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Productivity of Wheat (*Triticum Aestivum*) as Intercrop in *Grewia Optiva* Based Traditional Agroforestry System along Altitudinal Gradient and Aspect in Mid Hills of Garhwal Himalaya, India

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Abstract Grewia optiva, wonder tree of western Himalaya locally known as Bhimal is the most common multipurpose tree is a boon for the inhabitants of Garhwal Himalayan region. About 2/3rd of the cultivated area of Garhwal is rainfed and Wheat (Triticum aestivum) is the predominant food grain crop cultivated on the sloppy terraces in combination of G. optiva trees on terrace bunds. In Present study the productivity of wheat (Triticum aestivum) as intercrop in Grewia optiva based traditional agroforestry system along altitudinal gradient and aspect in mid hills of Garhwal Himalaya, India revels that G. optiva occupied average highest frequency (85%), stem density (145 trees/ha), TBC (7.68 m^2/ha), IVI (86.51), tree height (7.38 m), Crown spread (5.34 m) in the elevation 1000-1500 m of Northern aspect (E1/N site). In the elevation 1000-1500 m, it was observed that there is a reduction in grain, straw and biological yield of wheat as 17.59%, 17.77% and 17.71% respectively on the southern aspect compared to northern aspect. Further elevation 1500-2000 m, the reduction in the average grain yield was recorded 37.31% under G. optiva based traditional agroforestry system in E2/S site. The phenophases of the wheat crop is sown in the month of December which emerges to crown root initiation (CRI) in January followed by tillering, milking, maturity and final harvest during May while G. optiva remain dormant from December to February, leafless in March and new flush of shoots in May. This reversal phenopases of two components are complimentary in tree crop interaction to enhance productivity.

Keywords: *Agroforestry, Garhwal, Himalayas, Grewia optiva, wheat, yield*

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1. Introduction

Agroforestry is a new name for the old practice, exceptionally common in the Garhwal Himalayan regions of India. More than 70% population of this region depends upon agriculture for livelihood while the land suitable for agriculture is limited to few pockets only. The multifarious trees deliberately retained by the farmers on the farm bund forms the agroforestry combinations, which supplement the fodder, fuel, fiber, fruits and flosses as their life support system. The unusually wide altitudinal range, rapid change in altitudinal gradient even at small distances and high endemism make it interesting for studies (Singh and Singh, 1992). The increasing population is subsequently creating higher demands for the forest products and the alarming fact is that, even today the production from forestry sector is not enough to meet out the existing demands. The vegetation of the varying topography of the Garhwal Himalaya changes its species diversity, composition and structure along altitudinal gradient. Moreover the direction of the sun (aspect) in the hilly topography also plays an important role in the vegetation and land use pattern. The season is also an important factor which decides the availability of fodder to the livestock of this region, hence some trees which are boon for the region provides the green fodder in the lean period. Though there are many trees species in practice in the traditional Agroforestry systems in Garhwal Himalaya but some tree species are prioritized by the farmers for daily need and livelihood support.

Grewia optiva, wonder tree of western Himalaya locally known as *Bhimal* is the most common multipurpose tree is the boon for the inhabitants of Garhwal Himalayan region. This tree abundantly grown on the farmers filed under traditional agroforestry along with most of the agricultural crops. The *G. optiva*-wheat based combination is a common practice by the local people to supplement the additional benefits from the tree. The *G. optiva* is rated as good fodder tree having fairly high protein and nutrients without tannin content, moreover, supplies green fodder during lean period (winter) when generally no other alternative for green fodder are available in this region. *G. optiva* also support the farm community through its fiber, used for making ropes and the branches of this tree also used for making baskets. The tree is also used for fuelwood purpose in the areas where no other choice of good fuel is available. The Land-use systems in the Himalayan region comprised of forestry, agriculture, horticulture and animal husbandry (Sundiriyal *et al.*, 1994) however, the importance of agroforestry with *G. opiva* based combinations are highly supportive. Beside, *G. optiva* the other fodder tree species like *Melia azedarach, Ficus roxburghii, F. palmata, F. glumerarata, Boehmeria rugulosa, Celtis australis* etc are also found in the traditional agroforestry systems but their preference is always secondary by the farmers. About 2/3rd of the cultivated area of Garhwal Himalaya is rainfed and Wheat (*Triticum aestivum*) is the predominant food grain crop cultivated on the sloppy terraces in combination of *G. optiva* on terrace bunds. The productivity of wheat is usually reduced under tree cover but the additional benefits of *G. optiva* trees supplements the fodder, fuel and fiber that bound farmers to retain these trees on their farm bunds. The selection of intercrops depends mainly on edapho-climatic conditions of the area, farmer's need/traditions and resource availability (Saroj and Dadhwal, 1997).

The agroforestry interventions seem to be more worthwhile due to the share of tremendous pressure on forest for the fuel and fodder by these farm trees. Although a number of studies on the Himalayan agroforestry systems (Toky *et al.*, 1989; Ralhan *et al.*, 1991; Sundriyal *et al.* 1994; Semwal and Maikhuri, 1996; Singh *et al.*, 1997) are available, but the productivity of agricultural crops under agroforestry systems have not worked out properly. This study aimed to analyse the wheat productivity as intercrop under *G. optiva* based traditional agroforestry system along altitudinal gradient and aspect in mid hills of Garhwal Himalaya.

2. Materials and Methods

The study was carried out in the traditional agroforestry systems of mid hill situation of Chamba block of Garhwal Himalaya in district Tehri Garhwal (Uttarakhand), India located between 77°51' 30" to 80°30" E longitudes and 29°40' to 31°28" N latitudes. Geographically the area falls in transition zone of sub-tropical and temperate zone, with majority of agricultural fields fall in high degree of terraced slopes, resulted soil and water losses. The traditional agricultural fields are dominated with luxuriant and green lush natural vegetation. The soil of this region is acidic in nature varying in texture as per the availability of organic matter. Agricultural is the mainstay of livelihood of this region and the villagers are engaged in agricultural interventions all through the year which is usually low productive. Majority of the farmers of this region are small with fragmented land holding around 0.04 hectare. The 85% of the agricultural area is rainfed while some of the valley areas have limited irrigation through natural tributaries of rivers (locally known *Gadhera*). The study area covers three main seasons: rainy (Last week of June-August), winter (September-February) and summer (March-third week-June). The area receives an average annual rainfall of 1240 mm with most of the rain occurs during July to September (monsoon period). The mean annual temperature of the area varies from 9° to 33°C with occurrence of snowfall during November to February.

G. optiva (*Bhimal*) is an extremely common multipurpose tree of this region, grown on the farmers' field under traditional agroforestry design on terrace bunds along with all crop combinations. The *G. optiva*-wheat based agroforestry combination (agrisilviculture) is a common practice by the local people to supplement the additional benefits from the tree. The elevation and aspect (direction of sun light faced by slope) play a significant role in growth, development and composition of vegetation in the hilly areas. It has generally observed that the tree and agricultural crops change their productivity in varying slopes and aspect with morphological changes in the plant characters. The present study is planned in such a way that the feasibility of *G. optiva* based agroforestry combination could be assessed in accordance to different elevation and aspects. The effect on the productivity of wheat under *G. optiva* tree was the sole objective of the study in varying elevation and aspect.

2.1. Experimental Design

The experiment was conducted in four experimental sites during Rabi (November-March) season in the wheat fields dominated by *G. optiva* trees (agrisilviculture model) between 1000 to 2000 m of elevation. The four different study sites were based on elevation and aspects are as given below: E1/N -Northern aspect between 1000-1500 m msl; E1/S - Southern aspect between 1000-1500 m msl, E2/N- Northern aspect between 1500-2000 m msl, E2/S- Southern aspect between 1500-2000 m msl. The stratified random sampling was carried out in the area (sample intensity 0.1) with 40 samples laid in each site having quadrat size of 10x10 m, following Mishra, 1968. In each quadrat, the trees of different species were enumerated. The elevation and aspect of the area was measured with the help of GPS (Model No. Rino-130, Garmin). The composition of different agroforestry components were enumerated on the basis of population dynamics and functional diversity (James, 1988). The frequency, stem density (SD), Total Basal Cover (TBC) and Importance Value Index (IVI) analysis of *G. optiva* (in particular) and other associate trees (in general) in the existing agrisilviculture system in each study site was done. The elevation and aspect wise analysis was done to quantify the influence of physiographic variation on growth and yield of wheat under *G. optiva* based agroforestry system.

In each study site, the *G. optiva* trees per hectare was categorized in 0-10, 10-20, 20-30 and 30-40 cm diameter classes in four replications. In each sample plot, the diameter at breast height (DBH) of *G. optiva* was measured at 1.37 m using tree caliper while heights of trees were measured by Abney's level in meters. The diameter class was considered to be the major factor, influenced the growth and yield of wheat. The Crown spread (CS) of *G. optiva* was also measured for the assessment of effect of diameter and canopy on wheat productivity under different distance from the tree trunk.

In case of wheat crop, the 1x1 m quadrat was laid for the same agroforestry field at different distances under the average canopy of *G. optiva*. The Crown spread of *G. optiva* was measured with the five radial transects from the tree trunk randomly under each diameter class. The wheat crop growth was studied along transects at 1 m (D1), 1-2 m (D2), 3-4 m (D3) and 4-5 m (D4) distances from the *G. optiva* tree trunk. The open field with the distance >5 m from the tree trunk was considered as control. The different growth and yield attributes of wheat viz: number of plants, number of tiller per plant, plant height (cm), thousand grain weights (gm), grain yield, straw yield and biological yield was estimated under *G. optiva* tree and open condition. Finally the harvest index (HI) was calculated to determine the fraction of economically useful products of a plant in relation to its total productivity (grain to straw ratio) and calculated using following formula:

HI = (EY/BY) x 100

Where; HI = Harvest Index, EY = Economic Yield (grain yield),

BY = Biological Yield (grain + straw)

The same experiment was conducted in four different sites (E1/N, E1/S, E2/N and E2/S) to quantify the impact on wheat yield on different distances from tree trunk along varying elevation and aspect. Statistically the study was tested in Factorial Analysis of Variance (F-ANOVA) to find out the effect of two or more than two factors in different study sites and level of significance was tested at probability levels 5 per cent as per the procedure outlined by Snedecor and Cochran (1967). The main factors considered elevation, aspect, and distance from tree trunk for wheat productivity estimation. The productivity of sole wheat crop was performed in Randomize Block Design (RBD) and estimation was done in agronomical method. The statistical analysis was performed using MSTAT C and SPSS statistical software under PC atmosphere.

3. Results

The results of the present study (Table 1) showed that the *G. optiva* occupied average highest frequency (85%), stem density (145 trees/ha), TBC (7.68 m^2/ha), IVI (86.51), tree height (7.38 m), Crown spread (5.34 m) in the elevation 1000-1500 m of Northern aspect (E1/N site). The tree occupied average lower frequency (55%), density (70 trees/ha), TBC (4.58 m^2/ha), tree height (6.08 m) in the elevation 1500-2000m of Southern aspect (E2/S site). In the present study the proportionate Stem Density (SD %) distribution of *G. optiva* varied form 2.86% in 30-40 cm diameter class of E2/S site to 61.60% in 10-20 diameter class of E1/S site. The highest percentage of Stem Density (*G. optiva*) was recorded in 10-20 cm diameter class in all the sites as 57.24% (E1/N), 61.60% (E1/S), 52.63% (E2/N) and 57.14% (E2/S). The minimum percentage of Stem Density was observed in 30-40cm diameter class as 3.45% (E1/N), 3.20% (E1/S), 4.21% (E2/N) and 2.86% (E2/S).

Table 1. Ecobiometrics of *Grewia optiva* in traditional agroforestry practices

Parameters	Study sites			
	E1/N	E1/S	E2/N	E2/S
(% F)	85	75	60	55
SD (Trees ha^{-1})	145	125	95	70
TBC (m^2 ha^{-1})	7.68	6.08	5.03	4.58
IVI	86.51	65.74	58.52	53.71
DBH (cm)	17.03	16.38	15.19	14.13
Tree ht (m)	7.38	6.76	6.29	6.08
CS (m)	5.34	5.08	4.95	4.41
CI	1.63	1.78	1.65	1.72

% (F), percentage Frequency; SD, Stem density (Trees ha^{-1}); TBC, Total Basal Cover(m^2 ha^{-1}); IVI, Importance Value Index; CS, Crown Spread (m); DBH, Diameter at Breast Height (cm); CI, Crown index; E1 (1000-1500 m); E2 (1500-2000); N-Northern aspect; S-Southern aspect.

All the growth and yield attributes of wheat reduced under *G. optiva* tree in different study sites. The growth parameters as number of plants m^{-2}, plant height and Number of tiller per plant decreased significantly at 1 m distance (D1) from the tree trunk compared to other distances. Similarly the yield attributed (thousand grain weight, grain yield, straw yield and biological yield) reduced maximum under 1 m distance (D1) and gradually increased from 1 m to 4-5 m (D5). The minimum reduction of growth and yield attributes beneath the trees were noticed in 4-5 m (D5) distance from tree trunk as compared to other distances. The growth and yield attributes of wheat were significantly reduced in all the distances of wheat compared to control (wheat grown open areas without tree).

Table 2. Productivity of Wheat under traditional agroforestry systems in 1000-1500m elevation on northern aspect (E1/N)

Distance	No. of plants/m^2	Plant ht (cm)	No. of effective tiller /plant	1000 Grain wt (gm)	Grain (t ha^{-1})	Straw (t ha^{-1})	B.Y. (t ha^{-1})	H.I. (%)
D1 (up to 1m)	31.43	61.64	2.38	29.53	0.625	1.354	1.979	31.58
D2 (1-2m)	33.85	60.47	2.69	30.54	0.698	1.418	2.116	32.99
D3 (2-3m)	35.86	62.63	2.82	31.88	0.835	1.613	2.448	34.11
D4 (3-4m)	42.66	66.74	2.96	32.65	1.164	2.122	3.286	35.42
D5 (4-5m)	76.45	72.36	3.21	33.75	1.311	2.282	3.593	36.49
Mean	44.05	64.77	2.81	31.67	0.927	1.758	2.684	34.12
Control	81.54	86.65	3.78	38.38	1.417	2.186	3.603	39.33
CD 5%	14.78	24.80	0.89	2.07	0.15	0.16	0.30	7.06

On the northern aspect of elevation 1000-1500 m (E1/N), the number of wheat plant varied 31.43 (D1) to 76.45 (D5) per m^2, number of tiller/plant 2.38 (D1) to 3.21 (D5) and the grain yield from 0.625 t ha^{-1} (D1) to 1.311 t ha^{-1} (D5). The reduction of grain yield was observed to be highest 55.89% under D1, 50.74% (D2), 41.07% (D3), 17.85% (D4) and 7.48% (D5) compared to control (Table 2). The average reduction in this site was recorded to be 34.61% against the control. The biological yield (grain + wheat) in the site varied from 1.979 t ha^{-1} (D1) to 3.593 t ha^{-1} (D5). The southern aspect in the same elevation (E1/S) showed the overall reduction in both growth and yield parameters of wheat. In this site the number of wheat plant varied 31.25 (D1) to 66.23 (D5) per m^2, number of tiller/plant 2.27 (D1) to 3.12 (D5) and the grain yield from 0.533 t ha^{-1} (D1) to 1.108 t ha-1 (D5). The biological yield (grain + wheat) in the site ranged from 1.746 t ha-1 (D1) to 3.062 t ha-1 (D5) (Table 3, Figure 1). The reduction of grain yield was observed to be maximum 56.10 % in D1 followed by 51.07% (D2), 46.79% (D3), 22.82% (D4) and 8.73% (D5) compared to control. The average reduction in the grain yield was noticed 37.19% of this site when compared with control. It was observed that there is a reduction in grain, straw and biological yield of wheat as 17.59%, 17.77% and 17.71% respectively on the southern aspect compared to northern aspect within the same elevation level under traditional agroforestry systems.

Table 3. Productivity of Wheat under traditional agroforestry systems in 1000-1500 m elevation on southern aspect (E1/S)

Distance	No. of plants/m^2	Plant ht (cm)	No. of effective tiller /plant	1000 Grain wt (gm)	Grain (t ha^{-1})	Straw (t ha^{-1})	B.Y. (t ha^{-1})	H.I. (%)
D1 (up to 1 m)	31.25	55.24	2.27	26.56	0.533	1.213	1.746	30.53
D2 (1-2 m)	29.73	58.29	2.66	29.29	0.594	1.174	1.768	33.60
D3 (2-3 m)	34.44	62.66	2.61	31.44	0.646	1.321	1.967	32.84
D4 (3-4 m)	42.48	71.36	2.83	32.35	0.937	1.565	2.502	37.45
D5 (4-5 m)	66.23	74.77	3.12	33.73	1.108	1.954	3.062	36.19
Mean	40.83	64.46	2.70	30.67	0.764	1.445	2.209	34.12
Control	76.15	84.85	3.48	36.83	1.214	1.887	3.101	39.15
CD 5%	14.41	14.11	0.21	1.60	0.11	0.14	0.14	3.35

Table 4. Productivity of Wheat under traditional agroforestry systems in 1500- 2000 elevation on northern aspect (E2/N)

Distance	No. of plants/m^2	Plant ht (cm)	No. of effective tiller /plant	1000 Grain wt (gm)	Grain (t ha^{-1})	Straw (t ha^{-1})	B.Y. (t ha^{-1})	H.I. (%)
E2/N								
D1 (up to 1 m)	30.47	71.47	2.73	31.44	0.524	1.093	1.617	32.41
D2 (1-2 m)	34.74	67.44	2.85	29.77	0.568	1.185	1.753	32.40
D3 (2-3 m)	46.84	68.58	3.14	31.56	0.821	1.637	2.458	33.40
D4 (3-4 m)	56.78	62.48	3.21	32.43	0.883	1.674	2.557	34.53
D5 (4-5 m)	68.53	72.64	3.43	32.78	1.031	1.932	2.963	34.80
Mean	47.47	68.52	3.07	31.60	0.765	1.504	2.270	33.51
Control	74.66	91.13	3.76	37.42	1.125	2.032	3.157	35.64
CD 5%	14.780	24.804	0.990	2.073	0.156	0.164	0.298	7.059

Table 5. Productivity of Wheat under traditional agroforestry systems in 1500- 2000 elevation on southern aspect (E2/S)

Distance	No. of plants/m^2	Plant ht (cm)	No. of effective tiller /plant	1000 Grain wt (gm)	Grain (t ha^{-1})	Straw (t ha^{-1})	B.Y. (t ha^{-1})	H.I. (%)
D1 (up to 1 m)	28.24	51.48	2.87	29.33	0.500	1.172	1.672	29.90
D2 (1-2 m)	28.79	56.39	3.00	30.38	0.504	1.103	1.607	31.36
D3 (2-3 m)	32.74	59.92	3.14	29.65	0.594	1.212	1.806	32.89
D4 (3-4 m)	38.83	65.39	2.85	28.59	0.743	1.429	2.172	34.21
D5 (4-5 m)	65.49	71.25	3.36	29.62	0.944	1.784	2.728	34.60
Mean	38.82	60.89	3.04	29.51	0.657	1.340	1.997	32.59
Control	72.53	92.45	3.58	36.29	1.048	1.924	2.972	35.26
CD 5%	14.413	14.114	0.212	1.593	0.114	0.137	0.142	3.354

Table 6. Growth stages of *Grewia optiva* and wheat- Tree Crop interface

Months	Phenology and growth stages	
	wheat	*G. optiva*
December	Sowing	Dormant
January	Emergence to CRI	Dormant
February	Tillering and Heading	Dormant
March	Panicle initiation and Anthesis	Leafless
April	Milking and physiological maturity	Bud initiation
May	Harvesting	New Flush of leaves

The higher elevation (1500-2000 m) was observed in a reduction of growth and yield attributes of wheat compared to middle elevation (1000-1500 m). The northern aspect (E2/N) showed number of wheat plant 30.47 (D1) to 68.53 (D5) per m^2, number of tiller/plant 2.73 (D1) to 3.43 (D5) and the grain yield from 0.524 t ha-1 (D1) to 1.031 t ha-1 (D5) (Table 4). The grain yield was observed with a reduction of 53.42% (D1), 49.51% (D2), 27.02% (D3), 21.51% (D4) and 8.36% (D5) in different distances. The gradual reduction was also examined in the biological yield of the wheat from the distance of tree trunk as 1.617 t ha-1 (D1) to 2.963 t ha-1 (D5). The average reduction in the grain yield of wheat under agroforestry was reported 31.96% in E2/N site. On the southern aspect (E2/S) the number of wheat plants/m^2 are slightly lower compared to northern aspect and varied D1 (28.24) to D5 (65.49), similarly the grain and biological yield of wheat was also recorded to be lower as 0.500 t ha^{-1} (D1) to 0.944 t ha^{-1} (D5) (Table 5, Figure 2). The reduction in the average grain yield was recorded 37.31% under *G. optiva* based traditional agroforestry system in E2/S site.

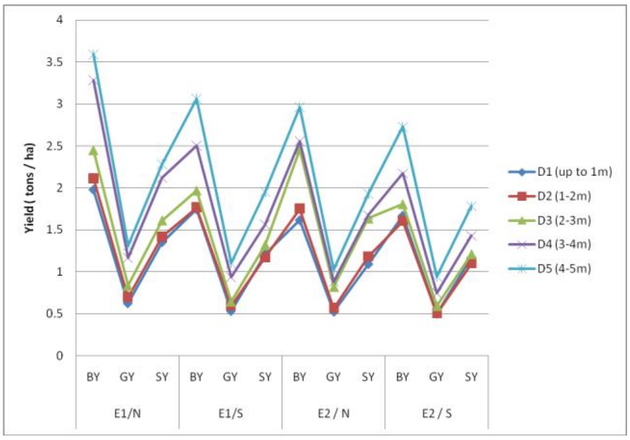

Figure 1. Biological Yield , Grain Yield and Straw Yield of wheat under traditional agroforestry systems in different elevation and aspect in Garhwal Himalayas

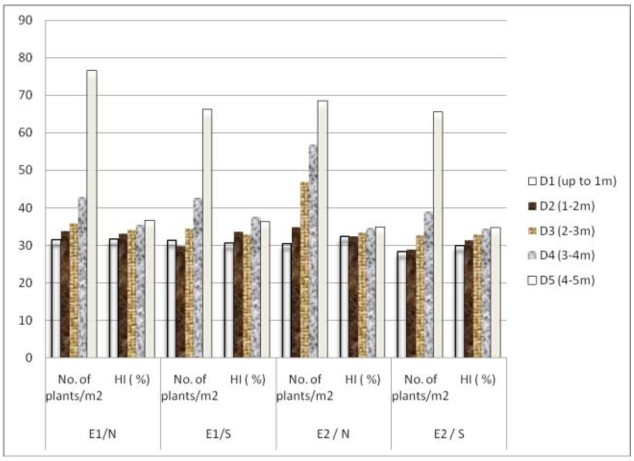

Figure 2. Wheat plants density and Harvesting Index under traditional agroforestry systems in different elevation and aspect in Garhwal Himalayas

Table 6 showed the phenophases of wheat and *G. optiva*, the wheat crop is sown in the month of December which emerges to crown root initiation (CRI) in January followed by tillering, milking, maturity and final harvest during May. *G. optiva* remain dormant December to February, leafless in March and new flush of shoots in May. This reversal phenopases of two component are complimentary in tree crop interaction to enhance productivity. The *G. optiva* provides fodder in the winter period which is the lean period of this hilly region.

4. Discussion

The traditional agroforestry practices are in practice by the local community since time immemorial. Though there are various multipurpose trees are deliberately retained by the farmers on their agricultural filed yet their density, frequency and abundance varied as per the social and climatic factors. *G. optiva* being a multipurpose species was widely preferred in agroforestry systems in Garhwal Himalayan regions of India. This species provides the fodder during the lean period (winter) and therefore, deliberately cultivated by farmers on the bunds of the agriculture fields. The fodder of this species is preferred by the animals and therefore, used for stall feeding, which is believed to enhance the milching of animals. According to Sahgal *et al.* (2003), the *G. optiva* is one of the most important fodder trees of north-western and central Himalaya and is found distributed throughout the Sub-Himalayan tracts. The species is considered as a boon for the Himalayan regions by several workers (Chandra and Sharma, 1977; Singh, 1982; Sehgal and Chauhan, 1989; Khybri *et al.*, 1992; Nautiyal *et al.*, 1998; Bhatt and Pathak, 2003). In the hilly areas of Garhwal Himalaya, farmers commonly use FYM in their fields after the harvest of Rabi and Kharif crops. The terraces have generally an outward slope therefore, after rains; the nutrients of FYM are washed away towards the bunds, where the farmers are deliberately retaining the fodder trees. These trees get sufficient nutrients from FYM, hence, have good growth and development. The practice of agroforestry justified that in agrihorticulture systems, the interaction of annual crops with fruit trees in different ecological regions of the country have shown quite encouraging response in terms of multiple outputs, with assured income generation (Bhuva *et al.*, 1989; Randhawa, 1990; Chundawat, 1993; Saroj *et al.*, 2000; Osman, 2003). Khybri *et al.* (1988) recorded the adverse effect of trees near the tree base, which subsequently increased with the age of trees.

In a similar type of agroforestry systems, Singh (1986) in Himachal Pradesh between 1000 to 2000 m asl. found that G. optiva, Celtis australis, Robinia pseudoacacia, Sapindus mukorossii, Melia azedarach, Eucalyptus spp., Bauhinia spp., Juglans regia, Toona ciliata, Quercus leucotrichophora, Populus spp., Prunus spp., Cedrus deodara, Quercus floribunda, Morus serrata etc. were the prominent tree species raised by farmers on bunds of their fields. On the other hand Tejwani (1987) also enlisted the trees used in agroforestry systems in Uttar Pradesh and Himanchal Pradesh between 500 to 2300 m elevation and revealed the same tree species i.e., Grewia optiva, Celtis australis, Quercus spp. as reported in this study, except few tree species i.e., Bauhinia variegata and Ficus roxburghii, which were reported from Himnchal Pradesh (Toky et al., 1989).

All the growth and yield attributes of wheat were decreased highest in closer vicinity of tree trunk at 1 m and lowest at 5 m from the tree trunk. The maximum yield was recorded in open condition. Similarly the number of wheat plant/m^2 was minimum at 1 m and maximum at 5 m away from tree trunk in all the sites. The minimum number of wheat plant near the tree trunk is primarily due to low amount of sunlight received by the plant and human interference while climbing the tree for consecutive collection of fodder. There could be a leachats form the branches and leaves are maximum at the basement of the tree. Sharma *et al*., (2000) was observed the similar results of reduction in plant population of wheat crop (34.2%) due to poplar tree at 0-3 m distance from tree base when compared with control. Though there was no proper trend was observed in the crop height under different distances from tree trunk, it is generally decreased in different sites as the distance from the tree trunk increased except in the distance of 5 m. The control (open) field had higher crop height compared to plants under shade. The reason behind more height of crop under shade for tendency to approach sunlight for photosynthesis, moreover plants have got the photophyllic nature and they incline in the direction of sunlight. The reduction in the grain yield was reported to be significantly ($p<0.01$, Table 2, Table 3, Table 4, Table 5) higher up to 1 m compared at 5 m distance in different sites. The diameter and crown spread were directly correlated with the grain yield and with increase of diameter and crown spread the yield was significantly reduced, thus light becomes the limiting factor. The crown spread plays a significant role in grain yield and the yield decreased with increase of crown spread. The crown index (ratio of crow length and crown width) gives the exact status of shade under tree. Some time the crown spread is more but the thickness/length of crown is lower, therefore both crown length and crown width have role to block the sun light. The *G. optiva* is extensive lopped during the winter period that also sometimes plays positive role in penetration of sun light to the grown level. The gradual and continuous collection of fodder from the tree also lead trampling of the wheat crop and that also create a reasonable part to reduce the yield of the wheat.

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