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Short communication

The influence of canopy architecture on light penetration, soil temperature and fruiting in sub-tropical pear

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Development of plant architecture in fruit plants is an above ground operation intending to harness maximum solar radiation to maximize production and quality of fruit per unit area. The profitability of orchard depends upon the efficient absorption and utilization of light. Of various environmental factors, solar radiation should be considered first, as a source of energy that drives the biological production of dry matter and ultimately fruit yield (Lakso, 1994). The light interception is determined by the amount and arrangement of leaves, fruits and branches with in the tree canopy, tree shape and size, spacing, row orientation and angular distribution of light from the sun (Palmer, 1981). Pear is the tree that, throughout its life, lends itself to mechanical bending and topping, though these practices must be hand-finished (Sansavini and Musacchi, 1994). 'Patharakh' (*Pyrus pyrifolia* Nakai) is one of the widely grown cultivar of asian pear in north-westren plains of India. The plants of this cultivar are vigorous in growth and prolific bearer. As the tree matures the lower spurs become less productive due to lack of available sunlight and bearing area gets confined to middle and top canopy of the tree. These fruits are difficult to harvest and growers/contractors used to pick these by bamboo sticks which leads to damage to spurs consequently loss of productive area. Tall pear trees produce smaller proportion of fruit in the lower canopy than the dwarf trees, increasing the labor cost associated with increased ladder time (Grossman *et al.,* 1997). Therefore, pear production on tall trees is likely to be less efficient than on shorter trees especially under high density system. The canopy of such trees needs to be managed by permitting adequate sunlight in order to maintain vigor especially in lower portion of tree. These investigations were focused to develop a strategy to improve the bearing in the lower canopy of tree by enhancing light availability through reduction of the tree height. To elucidate this hypothesis, the effect of pruning on light penetration and fruiting of pear trees was examined.

The present studies were done during 2009 at the New Orchard of Department of Horticulture, Punjab Agricultural University Ludhiana (India) situated at 30^{o} 40´ N and 75^{o} 48´ E with an altitude of 247 m amsl. The experimental trees of Patharnakh pear on *Kainth* (*Pyrus pashia*) rootstock were planted in 1998 at closer spacing of 4 x 4 m with rows orientation from East to West. The orchard is under the management practices according to the local standard programme for pears; surface flooding irrigation was applied. When the trees became five years old, their canopies began to have contact with each other, the trees were manually-topped to different heights i.e 1.0 m (T_1), 1.5 m (T_2), 2.0 m (T_3), 2.5 m (T_4) and 3.0 m (T_5) from the ground level during the dormant season. The control trees (T_6) were allowed to grow without any heading back treatment. Each year the new growth of each season emerging above the given treatment height was cut down to marked height in the month of December-January. After pruning operation, trees were applied Bordeaux paste to prevent microbial infections. The experiment was laid out in randomized block design with five replications per treatment. Observations on solar radiations penetration within tree canopy were made on clear sky days at morning, afternoon and evening continuously from April to July. Light penetration was calculated as the difference between the recorded incoming light above the tree canopies and that at different canopy levels within the tree canopy i.e upper, middle and lower. These measurements were done with the digital Lux meter (Model LQM 70-10, USA) and mean proportion of light penetration in each of canopy level was calculated in percent. The soil temperature was taken at monthly interval by soil thermometer installed 5 cm deep in soil underneath the canopy of respective plant under treatment. The proportion of fruiting spurs was counted on each of marked branches from respective canopy portion of plant. The tree volume was calculated as per method described by Westwood (1978). Yield efficiency was calculated by dividing average fruit load with canopy volume. Data were statistically evaluated by using computer software programme CPCS1 (Cheema and Singh, 1990).

The effect of canopy height on solar light penetration recorded at different parts of tree canopy during morning, afternoon and evening is presented in Fig 1 (A-C). It is evident that overall higher light penetration was recorded during afternoon as compared to morning or evening times. At

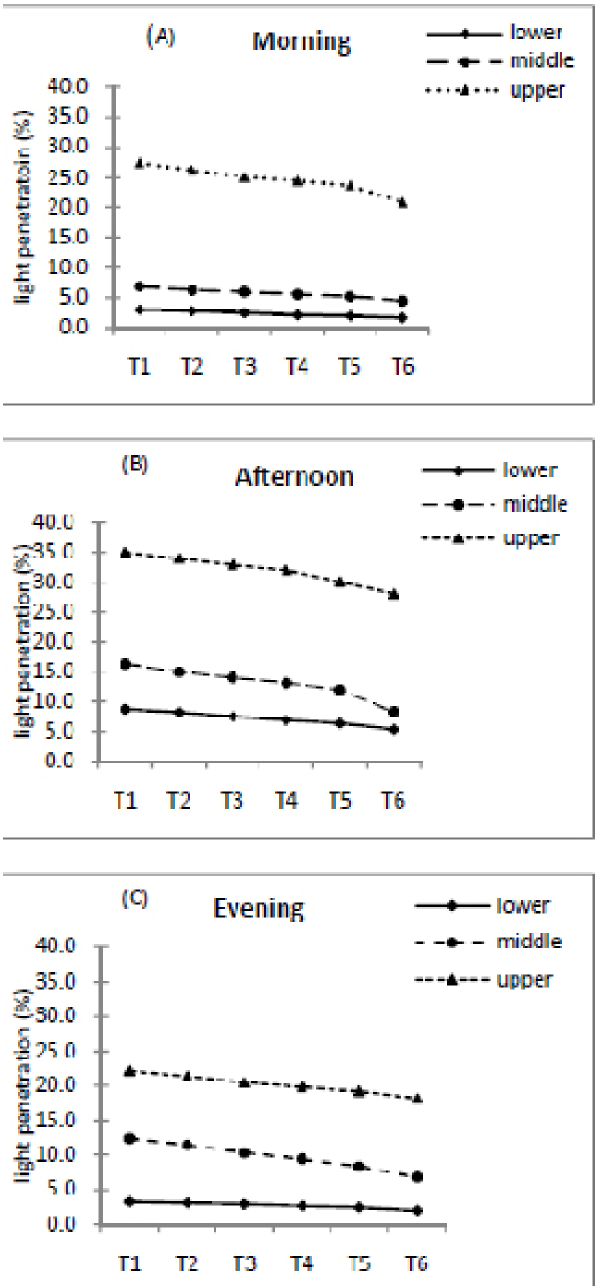

Fig. 1: Effect of pruning treatments on mean light penetration in different canopy depths Patharnakh pear trees during morning (A), afternoon (B) evening (C).

noon the sun is relatively perpendicular to the tree canopy and hence more light is penetrated throughout the canopy during afternoon as compare to morning or evening time. A higher photosynthetic photon flux transmission was reported in the afternoon than the morning by Ferree (1989). As regard to canopy position with respect to light penetration, the upper canopy of tree recorded considerable higher percentage of incident solar radiations irrespective of the time of day or pruning level and it decreased with depth of canopy. Similar decrease in light interception with depth of canopy in guava plants was observed by Brar *et al.,* (2009). Solar penetration decreased with increase in tree height and seems to be directly correlated with it. Trees retained at 1.0 m (T_1) height received highest solar radiation in all parts of canopy followed by trees retained at height of 1.5 m. The control (T_6) trees which were not headed back recorded lowest light penetration during throughout the canopy in all three time of the day. Similar results were reported by Sharma and Singh (2006) in mango.

The soil temperature decreased progressively from April to July. Highest soil temperature was recorded in the month of April (25.5 ^{o}C) and lowest in July month (22.1 ^{o}C). Among various pruning treatments, the trees retained at 1.0 m height recorded maximum soil temperature during all the months and minimum soil temperature under control trees.

Different pruning treatments affected the tree volume significantly (Table 1). Tree volume increased linearly with increase in pruning height of the trees. The greatest tree volume (89.60 m^3) was found in control trees and it was significant higher from rest of the treatments. The lowest canopy volume (29.26 m^3) was registered in tree retained at 1.0 m pruning height followed by trees at 1.5 m pruning treatment. Smaller tree volume in severely pruned trees may be ascribed to lower tree height retained during heading back operation. These results are in conformity with the findings of Marini *et al.,* (1993) who have reported that heading back of scaffolds limbs resulted reduced tree spread in apple trees.

The proportion of fruit spurs were significantly affected by the various pruning treatments (Table 1). Plants pruned at 1.0 height recorded highest proportion of fruiting spurs (34.1 %) in its lower canopy as compared to other treatments. The minimum proportion of fruiting spurs in lower canopy was observed in unpruned trees indicating that bearing area in unpruned trees shifted to upper parts of tree canopy. In middle canopy, the maximum proportion of fruiting spurs (46.9 %) was recorded in trees pruned at 1.5 m followed by 1.0 m height. The trees pruned at 3.0 m height recorded lowest (32.5 %) proportion of fruiting spurs in middle canopy of tree. The fruiting spurs in upper canopy showed a reverse trend and it were maximum (58.0 %) in control trees than rest of treatments. The minimum proportion of fruiting spurs in upper canopy was noticed in trees which were low headed. Significant reduction in light level in the pear canopy can decrease yield by decreasing flower bud differentiation and fruit set (Barritt *et al.,* 1987).

The pruning treatments significantly affected the yield

Table 1: Effect of pruning treatments on tree volume, fruiting spurs proportion and yield efficiency of Patharnakh pear tree

Treatment	Tree volume (m^3)	Fruiting Spurs (%)			Yield efficiency (kg m^{-3})
		Lower canopy	Middle canopy	Upper canopy	
T_1	29.26	34.1	43.9	22.0	0.43
T_2	36.80	26.9	46.9	26.2	0.77
T_3	40.44	23.7	43.2	36.1	1.01
T_4	43.06	22.0	33.4	42.6	1.17
T_5	46.67	22.3	32.5	45.2	1.05
T_6	89.60	5.8	36.2	58.0	0.57
$CD_{0.05}$	5.30	3.21	3.20	3.90	0.03

efficiency of Patharnakh pear trees (Table 1). The yield efficiency was higher at medium height trees than either of short or tall ones. It improved with pruning height up to T_4 level and then decreased subsequently. Maximum yield efficiency was recorded in 2.5 m pruned trees (1.17 kg m^{-3}). Similarly, minimum yield efficiency (0.43 kg m^{-3}) was observed in trees that were severely pruned (T_1). The reduction in yield efficiency in low head trees may be attributed to lesser crop load in relation to vegetative growth. The T_4 pruning treatment optimizes the crop load and vegetative growth and hence has maximum yield efficiency. Similarly in peach trees, Tworkoski and Glenn (2010) found that intense pruning reduced the yield efficiency with concomitant decrease in crop load.

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