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Standardization of Harvesting Technique of *Grewia Optiva* Drumm. Burr. for Sustainable Utilization towards Livelihood of Rural Communities

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ABSTRACT

Grewia optiva (bimal) is a multipurpose tree and commonly used under agroforestry in Western Himalaya. Various tree management practices are carried out under agroforestry to optimize productivity and better utilization of resource by farmers and other associated people. In this experiment, quantification of lopping of the *G. optiva* was standardized for food, fodder, fuelwood and other subsistence requirements. *G. optiva* population survey and socio economic survey in study area was also carried out to collect the information on tree population, income resources, status of employment, prominent livestock, possibilities of income generation for livelihood in *G. optiva* grown area. The results of the study suggest that 75% lopping of tree may be done for fodder, fuel etc. and remaining 25% twigs to obtain fodder and fibre in ensuing season. The most loving animal, goat was observed in study area and youth may generate steady income for their livelihood, if opt the technology

Introduction

Grewia optiva, locally known as bhimal, is a multifaceted tree species exhibiting a range of valuable properties that render it an indispensable resource for local communities. Its attributes include high-quality fodder leaves, soft bark containing saponin, utilized in hair care products (Luna, 2005), rich fiber in the bark, employed in crafting, robust ropes, durable backpacks (kurna) and baskets (kandi), various items such as bags, purses, chappals, mats, and wall hangings.

Bhimal-based feeding packages have been deemed suitable, sustainable, and beneficial for goat production in Nepal's mid and far Western hill regions (Pandey *et al*., 2017). Its recognition is as one of the most significant fodder trees in the North-Western and central Himalaya, with widespread distribution throughout the sub-Himalayan tract (Sehgal *et al*., 2003). Timber is used as Shaft construction, shoulder poles, cot frames, paddles, tools and axe handles and soft branches employed in basket-making (Gill *et al*., 2016). Seeds are laxative. Paste of the seeds mixed with a glass of hot milk is given to pregnant ladies to facilitate easy delivery. Leaves enhance the lactation potential in cattle. The fibre of young stems are crushed into paste and mixed with hot water and used shampoo by local ladies for washing hair (Kholiya *et al*., 2020).

It is proven multipurpose tree and commonly is used in agroforestry in western Himalayas. Most of the scientific communities of the world have confirmed the role of agroforestry as savior of humankind against the devil of climate change (IPCC, 2007).To optimize productivity and resource utilization in agroforestry systems, farmers must employ various tree management practices. These practices aim to produce desirable products, manage tree canopies and roots for efficient resource use, cycle organic residues for nutrient management, implement proper harvesting techniques for timber and non-timber products and protect trees from biotic and abiotic stresses. The primary objective of tree management is to minimize negative tree-crop interactions and maximize positive synergies. Management practices are tailored to the specific tree species and its intended purpose. Tree management can be broadly categorized into two main areas viz. aboveground management: focuses on canopy management, pruning, and harvesting techniques and belowground management: concentrates on root management, soil health, and nutrient cycling. Farmers can optimize the benefits of agroforestry systems, promote ecological balance, and enhance overall productivity by adopting these practices.

The above ground management practices are carried out by pruning, thinning, pollarding, lopping and coppicing. Lopping is the cutting off tree branches *e.g.* mainly of leafy branches or twigs from a tree (Akunda and Huxley, 1990). The time window for renewal of interspecific competition for light to meet seasonal needs for food, fodder, fuelwood and other subsistence requirements, to encourage new flush of growth, and to maintain the hygiene of the trees. The lopping period varied from species to species (Rawat and Vishvakarma, 2011).

In this present study, experiments had been conducted on standardization of lopping technique of the *G. optiva* to test whether traditional 100% lopping is suitable for food, fodder, fuelwood and other subsistence requirements. Socio economic survey in study area was also carried out to find out most loving animal and how unemployed youth can generate income for their livelihood in *G. optiva* grown area.

Materials and Methods

Existing population survey of *Grewia optiva* and Socio economic Survey

Survey for existing population of *G. optiva* (bhimal) was conducted at selected site in Uttarakhand to delineate the population by standard method (Srivastav *et al*., 2015). Thereafter, socio economic survey was also carried out in area for obtaining youth population and income resources information using random sampling after developing the requisite format. There were four different experiment sites selected for study such as village Kalsi,Vikasnagar, Dehradun, village Amgaon, Yamkeswar, Pauri Garhwal and village Walna, Ranikhet, Almora, Uttarakhand were. Experimental sites are mentioned in below:

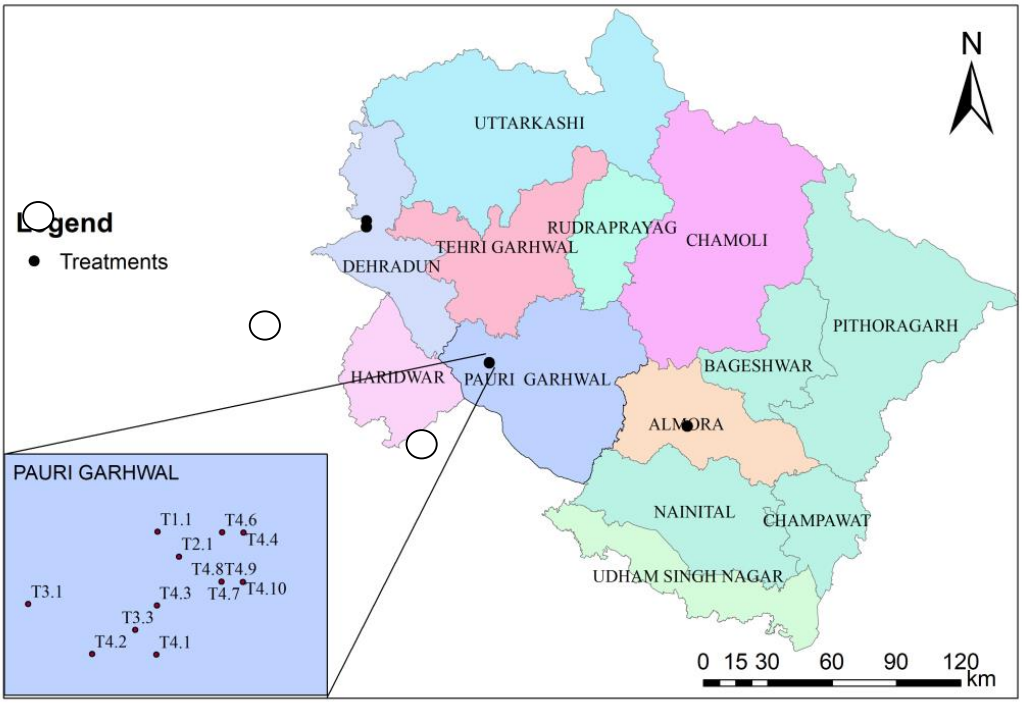

Figure 1. Study area for experiments in Uttarakhand

Selection of trees for standardization of lopping method

After survey in the study area, population of *G. optiva* were marked and trees of natural stand of *G. optiva* were selected for standardization of harvesting techniques. 03 trees for T1, T_2 and T_3 treatments while 10 trees for T_4 treatment were selected at each site, pruned them for standardization of lopping methods of harvesting techniques as follows:

T_1- 25% lopping of twigs of selected trees

T_2- 50% lopping of twigs of selected trees

T_3- 75% lopping of twigs of selected trees

T_4- 100% lopping of twigs of selected trees

The initial data recorded from of all selected trees are presented in Table 1, 2 and 3. The available fodder quantity was harvested in winter and summer, weighed and recorded no of sprouts at each tree as per treatment.

Results and Discussion

The initial growth data of selected trees before application of lopping method were recorded of all the sites (Table 1, 2 and 3).

Table 1. Initial growth performance of selected *Grewia optiva* trees at Animal Breeding Farm Kalsi, Dehradun, Uttarakhand

Treatments		Height (m)	Mean Girth (cm)	Elevation	GPS Location of trees
T_1=25% lopping of twigs	$T_{1.1}$	6.5	29	516.4 m	N 30° 31' 16.7" E 77° 50' 33.1"
	$T_{1.2}$	5.5	23	517.4 m	N 30° 31' 16.7" E 77° 50' 32.8"
	$T_{1.3}$	5.8	25	515.4 m	N 30° 31' 17.1" E 77° 50' 29"
	Mean	5.93	25.67	516.4m	
T_2=50% lopping of twigs	$T_{2.1}$	5.6	30	516.1 m	N 30° 31' 16.8" E 77° 50' 32.6"
	$T_{2.2}$	5.5	19.67	516.4 m	N 30° 31' 16.8" E 77° 50' 32.3"
	$T_{2.3}$	5.8	30.00	516.7 m	N 30° 31' 17.3" E 77° 50' 28.5"
	Mean	5.63	26.56	516.4m	
T_3=75% lopping of twigs	$T_{3.1}$	4.9	20.00	516.8 m	N 30° 31' 116.8" E 77° 50' 32.1"
	$T_{3.2}$	5.5	24.80	516.4 m	N 30° 31' 16.8" E 77° 50' 31.9"
	$T_{3.3}$	4.9	25.00	517.4 m	N 30° 31' 17.6" E 77° 50' 28.3"
	Mean	5.10	23.27	516.87m	
T_4=100% lopping of twigs	$T_{4.1}$	6	19.25	516.2 m	N 30° 31' 16.9" E 77° 50' 31.7"
	$T_{4.2}$	6.2	24.50	517 m	N 30° 31' 16.9" E 77° 50' 31.0"
	$T_{4.3}$	5.9	26	516.9 m	N 30° 31' 16.9" E 77° 50' 31.2"
	$T_{4.4}$	5.8	27.00	515.7 m	N 30° 31' 17.1" E 77° 50' 29.9"
	$T_{4.5}$	5.4	24.80	516.6 m	N 30° 31' 17.1" E 77° 50' 29.7"
	$T_{4.6}$	6.4	26.80	519.6 m	N 30° 31' 17.5" E 77° 50' 34.5"
	$T_{4.7}$	5.8	27.30	520.9 m	N 30° 31' 17.5" E 77° 50' 34.5"
	$T_{4.8}$	5.7	26.80	520.9 m	N 30° 31' 16.9"

					E 77° 50' 34.2"
	$T_{4.9}$	4.8	27.40	521.4 m	N 30° 31' 16.8" E 77° 50' 34.1"
	$T_{4.10}$	6.5	25.70	520.7 m	N 30° 31' 16.7" E 77° 50' 34.1"
	Mean	6.00	25.56	518.59m	-

Table 2. Initial growth performance of selected *Grewia optiva* trees at Amgaon/ Kandi, Pauri Garhwal, Uttarakhand

Treatments		Height (m)	Mean Girth (cm)	Elevation	GPS Location of trees
T_1=25% lopping of twigs	$T_{1.1}$	6.2	50	1050 m	N 29° 56'51.8" E 078° 27' 14.4"
	$T_{1.2}$	7.5	55	1047 m	N 29° 56' 62.3" E 78° 27" 14.2"
	$T_{1.3}$	6.7	65	1049 m	N 29° 56' 62.3" E 78° 27" 14.3"
	Mean	6.8	56.67	1048.67m	
T_2=50% lopping of twigs	$T_{2.1}$	5.9	45	1050 m	N 29° 56'51.7" E 078° 27' 14.5"
	$T_{2.2}$	6.1	55	1047 m	N 29° 56' 62.5" E 78° 27" 14.3"
	$T_{2.3}$	5.4	64	1046 m	N 29° 56' 62.5" E 78° 27" 14.1"
	Mean	5.8	54.67	1047.67m	
T_3=75% lopping of twigs	$T_{3.1}$	5.6	54	1047m	N29° 56' 51.5" E 78° 27" 13.8"
	$T_{3.2}$	5.8	59	1039m	N 29° 56" 51.4" E 78° 27" 14.3"
	$T_{3.3}$	5.7	58	1042m	N 29° 56" 51.4" E 78° 27" 14.3"
	Mean	5.7	57	1042.67m	
T_4=100% lopping of twigs	$T_{4.1}$	6.3	55	1043m	N29° 56' 51.3" E 78° 27" 14.4"
	$T_{4.2}$	6.5	57	1041m	N 29° 56" 51.3" E 78° 27" 14.1"
	$T_{4.3}$	5.8	59	1039m	N 29° 56" 51.5" E 78° 27" 14.4"
	$T_{4.4}$	6.8	55	1055 m	N 29° 56'51.8" E 78° 27' 14.8"

	$T_{4.5}$	7.6	49	1058 m	N 29° 56'51.6" E 78° 27' 14.7"
	$T_{4.6}$	8.1	58	1055 m	N 29° 56'51.8" E 78° 27' 14.7"
	$T_{4.7}$	8.7	57	1049 m	N 29° 56'51.6" E 78° 27' 14.7"
	$T_{4.8}$	6.4	55	1049 m	N 29° 56'51.6" E 78° 27' 14.7"
	$T_{4.9}$	5.9	61	1046 m	N 29° 56'51.6" E 78° 27' 14.7"
	$T_{4.10}$	6.8	57	1046 m	N 29° 56'51.6" E 78° 27' 14.8"
	Mean	6.89	56.3	1048.10m	-

Table 3. Initial growth performance of selected *Grewia optiva* trees at Walna, Ranikhet, Almora, Uttarakhand

Treatments		Height (m)	Mean Girth (cm)	Elevation	GPS Location
T_1=25% lopping of twigs	$T_{1.1}$	5.6	47	1317m	N29° 41' 4.2" E 79° 25" 29.1"
	$T_{1.2}$	4.8	57	1303m	N 29° 41" 4.6" E 79° 25' 30.3"
	$T_{1.3}$	5.5	53	1302m	N 29° 41' 4.6" E 79° 25' 30.3"
	Mean	5.30	52.33	1307.37m	
T_2=50% lopping of twigs	$T_{2.1}$	6.5	54	1316m	N29° 41' 4.1" E 79° 25' 29.3"
	$T_{2.2}$	5.8	51	1316m	N 29° 41" 4.0" E 79° 25' 29.4"
	$T_{2.3}$	6.3	48	1303m	N 29° 41" 5.7" E 79° 25' 30.2"
	Mean	6.20	51.00	1311.67m	
T_3=75% lopping of twigs	$T_{3.1}$	5	48	1317m	N29° 41' 4.0" E 79° 25" 29.2"
	$T_{3.2}$	5.25	54	1319m	N 29° 41" 3.9" E 79° 25' 29.1"
	$T_{3.3}$	5.25	53	1297m	N 29° 41" 5.1" E 79° 25' 30.4"
	Mean	5.17	51.67	1311.00m	

T_4=100% lopping of twigs	$T_{4.1}$	6.8	54	1316m	N29° 41' 4.3" E 79° 25" 29.1"
	$T_{4.2}$	6.9	58	1316m	N 29° 41" 4.1" E 79° 25" 28.9"
	$T_{4.3}$	6.3	54	1320m	N 29° 41" 4.4" E 79° 25" 28.7"
	$T_{4.4}$	5.9	58	1321m	N 29° 41" 4.0" E 79° 25" 28.7"
	$T_{4.5}$	6.8	58	1317m	N 29° 41" 3.8" E 79° 25" 28.7"
	$T_{4.6}$	7.3	53	1317m	N 29° 41" 3.5" E 79° 25" 28.7"
	$T_{4.7}$	5.4	54	1321m	N 29° 41" 3.5" E 79° 25" 28.5"
	$T_{4.8}$	7.5	47	1320m	N 29° 41" 3.3" E 79° 25" 28.3"
	$T_{4.9}$	6.1	58	1316m	N 29° 41" 2.7" E 79° 25" 28.7"
	$T_{4.10}$	7.7	49	1315m	N 29° 41" 2.4" E 79° 25" 28.6"
	Mean	6.67	54.30	1186.30m	-

Survey for assessment of population of *Grewia optiva*

Population survey of *Grewia optiva* was conducted in study area. Four villages viz. Chandau, Jasau Kharaya, Malhau and Tipau in Kalsi Block, Dehradun were selected. The residents of concerned villages were interviewed (Figure 2) and status of *Grewia optiva* was observed 33.10% in Chandau, 46.95% in Jasau Kharaya, 47.30% in Malhau and 57.66% in Tipau as compared to other species such as Banj (*Quercus leucotrichopra*), Bass (Bambusoideae), Burans (*Rhododendron arboreum*), Deodar (*Cedrus deodara*), Kachnar (*Bauhinia varigata*), Khadik (*Celtis australis*), Gorial, Keemu and Padink (Figure 2). Most of the fodder species were noticed in the area.

Survey for assessment of population of *G. optiva* was conducted in four villages viz. Aamgaon, Dungadhar, Kandi and Thangar in Yamkeswar block, Pauri Garhwal. As per survey in villages and interaction with people, status of *G. optiva* was observed 45.39% in Aamgaon, 74.13% in Dungadhar, 76.54% Kandi and 62.45% in village Thangar of Yamkeswar block, Pauri Garhwal as compared to other species such as Cheer (*Pinus roxburghii*), Anola (*Emblica officinalis/ Phyllanthus emblica*), Githi (*Dioscorea bulbifera*), Guava (*Psidium guajava*), Gullar (*Ficus racemosa*), Khadik (*Celtis australis*), Kolan (*Pterichis triangularilabia*), Mango (*Mangifera indica*), Nashpati pear (*Pyrus communis*), Nashpati (*Pyrus communis*), Orange (*Citrus sinensis*), Sahtoot (*Morus alba*) and Kavach (Figure 3). Existence of fruit and fodder trees was also observed in the area.

Survey for existing population of *Grewia optiva* was conducted in other four villages viz. Karchuli, Khadgoli, Rikholi and Walna in Ranikhet, Almora. The residents of concerned villages were interviewed and on the basis of interaction with people status of *Grewia optiva* was observed 58.52% *in* Karchuli 31.78% in Khadgoli, 64.50% Rikholi and 53.54% in Walna as compared to other species such as Aadu (*Prunus persica*), Anar (*Punica granatum*), Apple (*Malus domestica*), Apricot (*Prunus armeniaca*),Cheer (*Pinus roxburghii*),Guava (*Psidium guajava*), Jamun(*Syzygium cumini*), Khadik (*Celtis australis*), Mango (*Mangifera indica*), Nashpati (*Pyrus communis*), Timal (*Ficus racemosa*) and Bithan (Figure 4). Climatically, the area is rainfed and farmers interested to retain fruits trees including fodder species in the area.

In the study *Grewia optiva* existing population was observed ranging from 31.78% to 74.54% in the area where interested person may show the curiosity in fibre extraction for improvement of their livelihood.

Socioeconomic Survey

Forests and trees contribute in multiple ways by reducing food insecurity, supporting sustainable livelihoods and alleviating poverty. Forests play important provisioning and supporting roles in the livelihoods of rural households (Byron and Arnold, 1999; Sunderlin *et al*., 2005) and many of those who live in extreme poverty are to some degree reliant on forests for their livelihood. The first role is the supporting function of forest and environmental resources to household consumption, where forest or wild products form an important part of the household's subsistence food and farm inputs to generate household income. The second role played by forests is as a buffer in periods with low income or low food availability (e.g. as gap filler between crop harvest periods) and during income or assets shocks, e.g. crop failure or loss of a family member.

The Hill agriculture in Uttarakhand is categorized by small and scattered holdings. Lack of irrigation in the traditional agricultural practices resulted in low yield of crops. The agricultural production is not enough to meet even half of the demands of the region. Therefore, people migrate from this area in search of jobs and the remittances received from migrated family members are an important source of their sustenance (Sharma *et al*., 1999). Biswas and Biswas, (1985) reported that rural people are aware of dependency on the goods and services provided by trees. Nonetheless, factors such as increasing pressure of human and cattle

population on the land, illegal and commercial logging for conversion of forest land for various developmental activities have led to large scale destruction of forests.

Products from non-cultivated ecosystems such as natural forests, woodlands, wetlands, lakes, rivers and grasslands can be a significant source of income for rural households, providing energy, food, construction materials and medicines both for subsistence and cash uses. Energy source Forests and trees are usually important sources of energy to rural and even urban households in developing countries. Wood fuel, in the form of either fuel wood or charcoal, is used for heating, cooking, production input (such as brick making) and lighting (especially where electricity is unavailable) (Heltberg, 2004).

As we know by conducting socio-economic surveys, a lot of data are collected about the social, political and economic aspects of a place. This data helps us in visualizing the current scenario and consequences of our decision. In the present study data related to current population, land holding, income sources, employment status, cattle population and other relevant data had been collected to generate the information in study area.

In Kalsi area, four villages viz. Tipau, Chandau, Malhau and Jasau Kharaya were selected for study. There were higher population observed in Jasau Kharaya (280) and Chandau (270) followed by Tipau (262) and Malhau (204) while higher no of families residing in Tipau (30) followed by Jasau Kharaya (27), Malhau (23) and Chandau (22). Higher literacy rate was observed in Chandau (27%) (Figure 5A). The medium sized land holders (5-10 acres) are available in sufficient no in all the villages surveyed viz. Jasau Kharaya (917) as compared to other villages surveyed. There are comparable positions of labourers in every village surveyed. There were approximate equal no of unemployed youth ranging from 100 to 111 observed in these villages (Figure 5B). There were maximum no of goats 314 (69.16%) in Jasau Kharaya followed by 222 (67.27%) in village Tipau, 206 (63.19%) in village Chandau and 144 (69.16%) in village Malhau (Table 4).

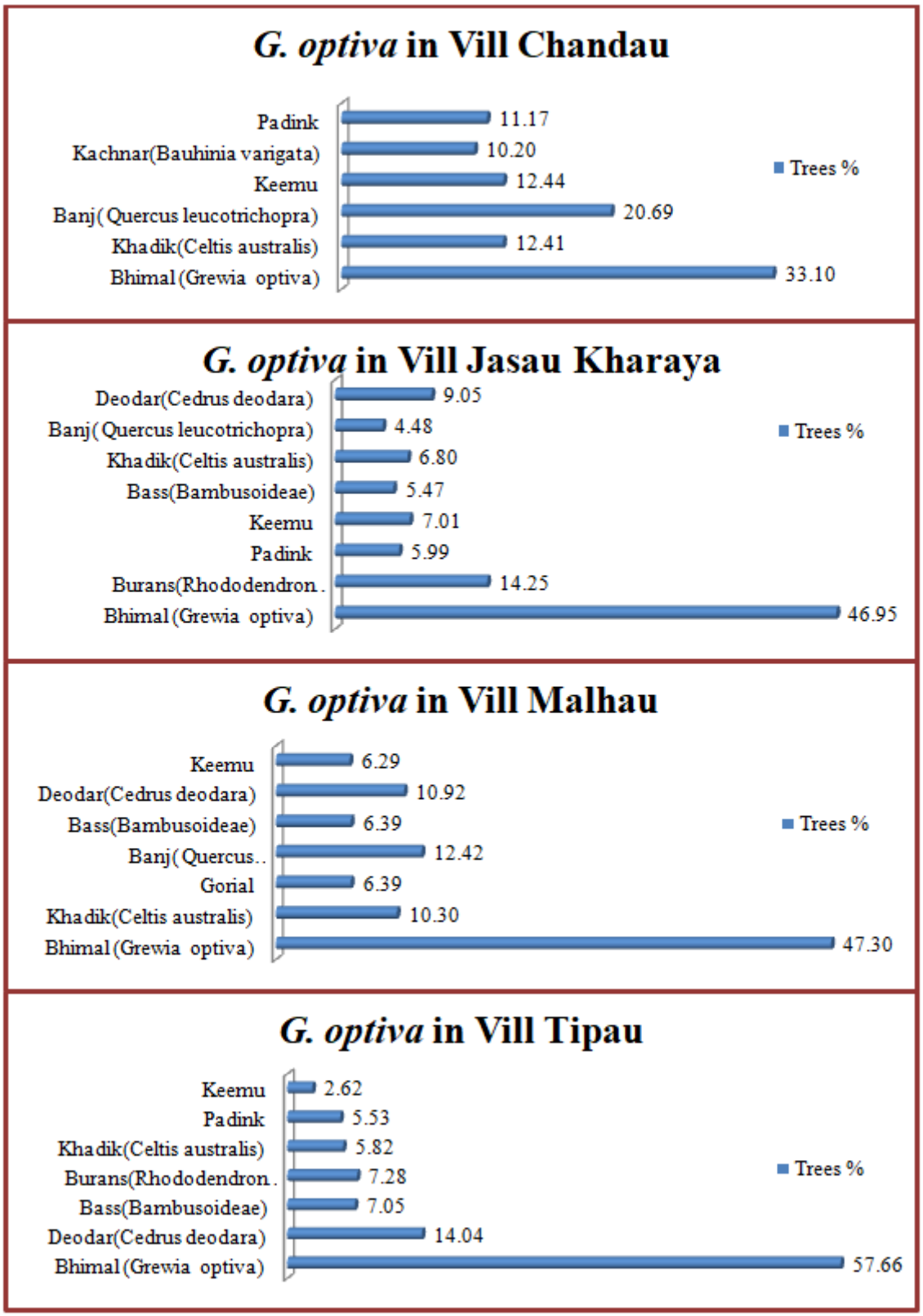

Figure 2. Population of *Grewia optiva* in Kalsi Block, Dehradun

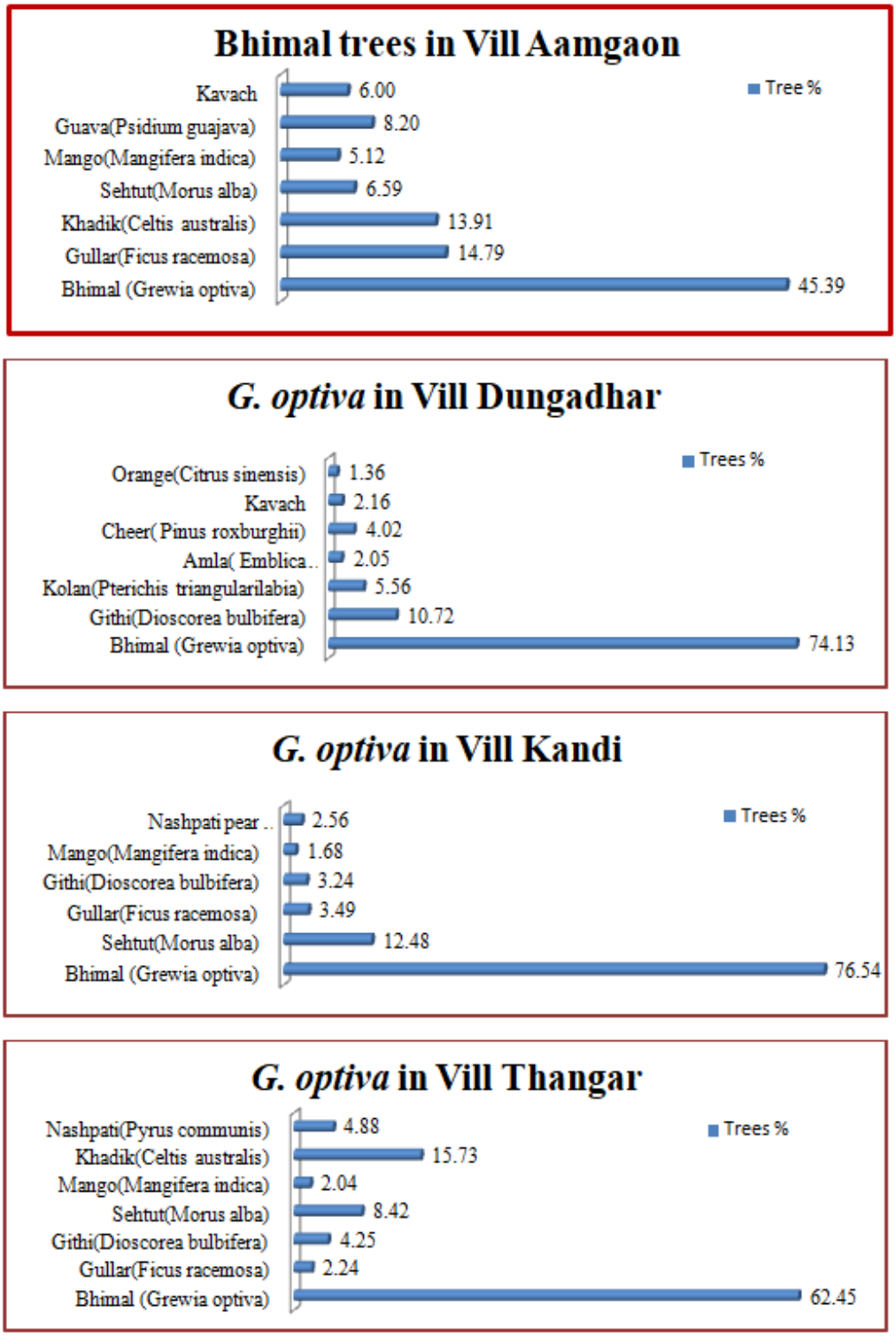

Figure 3. Population of *Grewia optiva* in Yamkeswar Block, Pauri Garhwal

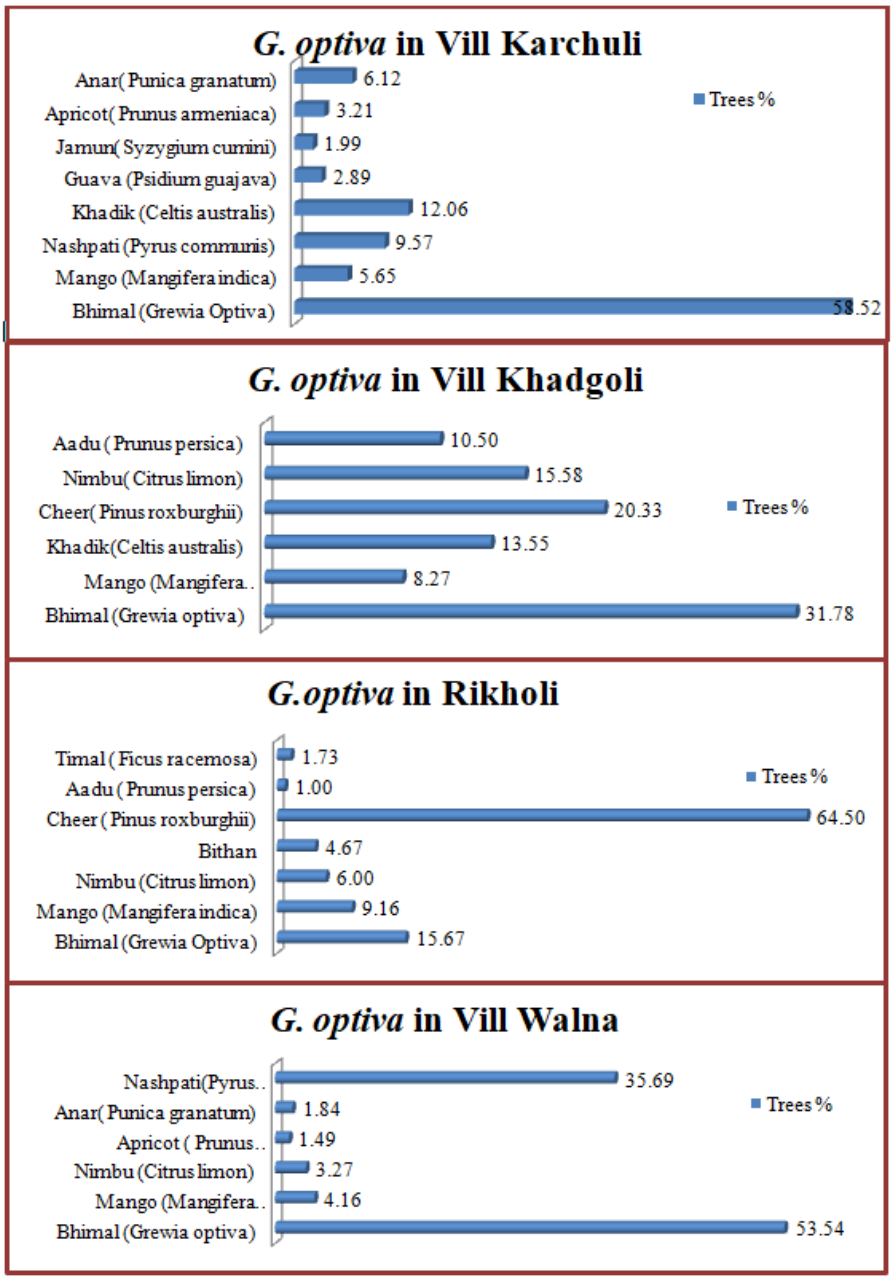

Figure 4. Population of *Grewia optiva* in Ranikhet Block, Almora

In Yamkeswar block, Pauri Garhwal, four villages viz. Amgoan, Dungadhar, Kandi and Thanger were selected for study. There were higher population observed in Dungadhar (700) and Thanger (349) followed by Kandi (340) and Amgoan (154) similarly higher no of families residing in Dungadhar (250) followed by Kandi (78) Thanger (76) and Amgoan (19). While higher literacy rate was observed in Amgoan (26%). The medium sized land holders (5-10 acres) are available in sufficient no in all the villages surveyed viz. Dungadhar (140), Kandi (33), Thanger (30) and Amgoan (2) as compared to big farmers (above 10 acre) and small farmers (0-5 acre) (Figure 6A). There are comparable positions of labourers in every village surveyed) (Figure 6B). There were approximate equal no of unemployed youth as compared to other earning sources adopted ranging from 4 to 70 observed in villages. These results had indicated that availability of adult man power is good enough to manage, harvest the fodder trees species and bhimal fibre extraction in the study area. A similar result was reported by the FAO (2012) in Nepal. There were maximum no of goats 700 (36.84%) in village Dungadhar followed by 300 (67.87%) in village Thanger and in Kandi village (Table 5).

In Ranikhet, Almora area, four villages viz. Walna, Rikholi, Karchuli and Khadgoli were selected for study. There were higher population observed in Karchuli (501) and Khadgoli (357) followed by Walna (329) and Rikholi (194) similarly higher no of family residing in Karchuli (121) followed by Khadgoli (83), Walna (68) and Rikholi (43). Higher literacy rate was also observed in Khadgoli (85.41%) followed by Rikholi (78.66%), Karchuli (76.47%) and Walna (70.93%) (Figure 7A). As per the data collected during the survey, the medium sized land holders (5-10 acres) are available in sufficient no in all the villages surveyed viz Karchuli (50), Khadgoli (30), Walna (28) and Rikholi (22) as compared to big farmers (above 10 acre) and

small farmers (0-5 acre) (Figure 12A). There are comparable positions of labourers in every village survey (Figure 7B). There were maximum no of goats 700 (36.84%) in village karchuli (Table 6).

However, main occupation was found agriculture in all studies area followed by laboring for earning their bread and butter. Observation is in accordance of Mittal *et al.* 2008 stated that more than three-fourths of Uttarakhand's total population depend on agriculture for their livelihood. The most loving livestock was observed goats in every study village. They are also rearing other domestic animals for milking and ploughing purposes like Cows, buffalos and oxen in the area. There was observed electricity, irrigation facility and drinking water facility in every village but rural people are fully not dependant on LPG. They use equally other fuels like cow dung cakes and fuelwood too.

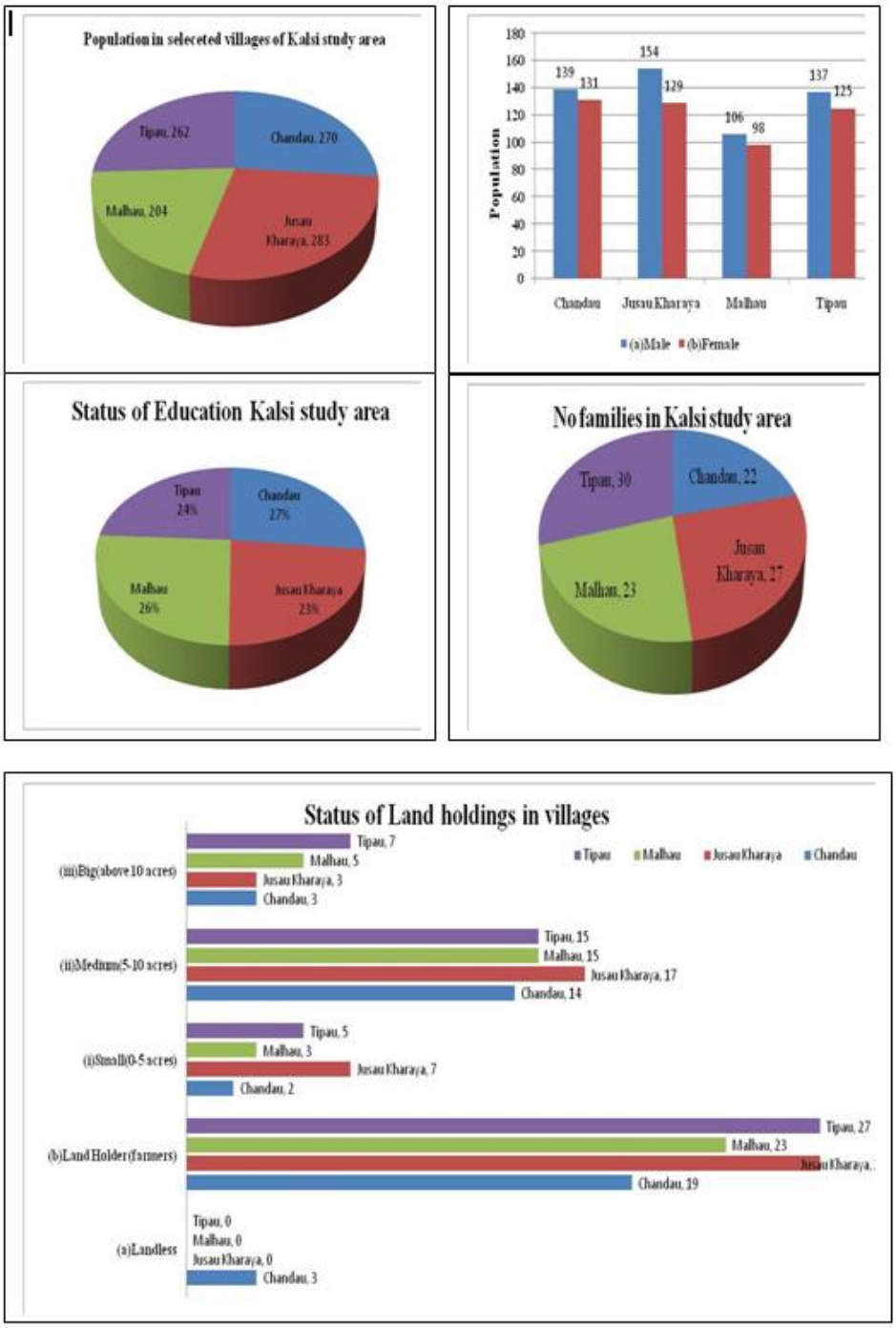

Figure 5A. Socioeconomic status in selected villages of Kalsi study area, Vikasnagar, Dehradun, Uttarakhand

(*Source:*[*https://myroots.euttaranchal.com/village-chandau-dehradun-44875.html*](https://myroots.euttaranchal.com/village-chandau-dehradun-44875.html))

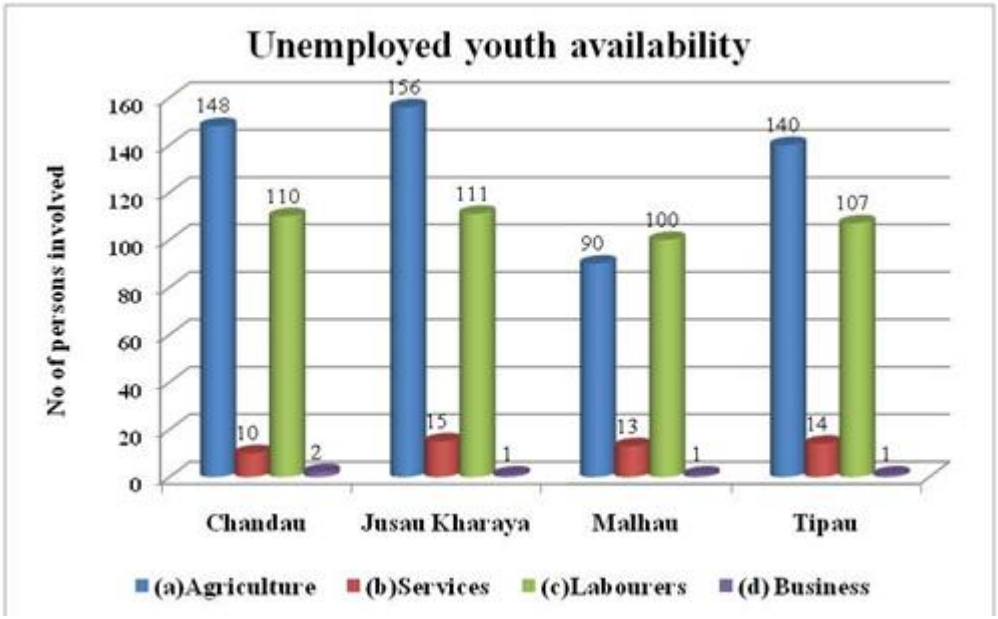

Figure 5B. Socioeconomic status in selected villages of Kalsi study area (*Source:https://myroots.euttaranchal.com/village-chandau-dehradun-44875.html*)

S.No.	Particulars	No of cattle and other facilities available in the selected area			
		Chandau	**Jusau Kharaya**	**Malhau**	**Tipau**
1.	**Live stocks**				
1.1	Buffalo	44 (14.4%)	36 (7.93%)	22 (9.02%)	12 (3.64%)
1.2	Cows	20 (6.53%)	50 (11.01%)	30 (12.30%)	24 (7.27%)
1.3	Oxen	56 (18.3%)	54 (11.89%)	48 (19.67%)	72 (21.82%)
1.4	Goats	206 (63.19%)	314 (69.16%)	144 (59.02%)	222 (67.27%)
2.	**Household fuel consumption**				
2.1	Electricity	100%	100%	100%	100%
2.2	LPG	20%	30%	15%	20%
2.3	Dung cake	60%	60%	30%	40%
2.4	Fuel wood	20%	10%	55%	40%
3.	**Water facilities**				
3.1	Irrigation (tube well-own)	Yes (4 nos.)	Yes (2 nos.)	Yes (10 nos.)	Yes (6 nos.)
3.2	Drinking water-Govt. Agency	Yes	Yes	Yes	Yes

Table 4. Socioeconomic status (Cattle) in selected villages of Kalsi study area

(*Source:https://myroots.euttaranchal.com/village-chandau-dehradun-44875.html*)

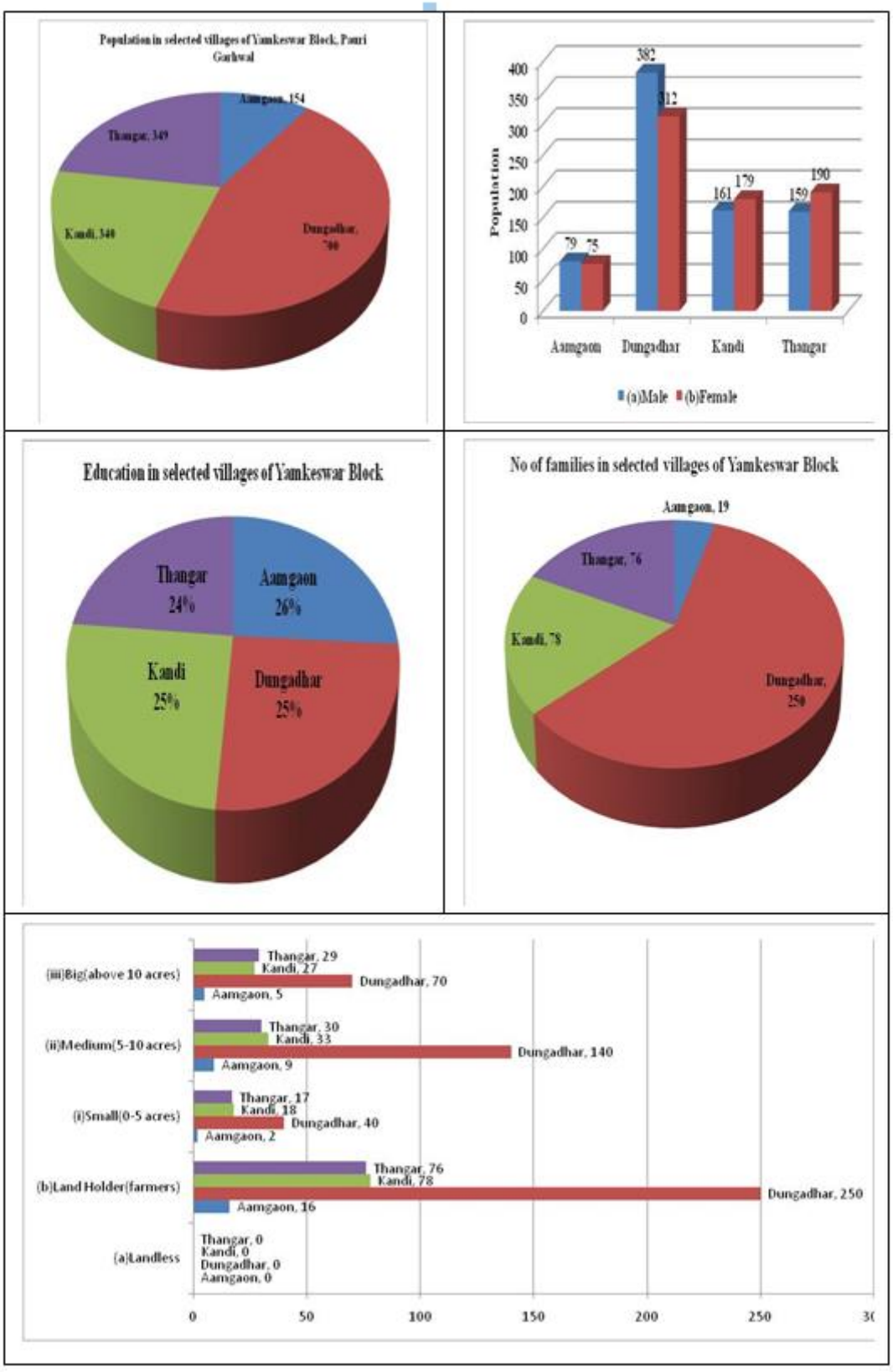

Figure 6A. Socioeconomic status in selected villages of Yamkeswar block, Pauri Garhwal, Uttarakhand

(Source: https://www.census2011.co.in/data/subdistrict/314-yamkeshwar-pauri-garhwal-uttarakhand.html)

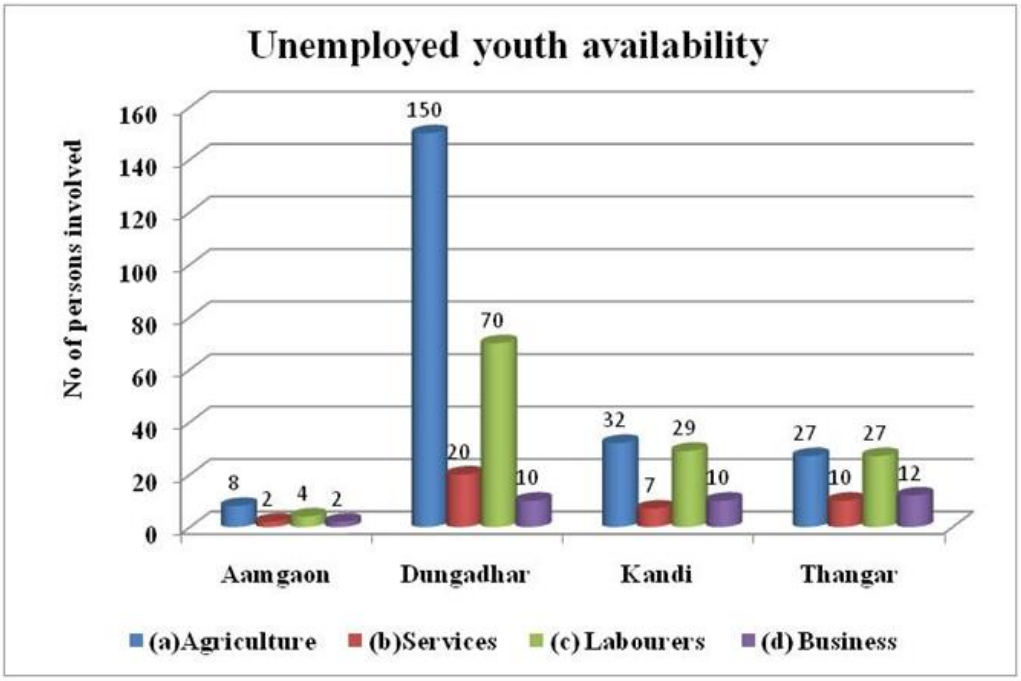

Figure 6B. Socioeconomic status in selected villages of Yamkeswar block, Pauri Garhwal, Uttarakhand

(Source: https://www.census2011.co.in/data/subdistrict/314-yamkeshwar-pauri-garhwal-uttarakhand.html)

S.No.	Particulars	No of cattle and other facilities available in the selected area			
		Aamgaon	**Dungadhar**	**Kandi**	**Thangar**
1.	**Live stocks**				
1.1	Buffalo	17 (18.28%)	300(15.79%)	45 (14.42%)	11 (2.49%)
1.2	Cows	48 (51.6%)	650(34.21%)	195 (62.5%)	102 (23.08%)
1.3	Oxen	8 (8.6%)	250(13.16%)	42 (13.46%)	29 (6.56%)
1.4	Goats	20 (21.56%)	700(36.84%)	30 (9.62%)	300 (67.87%)
2.	**Household fuel consumption**				
2.1	Electricity	100%	100%	100%	100%
2.2	LPG	60%	46%	32%	25%
2.3	Dung cake	10%	17%	20%	15%
2.4	Fuel wood	30%	37%	48%	60%
3.	**Water facilities**				
3.1	Irrigation (tube well-own)	Yes (5 nos.)	Yes (21 nos.)	Yes (12 nos.)	Yes (7 nos.)
3.2	Drinking water-Govt. Agency	Yes	Yes	Yes	Yes

Table 5. Socioeconomic status (Cattle) in selected villages of Yamkeswar block, Pauri Garhwal, Uttarakhand

(Source: https://www.census2011.co.in/data/subdistrict/314-yamkeshwar-pauri-garhwal-uttarakhand.html)

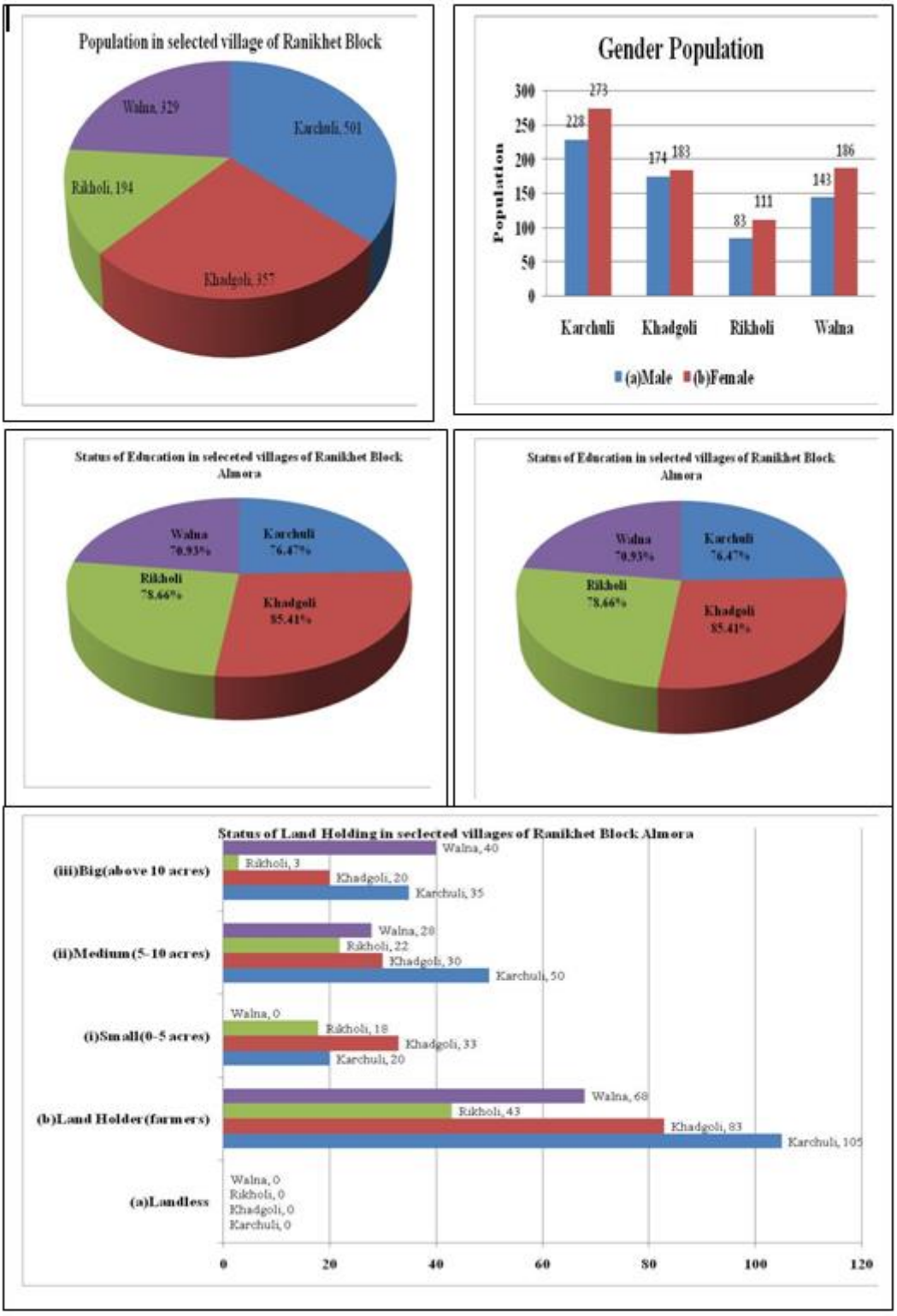

Figure 7A. Socioeconomic status in selected villages of Ranikhet, Almora, Uttarakhand (*https://myroots.euttaranchal.com/village-ranikhet-range-almora-52572.html*)

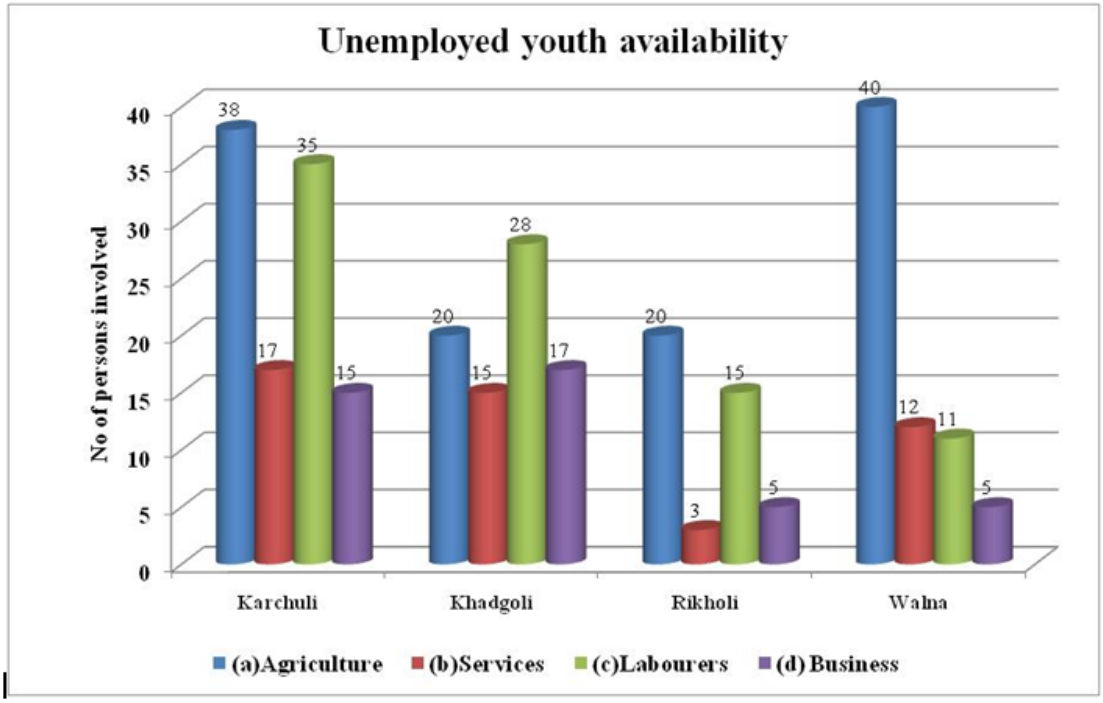

Figure 7B. Socioeconomic status in selected villages of Ranikhet, Almora, Uttarakhand

S.No.	Particulars	No of cattle and other facilities available in the selected area			
		Karchuli	**Khadgoli**	**Rikholi**	**Walna**
1.	**Live stocks**				
1.1	Buffalo	112(22.6%)	28(15.73%)	25(10.64%)	11(3.4%)
1.2	Cows	120(24.19%)	119(66.85%)	42(17.87%)	161(49.69%)
1.3	Oxen	32(6.45%)	11(6.18%)	18(7.66%)	31(9.57%)
1.4	Goats	232(46.77%)	20(11.24%)	150(63.66%)	121(37.35%)
2.	**Household fuel consumption**				
2.1	Electricity	100%	100%	100%	100%
2.2	LPG	60%	61%	67%	57%
2.3	Dung cake	23%	18%	23%	33%
2.4	Fuel wood	17%	21%	10%	10%
3.	**Water facilities**				
3.1	Irrigation (tube well-own)	Yes (25 nos.)	Yes (17 nos.)	Yes (12 nos.)	Yes (27 nos.)
3.2	Drinking water-Govt. Agency	Yes	Yes	Yes	Yes

Table 6. Socioeconomic status (Cattle) in selected villages of Ranikhet, Almora, Uttarakhand

(*https://myroots.euttaranchal.com/village-ranikhet-range-almora-52572.html*)

Fodder and shoots performance

Fodder Yield

Average fodder yield in T_1, T_2, T_3 and T_4 was observed 2.78 Kg, 4.78 Kg, 6.15 Kg and 10.20 Kg respectively in Kalsi, Vikasnagar, Dehradun, Uttarakhand (data not presented) while fodder yield during winter season in T_1, 3.30 to 3.47 Kg, T_2 5 to 5.60Kg, T_3 6.87 to 7.13Kg and in T_4 11.28 to 11.42 Kg, were observed (Figure 8) while in Summer season T_1, 1.97 to 2.23 Kg, T_2 4.10 to 4.37Kg, T_3 5.17 to 5.53Kg and in T_4 8.29 to 9.68 Kg were observed (Figure 9).

On average fodder yield in T_1, T_2, T_3 and T_4 was observed 2.97 Kg, 4.99 Kg, 6.08 Kg and 10.31 Kg respectively in Amgoan, Yamkeswar block, Pauri Garhwal, Uttarakhand (data not presented). Fodder yield during winter season (Figure 10) in T_1, 3.30 to 3.70 Kg, T_2 5.43 to 5.60 Kg, T_3 6.50 to 7.33 Kg and in T_4 10.96 to 11.10 Kg were observed while in summer season T1, 2.23 to 2.53 Kg, T_2 4.30 to 4.77 Kg, T_3 5.13 to 5.30 Kg and in T_4 9.51 to 9.83 Kg (Figure 11) were observed.

On average fodder yield in T_1, T_2, T_3 and T_4 was observed 2.40 Kg, 4.26 Kg, 5.27 Kg and 8.48 Kg respectively in Walna, Ranikhet, Almora, Uttarakhand (data not presented). Fodder yield in T_1, 2.40 to 2.90 Kg, T_2 4.67 to 4.80 Kg, T_3 5.17 to 5.33 Kg and in T_4 8.49 to 8.92 Kg were observed in winter season (Figure 12) while in summer season T_1, 2.07 to 2.27 Kg, T_2 3.70 to 3.87 Kg, T_3 5.07 to 5.57 Kg and in T_4 8.13 to 8.35 Kg were observed (Figure 13).

Fodder yield was observed higher in winter season in all the treatments.

Shoots performance after lopping

On average no of shoots in T_1, T_2, T_3 and T_4 were observed 79.33, 163.60, 257.47 and 306.52 respectively in Kalsi, Vikasnagar, Dehradun, Uttarakhand (data not presented). Shoots performance during winter season average shoots in T_1, 86.67 to 88, T_2 174.33, T_3 261.67 to 271.33 and in T_4 328.10 to 333.90 (Figure 14) were observed while in summer season T_1, 72 to 75.33, T_2 155 to 158.33, T_3 241.67 to 257.67 and in T_4 286.40 to 300.60 were observed. Mean no of shoots in T_1 T_2 T_3 and T_4 were observed 80.40, 166.67, 263.87 and 318.40 respectively. Shoots performance during winter season average shoots in T_1, 88.33 to 93, T_2 180.67 to 182.33, T_3 278.67 to 296 and in T_4 338.10 to 358.90 were observed while in summer season T_1, 70.67 to 75.33, T_2 147 to 164, T_3 241.33 to 256 and in T_4 292.40 to 307.30 (Figure 15) were observed.

Shoots performance in Amgoan, Yamkeswar, Pauri Garhwal**,** Uttarakhand was recorded on average no of shoots in T_1 T_2 T_3 and T_4 were observed 80.40, 166.67, 263.87 and 318.40 respectively (data not presented). Shoots performance during winter season in Amgoan, Yamkeswar, Pauri Garhwal**,** Uttarakhand mentioned in Figure 16. On average shoots in T_1, 88.33 to 93, T_2 180.67 to 182.33, T_3 278.67 to 296 and in T_4 338.10 to 358.90 were observed (data not presented) while in summer season T_1, 70.67 to 75.33, T_2 147 to 164, T_3 241.33 to 256 and in T_4 292.40 to 307.30 were observed (Figure 17). Total No of higher shoots were observed in winter season in all the treatments.

Average number of shoots in T_1 T_2 T_3 and T_4 were observed 73.07, 153.60, 237.47 and 312.28 respectively in Walna, Ranikhet, Almora, Uttarakhand (data not presented). Shoots performance during winter season (Figure 18) in T_1, 80 to 83.67, T_2 169.67 to 170, T_3 259 to 265 and in T_4 336.40 to 350.50 were observed while in summer season T_1, 66 to 68, T_2 138.33 to 144.67, T_3 206 to 231 and in T_4 269.40 to 304.60 were observed (Figure 19).

Total number of higher shoots were observed in winter season in all the treatments but observed higher fodder yield in winter as compared to summer in the experiments. Majority of the tree fodder species were used in summer due to availability of deciduous species. However some tree species are also used in winter, when the availability of fodder was scarce, due to evergreen. In the present study fodder yield was observed more in winter as compared to summer season lopping of trees. Our results are in accordance with Nautiyal *et.al*. 2018 reported that rainy season helps to produce plenty of green grasses and other herbaceous plants which are used as fodder. There are seasonal variations in fodder availability. It was observed that trees are generally lopped in summer and winter seasons. During rainy season, abundant green fodder is available while shrubs are chiefly browsed by goats and sheep. The findings are supported with the study conducted by Samant *et al.* (2007) who listed 150 species of fodder including trees, shrubs and herbs which are used as fodder for livestock in the Indian Himalayan Region. Some of the species are similar with that of our findings.

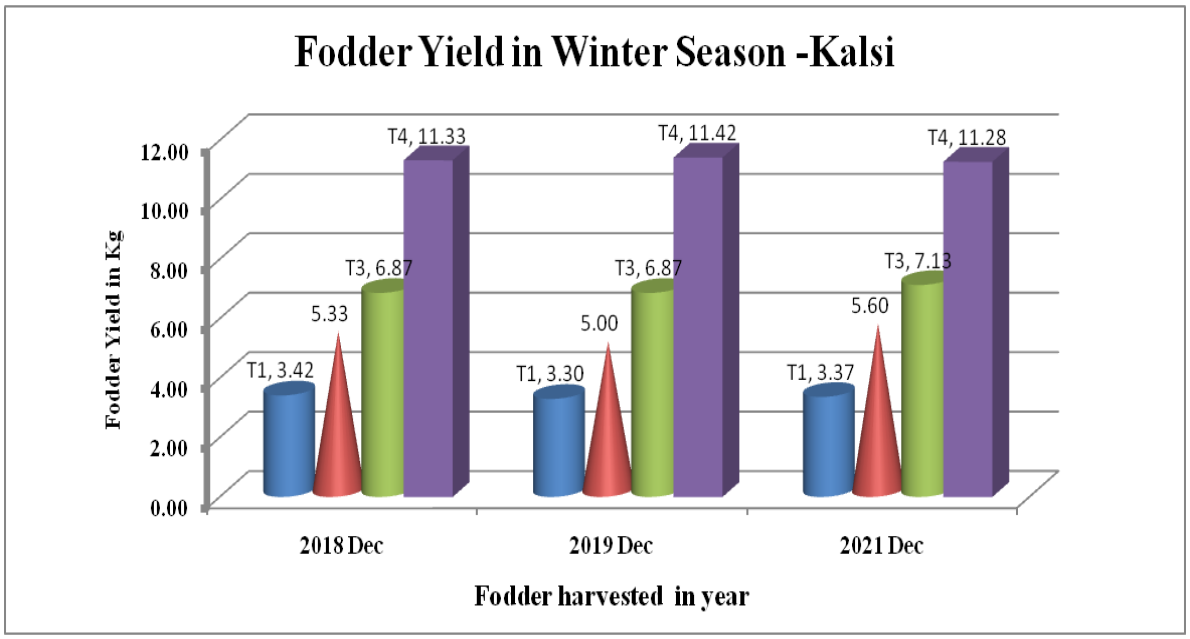

Figure 8. Fodder yield during winter season (Nov- Dec) in Kalsi, Vikasnagar, Dehradun, Uttarakhand

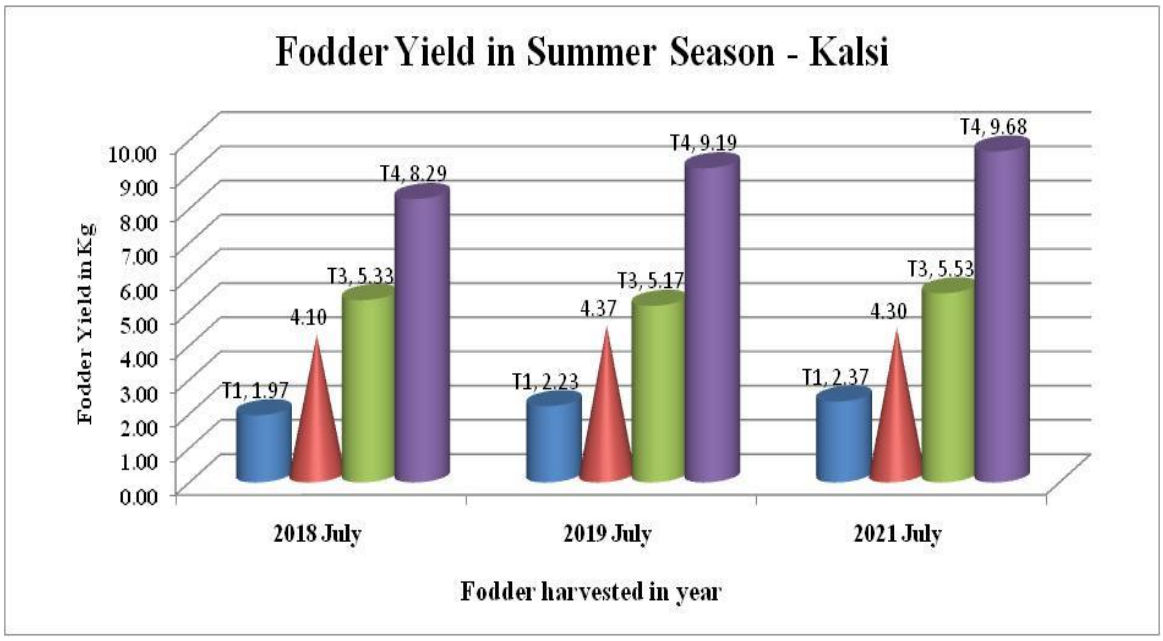

Figure 9. Fodder yield during summer season (Jun- July) in Kalsi, Vikasnagar, Dehradun, Uttarakhand

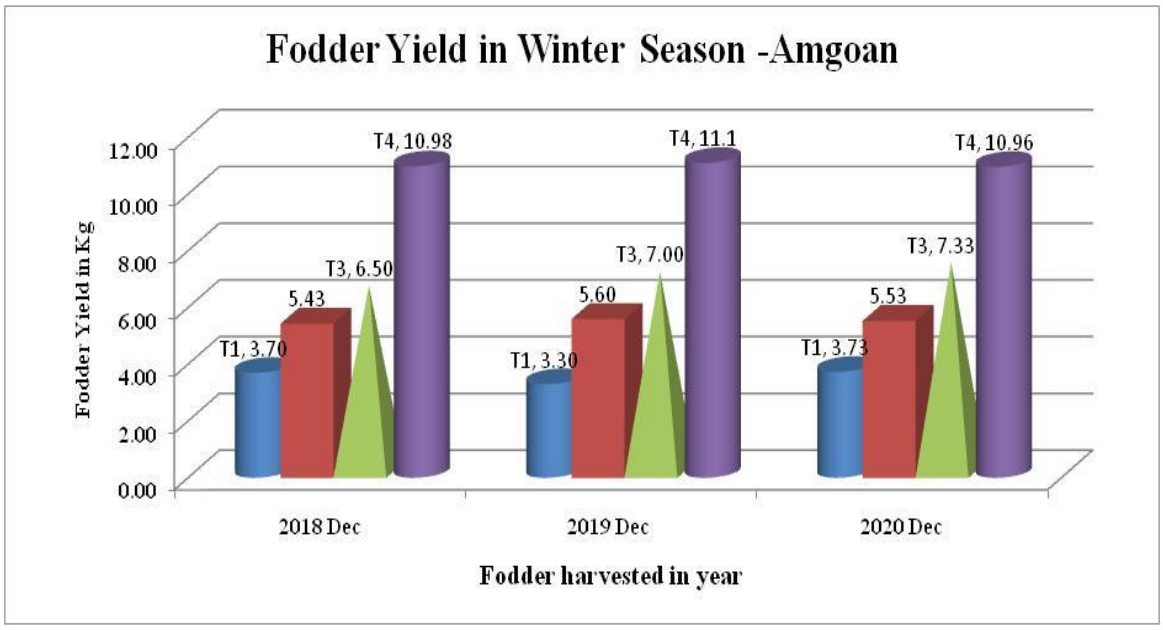

Figure 10. Fodder yield during winter season (Nov- Dec) in Amgoan, Yamkeswar block, Pauri Garhwal, Uttarakhand

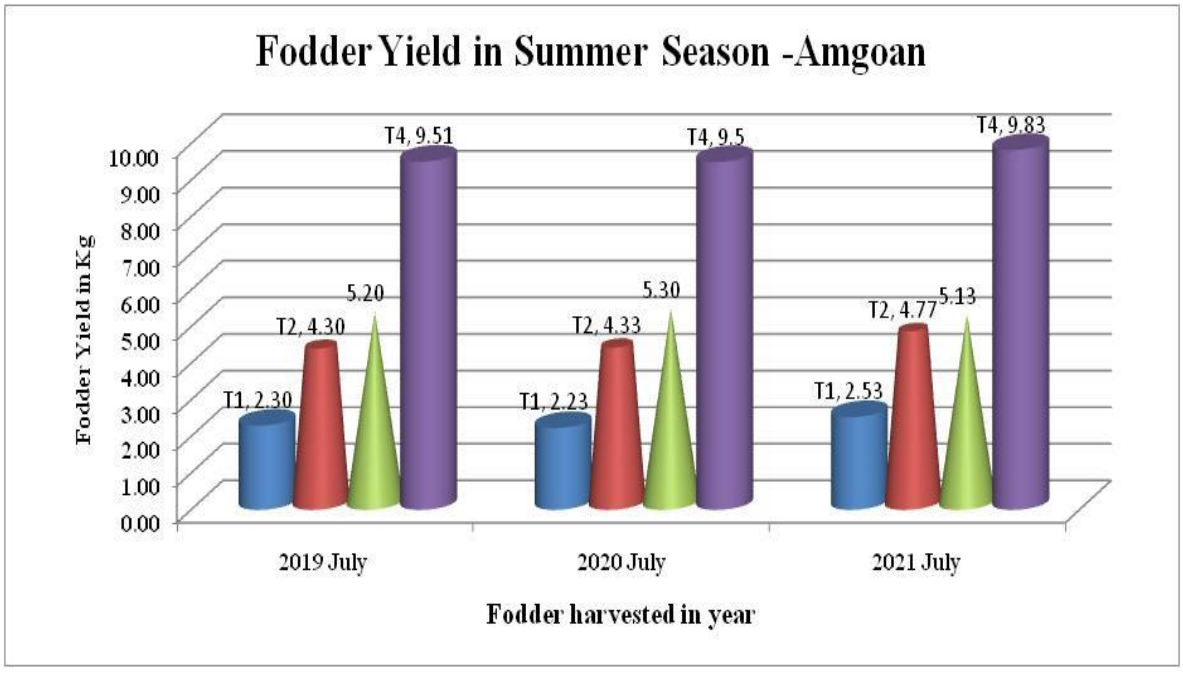

Figure 11. Fodder yield during summer season (Jun- July) in Amgoan, Yamkeswar block, Pauri Garhwal, Uttarakhand

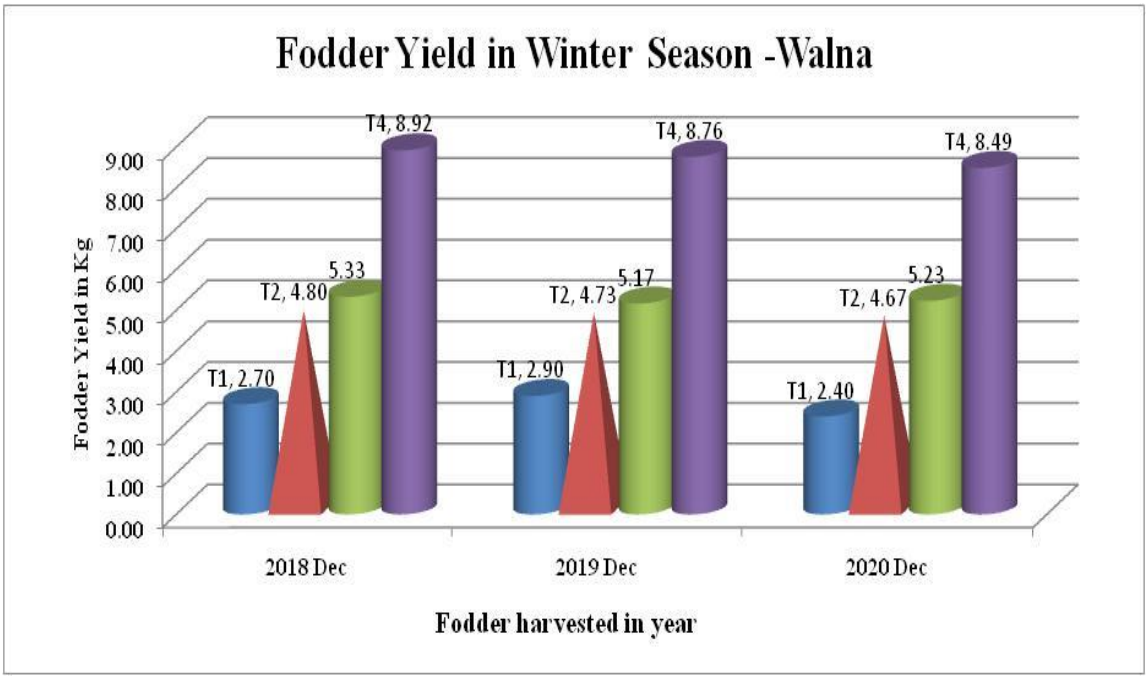

Figure 12. Fodder yield during winter season (Nov- Dec) in Walna, Ranikhet, Almora, Uttarakhand

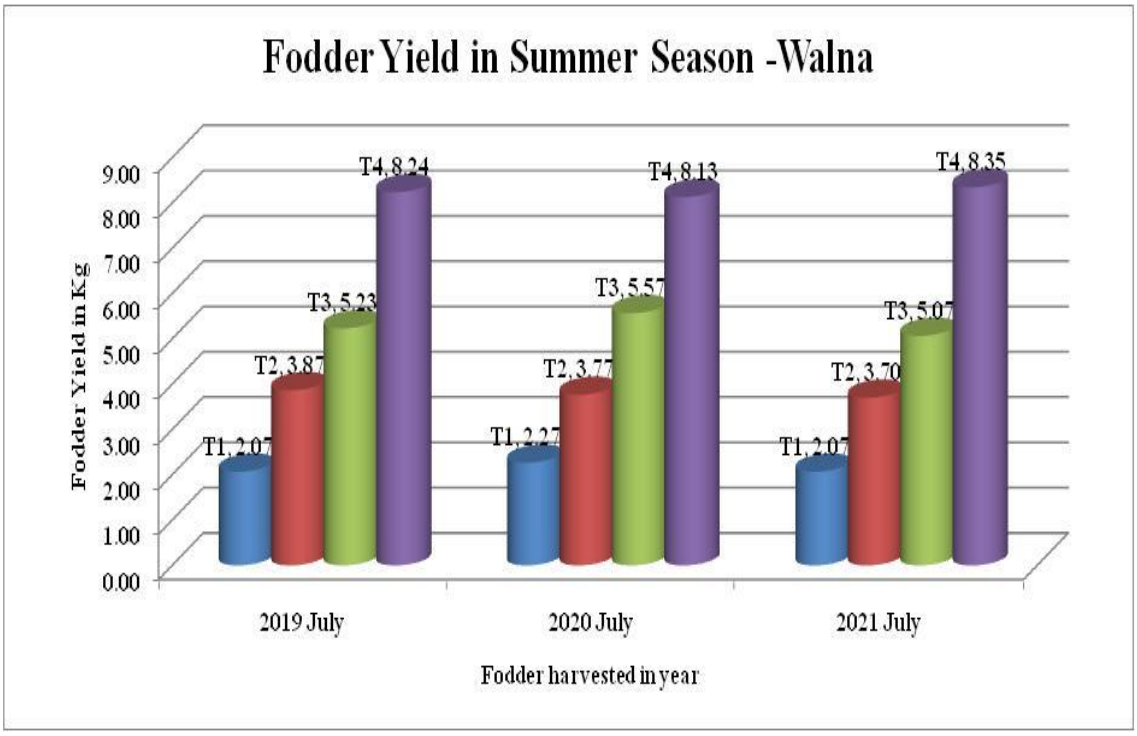

Figure 13. Fodder yield during summer season (Jun- July) in Walna, Ranikhet, Almora, Uttarakhand

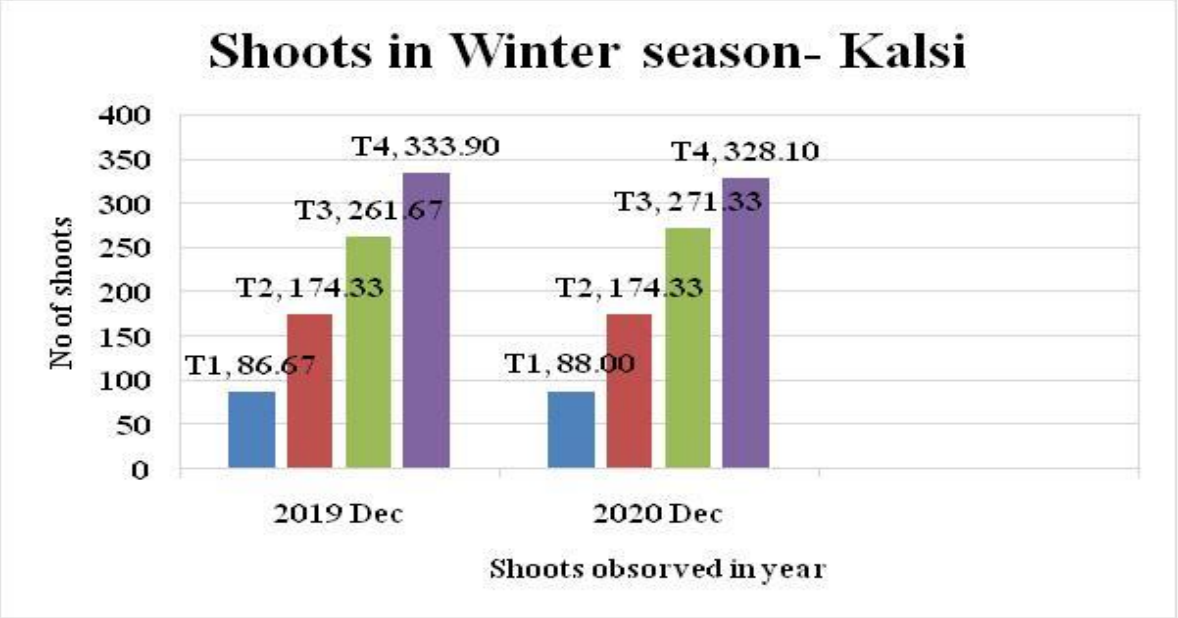

Figure 14. Number of shoots during winter season (Nov- Dec) in Kalsi, Vikasnagar, Dehradun, Uttarakhand

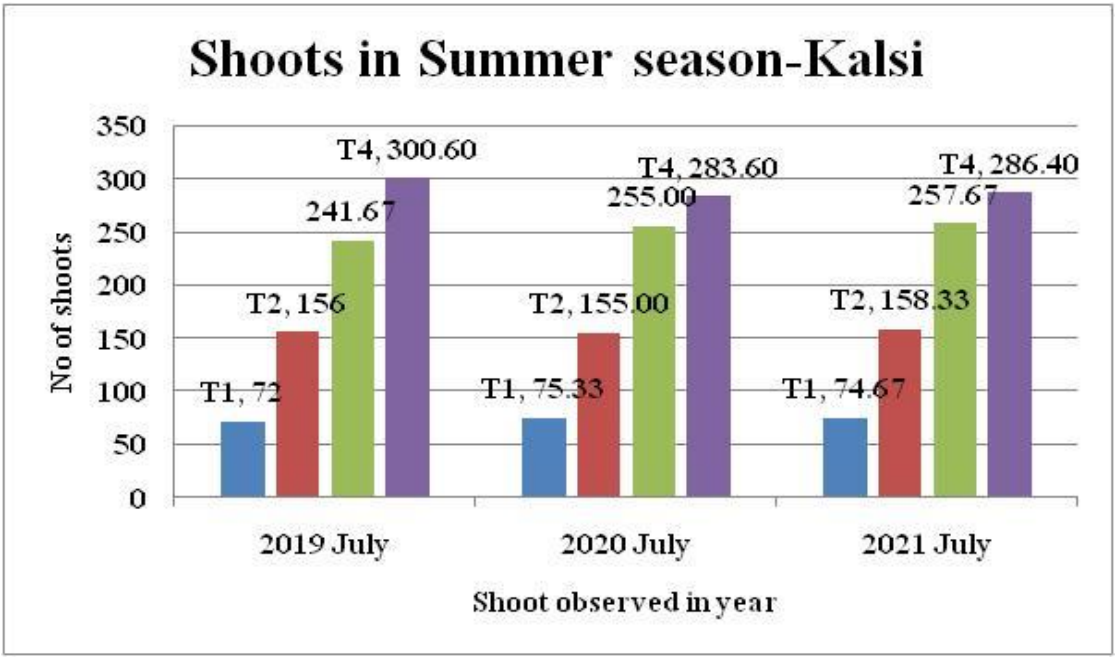

Figure 15. Number of shoots during summer season (June -July) in Kalsi, Vikasnagar, Dehradun, Uttarakhand

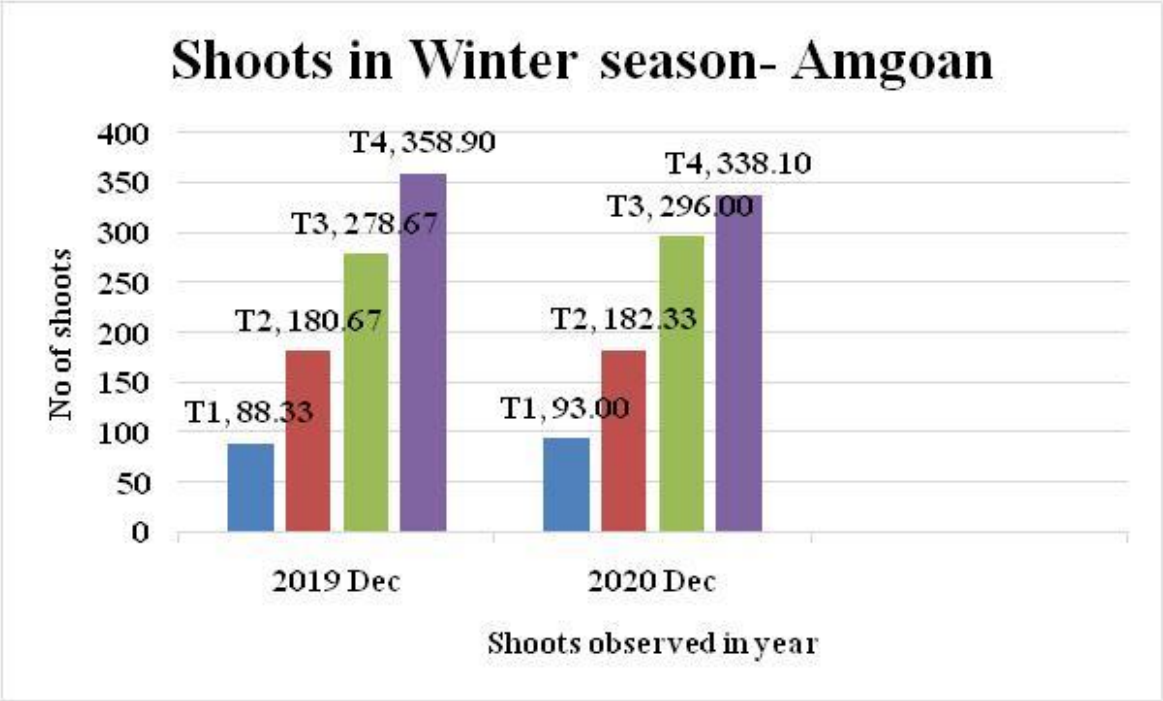

Figure 16. Number of shoots during winter season (Nov- Dec) in Amgoan, Yamkeswar block, Pauri Garhwal, Uttarakhand

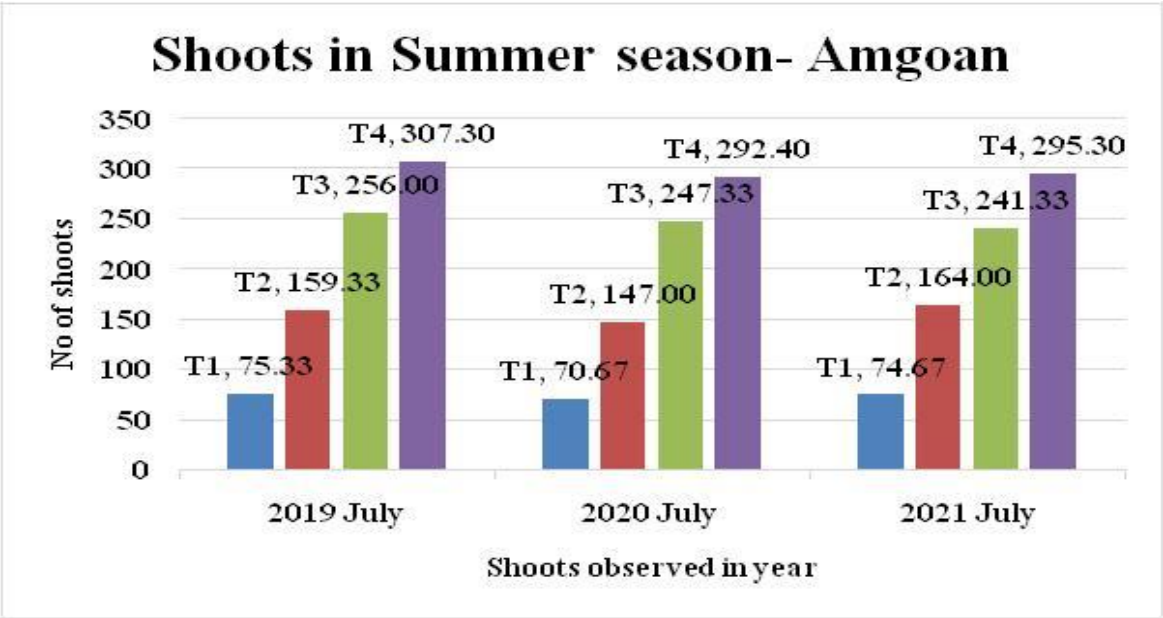

Figure 17. Number of shoots during summer season (June -July) in Amgoan, Yamkeswar block, Pauri Garhwal, Uttarakhand

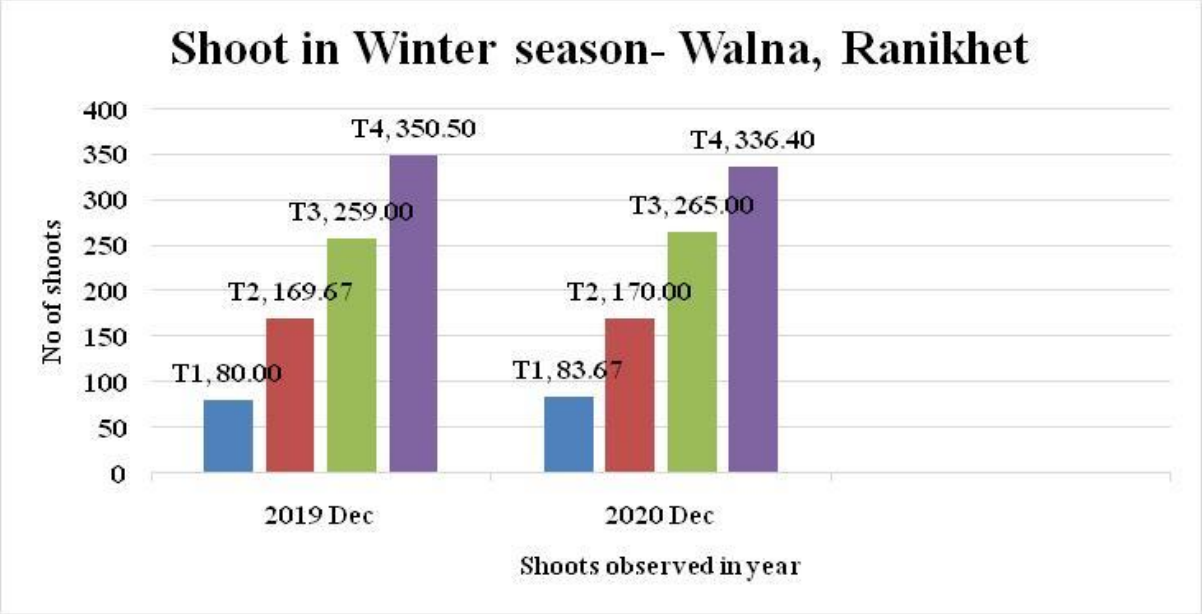

Figure 18. Number of shoots during winter season (Nov- Dec) in Walna, Ranikhet, Almora, Uttarakhand

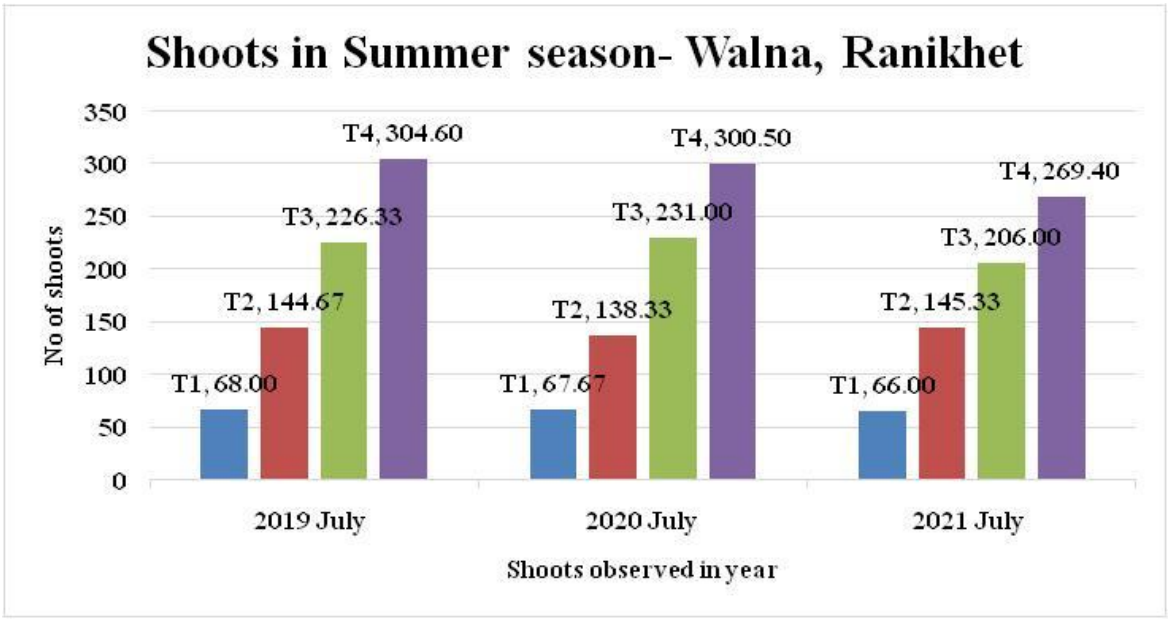

Figure 19. Number of shoots during summer season (June -July) in Walna, Ranikhet, Almora, Uttarakhand

On the basis of results obtained at all the sites experiments from above study it is suggested that 75% of lopping of bhimal tree may be preferred for taking sustainable green fodder and fibre for livelihood improvement. In the present study shows its accordance with Mehta *et al*. (2011).

However, main occupation was found agriculture in all studies area followed by laboring for earning their bread and butter. Observation is in accordance of Mittal *et al.* 2008 stated that more than three-fourths of Uttarakhand total population depend on agriculture for their livelihood. There was observed electricity, irrigation and drinking water facilities in every village but rural people are fully not dependant on LPG. They use equally other fuels like cow dung cakes and fuelwood too.

In every study village, goats emerged as the most beloved and widely kept livestock. In addition to goats, residents also rear other domestic animals for various purposes, including, milking: (cows and buffalos) and ploughing (oxen).The prevalence of these animals highlights the importance of livestock in the local economy and livelihood pattern, serving as a vital source of Nutrition (milk and meat), Labor (ploughing and transportation) and Income (sale of animals and dairy products). There were observed unemployed youth > 100 study area villages. The twigs of *G. optiva* after taking fodder for their domestic animals, fibre may be extracted by using eco-friendly fungal dry retting technology (Kumar and Ali, 2024) and or other method developed by Forest Research Institute, Dehradun, India using Modified Steam Explosion Treatment Machine (MSETM) for livelihood improvement.

Acknowledgment

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