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SHORT COMMUNICATION

PRODUCTIVITY OF *Capsicum annuum* UNDER *Grewia optiva*-BASED TRADITIONAL AGROFORESTRY SYSTEM IN MID HILL ZONE OF HIMACHAL PRADESH (INDIA)

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ABSTRACT

Agroforestry is relatively a new name for a set of old practices. The multifarious trees deliberately retained by the farmers on the farm bund form the agroforestry combinations, which supplement the fodder, fuel, fiber, fruits and flosses as their life support system. *Grewia optiva* is an important fodder tree retained on farm bunds by farmers in Western Himalayan region. The present investigation was aimed to study the effect of *G. optiva* based traditional agroforestry system i.e. agri-silviculture, on the productivity of bell pepper (*Capsicum annuum*). The crown spread of tree was considered major factor and categorized into different classes for quantifying its effect on crop growth and production along radial transects from tree trunk. Results revealed that the crown classes significantly affected the yield of bell pepper causing about 33% reduction in yield under tree canopy as compared to the open condition.

Keywords: Agroforestry, bell pepper, crown spread, *Grewia optiva*, productivity.

INTRODUCTION

In Himalayan region a number of indigenous agroforestry systems are familiar which include agri-silviculture, agri-horti-silviculture, agri-horticulture, pastoral-silviculture, pastoral-horticultural, agri-silvi-pastoral, horti-pastoral etc. (Kumari *et al.*, 2008; Kumar *et al.*, 2018). Of these agri-horti-silviculture, agri-silviculture and agri-horticulture are frequently adopted in Himachal Pradesh (India). The agroforestry interventions seem more valuable due to the tremendous pressure on forests for fuel and fodder (Bijalwan and Dobriyal, 2014). Considering the needs of marginal family members, these agroforestry systems are more compassionate and sustainable than single agricultural system (Bijalwan, 2011). The assortment of trees on the edges of agricultural field is a farmer-friendly and compatible practice. Fodder tree species like *Grewia optiva, Melia azedarach, Ficus roxburghii, F. palmata, F. glomerata, Boehmeria rugulosa, Celtis australis* etc. are found in traditional agroforestry systems; however, the significance of agroforestry with *Grewia opiva*-based combination is highly supportive. *Grewia optiva*-based agroforestry combination (agri-silviculture) is a common practice followed in Himalayas to supplement the additional benefits from tree. This tree is abundantly grown on farmer's field under traditional agroforestry along with most agricultural crops. *G. optiva* is rated as a good fodder tree having fairly high protein (17.3-21.0%) and nutrients with no tannin content. Moreover, it supplies green fodder during lean period (winter) when generally

no other alternative for green fodder is available in this region (Bijalwan and Dobriyal, 2014). It is sparingly found in forest area and is mostly raised along agriculture fields. The challenge in the design of agroforestry systems lies in managing the interacting components advantageously i.e. maximize positive interactions and minimize negative ones. A well-planned and suitably managed agroforestry system could economically be more productive, ecologically sound and socially acceptable; therefore, may assist in sustainable agricultural production. *G. optiva* is an important fodder tree in the study region and bell pepper (*Capsicum annuum* L.) is an important cash crop grown by the farmers. The present study was aimed to analyze *Grewia optiva* - based traditional agroforestry system with respect to its effect on productivity of bell pepper.

MATERIALS AND METHODS

The study was conducted in Pacchad region of district Sirmour, Himachal Pradesh (India) during *kharif* season (June, 2016-October, 2016) in 2016-2017 on farmer's fields who have been practicing traditional agroforestry. The experimental site was located at an elevation between 1250-1300 m amsl, which fall in the sub-tropical region of Himachal Pradesh (India) and was located between 30°48'47.22'' N latitude and 77°07'27.6'' E longitude in North-East aspect. The crown spread of trees was categorized into three classes *viz.*, crown class I [< 3 m crown spread (C1)], crown class II [3-6 m crown spread (C2)] and crown class III [> 6 m crown spread (C3)] for quantifying its effect on crop performance. Radial transects at right angle to each other were drawn and parameters studied along radial transects at 1 m [D_1 (1 M)], half the crown radius [D_2 (H)], perimeter of crown radius [D_3 (P)] and outside the canopy [D_4 (control)] by plotting quadrat of 1 × 1 m^2. In all there were 12 treatment-combinations *viz*., 3 crown classes and 4 distances from tree trunk.The experiment was conducted in a randomized block design (factorial).

Three trees from each crown class were selected for observations on different growth and yield parameters *viz*., number of plants m^{-2}, plant height, plant spread, number of fruits $plant^{-1}$, average fruit weight and fruit yield of bell pepper. Total number of plants in each sampling plot was counted and expressed as number of plants m^{-2}. The average plant height was calculated by dividing the sum of plant height of sampled plants in a sampling plot by the total number of sampled plants in the plot. Plant spread was recorded at peak fruiting stage and was measured from middle of the plant in east, west, north and south directions with the help of graduated scale. The marketable fruits were counted at each harvest from the sampled plants and averaged to obtain the number of fruits $plant^{-1}$. The average fruit weight was obtained by dividing the total fruit yield by total number of fruits of selected plants. Fruit yield in each plot was also recorded. Light intensity was measured with luxmeter. The data was subjected to statistical analysis (Gomez and Gomez, 1984). Wherever, the experimental effects were exhibited significance at 5% probability level, the critical difference was calculated.

RESULTS AND DISCUSSION

The growth and yield of bell pepper were significantly affected under the influence of canopy of *G. optiva* trees retained on farm bunds by the farmers. All the growth and yield parameters showed maximum reduction at 1 m distance from tree trunk when compared with growth and yield in open condition; and increased gradually as distance of crop from tree trunk is increased. Light intensity was lower at 1 m from tree trunk and increased with increasing distance from tree trunk, suggesting

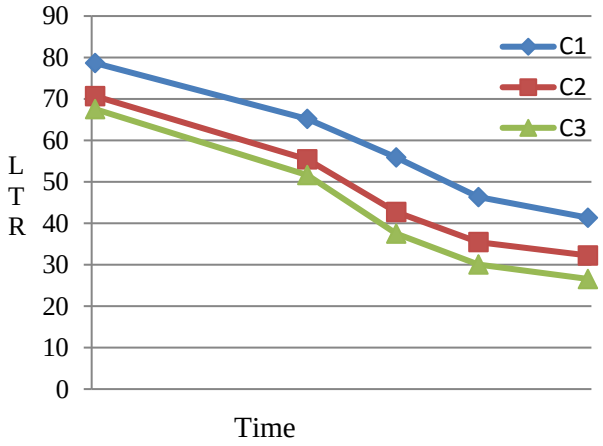

Fig. 1: Light transmission ratio [LTR] (%) under different crown classes taken at different time intervals (July, 2016 – September, 2016)

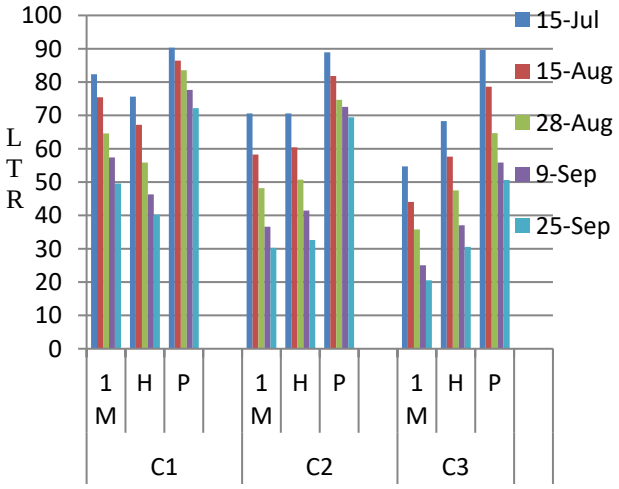

Fig. 2: Light transmission ratio [LTR] (%) at different distances from tree trunk under different crown classes taken at different time intervals (July 2016 - September 2016)

the prevention of light from reaching the ground by tree canopy. This may be one of the limiting factors in reduction of the overall crop production.

Light transmission ratio (LTR) under *Grewia optiva*

LTR decreased with increase in crown size and with advancement of time (from July to September) [Fig. 1]. Maximum LTR (78.6%) was observed in crown class I in July. Decrease in LTR was observed from July to September under all the crown classes. Further, there was increase in LTR with increase in distance from tree trunk and also with advancement of time there is decrease in LTR (%) under tree (Fig. 2). Minimum LTR (20.5%) was found under crown class III at distance of 1 m from tree trunk in September.

Effect of *Grewia optiva* on crop growth and production

The plant height of bell pepper was significantly affected by the distance from tree trunk; and the plant height increased as the distance from tree trunk increased (Table 2). Maximum plant height (47.89 cm) was found outside the tree canopy and minimum (40.78 cm) at a distance of 1 m from tree trunk. This may be attributed to the higher shade effect of tree near base. Manurung *et al.* (2007) reported higher plant height of bell pepper in plots without shade as compared to the plots under full shade. Plant height in plots without shade was at par with plots having medium shade. Thakur and Singh (2008) reported higher plant height of black gram and pea in open conditions and decrease in plant height with increase in shade intensities. They also reported increase in plant height with increase in distance from tree trunk and attributed it to higher shade intensities beneath the tree canopy.

The distance from tree trunk significantly affected plant spread of bell pepper with no effect of crown class on plant spread. Maximum plant spread (43.67 cm) was found outside the tree canopy in open condition and minimum (33.89 cm) at half the crown spread. The increase in plant spread may be attributed to the reduced shade effect (Bhat, 2015) in case of bell pepper under *Melia composita*.

Crown class and distance from tree trunk significantly affected the number of fruits plant^{-1} in bell pepper (Table 1 & 2). The number of fruits plant^{-1} were maximum (19.67) under crown class I and minimum under crown class III (17.83); while maximum number of fruits plant^{-1} (20.67) was found under open condition and minimum (16.67) at 1 m distance from tree trunk. Khan and Hasan (2015) reported higher number of fruits plant^{-1} of bitter gourd under open condition and lower number of fruits plant^{-1} under *Pongamia pinnata* and number of fruits plant^{-1} increased significantly with distance from tree trunk probably due to poor photosynthetic capacity and resource pool competition near the tree base.

Table 1: Effect of crown classes of *Grewia optiva* on growth and yield parameters of bell pepper

Parameters / Crown class	Plant height (cm)	No. of plants (m^{-2})	Plant spread (cm)	No. of fruits ($plant^{-1}$)	Avg. fruit weight (g)	Fruit yield ($t\ ha^{-1}$)
C1 (<3m crown spread)	45.08	5.92	38.83	19.67	33.33	38.95
C2 (3-6m crown spread)	44.17	5.83	37.25	18.25	32.33	34.96
C3 (>6m crown spread)	41.17	5.83	36.75	17.83	32.50	33.92
$LSD_{0.05}$	ns	ns	ns	1.21	ns	3.88

The average fruit weight was significantly affected by distance from tree trunk with maximum average fruit weight (35.33 g) outside the tree canopy and minimum (30.89 g) at distance of 1 m and half the crown radius from tree trunk. Islam *et al.* (2008) also reported non-significant effect of different light levels on fruit weight of tomato. Khan and Hasan (2015) reported higher fruit weight of bitter gourd under open condition and lower fruit weight under *Pongamia pinnata* and fruit weight increased significantly with distance from tree trunk. The reduced fruit weight under tree canopy was attributed to the competition for solar radiation, moisture and nutrients.

Table 2: Effect of distance from tree trunk of *Grewia optiva* on growth and yield of bell pepper

Parameters / Distance	Plant height (cm)	No. of plant (m^{-2})	Plant spread (cm)	No. of fruits $plant^{-1}$	Avg. fruit weight (g)	Fruit yield ($t\ ha^{-1}$)
D_1(1m from tree trunk)	40.78	5.67	34.11	16.67	30.89	29.20
D_2(half the crown radius)	41.00	5.78	33.89	17.11	30.89	30.30
D_3(perimeter of crown radius)	44.22	6.00	38.78	19.89	33.78	40.46
D_4(outside the canopy)	47.89	6.00	43.67	20.67	35.33	43.83
$LSD_{0.05}$	5.55	ns	4.99	1.39	1.88	4.48

Fruit yield was significantly affected by crown class and distance from tree trunk. Maximum fruit yield was found under crown class I and minimum under crown class III (Table 1). In case of distance from tree trunk, maximum fruit yield was obtained in open condition and minimum at 1 m distance from tree trunk (Table 2). Islam *et al.* (2008) found higher fruit yield of chilli under full sunlight as compared to reduced light conditions and attributed it to higher flower bud formation under full sunlight condition. Khatun *et al.* (2009) reported more fruit yield of brinjal under controlled conditions as compared to fruit yield near plantation. Further, with increase in distance from plantation fruit yield also increased. This was attributed to competition for growth resources.

The tree crown classes had no effect on the growth of bell pepper but significantly affected crop yield. Crop growth and yield showed increase with increase in distance from tree trunk indicating better growth and yield outside tree canopy. Tree shade appears a limiting factor for growth and yield under tree canopy; thus, demands proper canopy management practices for better crop productivity.

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