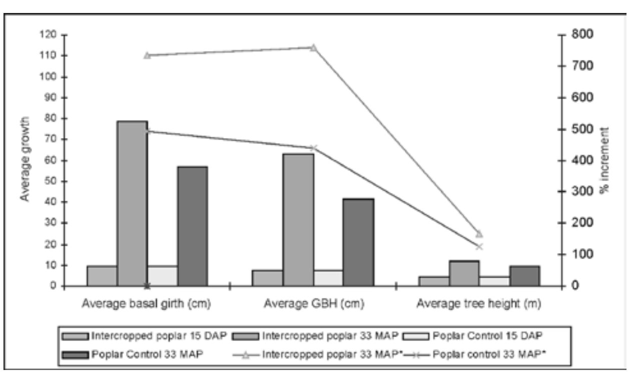
Among the fruit crops, effect of poplar trees on was variable in respect of rootstock girth, scion girth and tree height. The increase in peach plants was only 421.74; 498.21 and 102 72 per cent in stock girth, scion girth and tree height under poplar canopy where the incremental increase was as high as 712.30; 799.62 and 196.29 per cent under control conditions, respectively. Maximum increase was noticed in scion girth of Kinnow plants in both intercropped and open field condition. All the three vegetative characteristics of peach, plum and Kinnow showed higher values in open field as compared to intercropped fruit plants except plant height of Kinnow which was more in intercropped fruit plants. However, a reverse trend was observed for guava plants where all the vegetative parameters show greater values under poplar canopy as compared to open field conditions (Fig. 2). Stock and scion girth of fruit plants were slightly higher in control as compared to intercropped conditions. However, a reverse trend in height and canopy spread was observed in Kinnow and guava (Fig. 3). These two crops also showed comparatively higher photosynthetic rate (Table 1) under shade conditions than open field conditions, indicating that these crops could be better inter planted under horti-silvicutural system with poplar as main crop.

The Pn/E ratio which depicts water use efficiency was highest in shade in all the crops during evening hours as the transpiration rate was minimum in this period, thus indicating that the crops are able to efficiently utilize the water for fixation of CO_2. Mishra and Bhatt (7), while working with different *Leucaena leucocephala* genotypes under natural conditions in semi-arid tropics, reported similar results. Photosynthesis (Pn) and carboxylation efficiency (Pn/C



MAP- months after planting; DAP- days after planting

Fig. 2. Per cent increment in vegetative growth parameters of different fruit crops planted with poplar after 33 months of planting.



MAP- months after planting, DAP- days after planting

Fig. 1. Vegetative growth parameters of poplar planted with different fruit crops.

ratio) were seemingly positively correlated for guava, Kinnow and peach (Table 1). These observations are in line with those of Dejong *et al.* (3) in different genotypes of Kiwi fruit. It is evident from the data that net photosynthesis rate was higher in the shade than in the open and maximum photosynthesis was recorded in guava (7.57 µmol $m^{-2}s^{-1}$) and minimum in Kinnow (3.04 µmol $m^{-2}s^{-1}$). The stomatal conductance

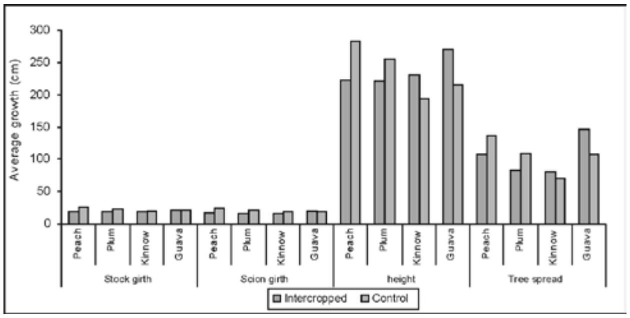


Fig. 3. Vegetative growth parameters of fruit crops influenced by poplar.

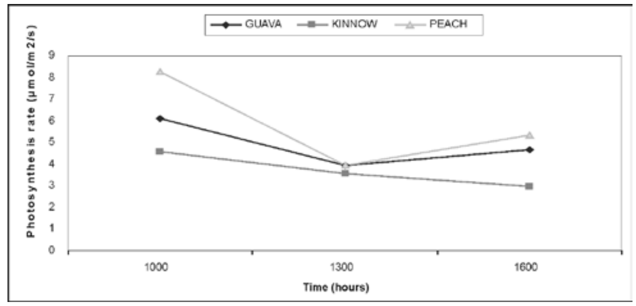


Fig. 4. Diurnal variation in the photosynthesis of guava, Kinnow and peach inter-planted with poplar.

Table 1. Physiological parameters of guava, Kinnow and peach as affected by shade of poplar tree canopy and open field conditions.

Fruit plant	Physiological parameter											
	Net photosynthesis (µmol $m^{-2}s^{-1}$)		Inter-cellular CO_2 C_{int} (ppm) (Ci)		Stomatal conductance (mmol $m^{-2}s^{-1}$)		Transpiration (mmol $m^{-2}s^{-1}$)		Water use efficiency (Pn/E)		Carboxylation efficiency (Pn/C_i)	
	Open	Shade	Open	Shade	Open	Shade	Open	Shade	Open	Shade	Open	Shade
Guava	6.28	7.57	521.87	456.43	103.08	116.02	5.76	4.62	0.0010	0.0016	0.0120	0.0160
Kinnow	1.47	3.04	456.94	436.07	20.76	29.26	1.59	1.52	0.0009	0.0020	0.0032	0.0069
Peach	5.53	5.96	485.53	447.20	60.63	76.17	4.31	3.65	0.0012	0.0016	0.0113	0.0133

was found to decrease with increasing atmospheric temperature and decreasing relative humidity (RH). The transpiration (E) rate was minimum under shade conditions irrespective of the fruit species used in the experiment leading to more water use efficiency in the shade conditions than in open. Maximum carboxylation efficiency of Kinnow indicates its higher productivity potential over the other fruit crops. Pn/C_i is positively correlated with stomatal conductance and water use efficiency showing the usefulness of these traits for selecting plant genotypes for higher productivity under shade conditions.

The Photosynthetic Active Radiation (PAR) was highest during afternoon with an average of about 926.7, 1018.9 and 1126.3 µmol $m^{-2}s^{-1}$ for guava, Kinnow and peach, respectively (Table 2). The least PAR was recorded during evening (4.00 pm) with 70.5, 63.1 and 101.8 µmol $m^{-2}s^{-1}$ for guava, Kinnow and peach, respectively. The transpiration rate was also highest during afternoon in guava (7.99 mmol $m^{-2}s^{-1}$), Kinnow (2.60 mmol $m^{-2}s^{-1}$) and in peach (6.60 mmol $m^{-2}s^{-1}$). At 4 pm, least transpiration rate was observed in all the three fruit plants. The photosynthesis rate was highest during morning hours in guava (6.10 µmol $m^{-2}s^{-1}$), Kinnow (4.57 µmol $m^{-2}s^{-1)}$ and peach (8.27 µmol $m^{-2}s^{-1}$). The lowest photosynthesis rate was recorded during afternoon in guava and peach but in Kinnow, it was lowest during evening hours (Fig. 4). Photosynthesis is a physiological process that is affected by the environmental factors. The fruit trees in general show daily changes in photosynthetic rate and a mid day depression of photosynthesis depending upon prevailing weather conditions during their growth period (Dhillon *et al.*, 4; Miah *et al.*, 6). At mid day with the stress of high temperature and intense irradiation, net photosynthesis rate may decrease almost near to zero (Su and Liu, 10). It is primarily due to the reduction in the stomatal conductance which leads to short supply of CO_2. As far as Kinnow is concerned, the variation in internal CO_2 during the day were less skewed than the other fruit crops, similarly the stomatal conductance was lower whether in open or shade as compared to other fruits might be due to the cuticular properties (waxy) affecting the gas exchange of leaves. Boyer *et al.* (2) studied the cuticular properties in *Vitis vinifera* and reported that cuticlar properties affect the stomatal conductance.

Table 2. Diurnal variation in eco-physiological parameters of fruit plants inter-planted with poplar.

Time	PAR (μmol $m^{-2}s^{-1}$)	Transpiration rate (mmol $m^{-2}s^{-1}$)	Stomatal conductivity (mmol $m^{-2}s^{-1}$)	T_{air} °C	T_{leaf} °C	Photosynthesis rate (μmol $m^{-2}s^{-1}$)	Internal CO_2 (ppm)
Guava							
10 am	581.2	4.10	142.73	36.8	38.6	6.10	425.80
1 pm	926.7	7.99	107.39	43.1	43.4	3.94	548.88
4 pm	70.5	c1.76	125.12	36.7	37.2	4.68	404.60
Kinnow							
10 am	417.4	1.43	41.43	34.5	34.8	4.57	416.65
1 pm	1018.9	2.60	16.45	42.3	45.7	3.58	412.95
4 pm	63.1	0.75	31.91	37.6	38.3	2.97	487.60
Peach							
10 am	349.3	2.19	89.27	37.3	38.2	8.27	436.87
1 pm	1126.3	6.60	47.41	44.5	47.6	3.96	491.73
4 pm	101.8	2.18	40.17	36.9	37.5	5.36	413.00

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Received: September, 2009; Revised: February, 2010; Accepted : August, 2010