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RESEARCH ARTICLE

GROWTH PERFORMANCE AND FODDER PRODUCTION BY *BAUHINIA VARIEGATA* L. AND *GREWIA OPTIVA* (DRUMM EX BURR.) UNDER RAINFED AGROFRESTRY IN TARAI REGION OF UTTARAKHAND

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ABSTRACT

An experiment on growth performance and fodder production from *B. variegata* and *G. optiva* was conducted at site-I; Dhaluwala majbata and Site-II; Dhaluwala kalan villages located at $77^0$57'7"E longitude and $30^0$2'31"N latitude with an altitude of 295m above mean sea level in plains of district Haridwar of Uttarakhand, a tarai region of the state. The seedlings of *B. variegata* and *G. optiva* were planted by keeping the distance 6mx6m (T1) and 6mx8m (T2) for both plant species at both sites as block plantation. The data recording from 2018 to 2021 was done on growth performance. Under the increment in height and girth of three years old plants of all the three species at site-I, Daluwala majbata, in 6mx6m spacing, *G. optiva* gained the height 150.60cm and girth 11.42cm and *B. variegata* ranked second with height 96.00cm and girth 13.81cm. In spacing of 6mx8m, *B. variegata* gained height of 101.89cm with girth 12.38cm while *G. optiva* gained height 136.69cm and girth 11.50cm in third year. At site-II, in spacing of 6mx6m, *B. variegata* showed height of 480.07cm with girth 21.31cm while *G. optiva* gained height of 431.67cm with girth 15.90cm. Likewise, in spacing of 6mx8m, *G. optiva* gained height of 504.46cm with girth 19.39cm and *B. variegata* showed height of 455.01cm but in girth performance *B. variegata* i.e. 20.57cm was found better than *G. optiva* i.e. 15.72cm. Data on canopy in east-west and north-south directions were also taken from 2018 to 2021. Fodder production was recorded in 4th year of the experiment after its establishment in 2018. The recording of data on fodder production was done by weighing the small green twigs leaves of trees after 50% lopping in the unit of kilograms/ tree and calculated in quintal/ ha. The fodder production in plantation of *B. variegata* with spacing of 6mx6m at site-I and II was 9.38quintal and 15.68quintal/ha respectively. Likewise, in plantation of 6mx8m spacing at site-I and II, the production of fodder in *B. variegata* was recorded as 7.24 quintal and 12.18 quintal/ha respectively. Likewise, the fodder production in plantation of *G. optiva* with spacing of 6mx6m at site-I and II was 8.98quintal and 14.26quintal/ha respectively. In plantation of 6mx8m spacing at site-I and II, the production of fodder in *G. optiva* was recorded respectively as 6.61quintal and 11.97quintal/ha. Overall, it was observed that both species have a potential to grow very well in tarai region of the state Uttarakhand under rainfed agroforestry. The present study reveals data taken on growth and fodder production of *B. variegata* and *G. optiva*.

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INTRODUCTION

It is a well known phenomenon that agroforestry is a system having great potential in land management by integrating trees and shrubs with agricultural crops on farmland and domestication of animals. In agroforestry, trees and shrubs provide various tangible and intangible benefits to farmers. Among these, most common benefits are fuel-wood, timber, fodder, poles, fruits and much more. Enhancement in productivity, soil fertility, nutrient cycling and soil conservation are the major positive effects of agroforestry practice**.** The aim of agroforestry is to enhance overall value of the system, maximize complementarily, decrease or eliminate competition and minimize crop displacement, through appropriate tree management. In Uttarakhand, many tree species are of multi-purpose uses and are directly associated with their livelihood. In hilly and tarai area of the state, multi-purpose trees meet the need of small timber, fuel, fodder and food. In foot and medium hills Bhimal (*G. optiva*) and Kachnar (*B. variegata*) are generally used for fodder for livestock. In tarai region of the state, the commercial agroforestry is mainly of Poplar and Eucalyptus based. Under commercial agroforestry in this region, production of fodder is lacking and farmers are keen to add more tree species to get fodder for their livestock specially, in lean period when fodder is not coming from agricultural crops.

G. optiva locally Known as Bhimal or Beul is found in sub–tropical zone of Western Himalaya. In North-West India, the species is common in the foot-hill and middle-hill regions of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Rather than in a forest area, it shows its existence on boundaries of farmland and river bank (Thakur *et al.* 2004 and 2005). *G. optiva* is a moderate size deciduous tree species, which belongs to the sub-tropical climate having maximum temperature 38^0C and minimum -2^0C, where frost is common during autumn and winter season (Luna 2005). The species is common where annual rainfall varies from 1200 to 2500 mm mainly in the summer season. The tree has a capacity to grow in almost any type of soil but sandy loam with proper moisture is most suitable for its proper growth. The tree can grow and survive under rain-fed conditions. It is a strong light demander and requires complete light for its optimal growth. Its fully mature leaves are a very good fodder for cattle, especially in winter. Bhimal is a wonder tree having many qualities which make it valuable for the local community. Leaves of the tree are very good fodder, the soft bark contains saponin which is used in shampoo and conditioner for hair wash (Luna 2005). The rich fiber of the bark hardens and then drenched bark is used to make strong ropes, Kurna (backpacks) and Kandi (baskets), bags, purses, chappals, mats, wall hangings, etc. The species is one of the most important fodder trees of North-Western and central Himalaya and is found distributed throughout sub-Himalayan tract. Overall, *G. optiva* is an important agroforestry species primarily grown for green fodder, fibre and small timber in the North-West Himalaya.

B. variegata (Kachnar) commonly known as mountain ebony is a small to medium-sized deciduous tree with a short bole and spreading crown, attaining a height of up to 15 m and diameter of 50 cm. In dry forests, the size is much smaller. *B. variegata* grows best in full sun or partial shade at elevations from sea level to 1800m. It occurs naturally in climates with hot, dry summers and mild winters (Orwa *et al.,* 2009). In its natural habitat the absolute maximum shade temperature varies from 37.5 to 47.5°C, the absolute minimum from 0^0C to 17°C with optimum rainfall of 760-1900mm. It avoids dry tracts with rainfall less than 500 mm. The tree can survive in a wide range of soils including well-drained, gravelly, shallow, rocky, sandy loam and loamy soils. One of the main uses of *B. variegata* is to provide fodder and fuel wood having calorific value as 4800 kcal/kg. The bark yields a suitable fibre. The wood is brown and moderately hard and used for agricultural implements. The tree yields a gum. The bark produces tannins, used in various shades of brown. *B. variegata* is a plant of tropical and subtropical climates with hot, dry summers and mild winters. It demands plenty of light and requires good drainage. Severe frost kills the leaves of seedlings and saplings, but they recover during summer. The tree is fairly resistant to drought but susceptible to fires. Leaves make good fodder and are greedily eaten by sheep, goats and cattle. The average annual fodder yield per tree is 15-20 kg of dry matter. The showy fragrant, pink, purple or white flowers make the tree attractive for an ornamental and for avenue plantings (Orwa *et al*., 2009). On an average, single tree of *B. variegata* provides 17kg fuel-wood and 22.0kg green fodder (Gupta, 1993). Thus both *G. optiva* and *B. variegata* are important fodder trees providing palatable fodder to livestock of farmers. Generally, it is observed that in tarai region of Uttarakhand, there is a shortage of green fodder from agricultural crops in three months of summer i.e. from April to June months in the year. Keeping in view the shortage of the green fodder, *G. optiva* and *B. variegata* were introduced on farmland in their new habitat in tarai region of Uttarakhand.

MATERIALSAND METHODS

Survey and site selection: A survey was conducted to find out suitable site for experimentation in relation to establishment Kachnar (*B. variegata*) and Bhimal (*G. optiva*) based agroforestry models in Tarai and Bhabar region of Uttarakhand. During survey people were asked for their daily requirements with special reference to the gap between demand and supply of products for livelihood including food, fodder, fuel and timber. An awareness and motivation programme was also conducted in the village Dhaluwala majbata where farmers of Dhaluwala kalan village also participated in the programme. A scientific know how on agroforestry was given to farmers and they were motivated to adopt agroforestry on their farmlands. After getting motivation from subject experts, farmers agreed to make the land available for experimentation. Hence, sites for experimentation were selected at Dhaluwala majbata and Dhaluwala kalan located at $77^0$57'7"E longitude and $30^0$2'31"N latitude with an altitude of 295m above mean sea level in plains of district Haridwar of Uttarakhand.

Establishment of experimental plots and data recording: After getting sites for experimentation, two plots each of one hectare were made ready at both sites by ploughing and removal of weeds and fenced properly for protection of plants from wildlife and other wandering animals. An experimental design layout for planting the *B. variegata* and *G. optiva* was conducted at the sites. According to design, plantation of 6 months old seedlings of all the three species was done in monsoon season i.e. July – August, 2018 with two treatments of spacing i.e. 6mx6m (T1) and 6mx8m (T2) in Randomized Block Design (RBD) with three replications of every species. An initial height and girth was recorded at the time of planting of the species. Growth on the basis of height and girth initial height and girth was taken and increment was recorded in coming three years i.e. in 2019 and 2021 after monsoon season and averaged to find out the average growth increment in centimeter unit. Measurement of canopy of trees was done in east-west and north-south directions. Management of plantation along with agricultural crops including, weeding, hoeing and pruning was done as per requirement from time to time. To calculate the fodder in fourth year, five trees of *Grewia optiva* and *Bauhinia variegata* were taken for data recording and 50% lopping of each tree was done from all the directions of the tree canopy. After lopping, green tender twigs and leaves of each tree were weighed in kilogram unit and quantity of fodder per ha was calculated in quintal/ ha by following formula:

$$\frac{\text{Weight of fodder from a tree X number of trees in a hectare}}{100}$$

RESULTS

Results on growth performance of *G. optiva* and *B. variegata* are shown in Table-1. Under the increment in height and girth of three years old plants of all the three species at site-I, Daluwala majbata, in 6mx6m spacing, *G. optiva* gained the height 150.60cm and girth 11.42cm and *B. variegata* ranked second with height 96.00cm and girth 13.81cm which was better than *B. variegata*.

Table 1. Growth and Mean Annual Increment in Kachnar and Bhimal in 3 years from 2019 to 2021

Site-I. Daluwala majbata												
Spacing 6mx6m												
Species	Initial growth (2018)		Increment in 1st year (2019)		Increment in 2nd year (2020)		Increment in 3rd year (2021)		Mean Annual Increment (MAI)		MAI (%)	
	Ht	Girth	Ht	Girth	Ht	Girth	Ht	Girth	Ht	Girth	Ht	Girth
B. variegata	63.00	0.63	23.70 (86.70)	02.77 (3.40)	73.70 (136.70)	06.48 (7.11)	096.00 (159.00)	13.81 (14.44)	32.00	04.60	33.33	33.33
G. optiva	66.45	0.91	52.85 (119.30)	00.79 (1.70)	92.85 (159.30)	05.06 (5.97)	150.60 (217.05)	11.42 (12.55)	50.20	03.81	33.33	33.36
Spacing 6mx8m												
B. variegata	62.11	1.06	27.59 (89.70)	01.04 (2.10)	77.59 (139.70)	05.72 (6.78)	101.89 (164.00)	12.38 (13.44)	033.96	04.13	33.33	33.36
G. optiva	57.33	0.83	38.70 (95.70)	00.94 (1.77)	78.37 (135.70)	05.24 (6.07)	136.69 (194.02)	11.50 (12.33)	045.56	03.83	33.33	33.36
Site-II. Daluwala kalan												
Spacing 6mx6m												
Species	Initial growth (2018)		Increment in 1st year (2019)		Increment in 2nd year (2020)		Increment in 3rd year (2021)		Mean Annual Increment (MAI)		MAI (%)	
	Ht	Girth	Ht	Girth	Ht	Girth	Ht	Girth	Ht	Girth	Ht	Girth
B. variegata	56.33	1.13	43.47 (99.80)	03.57 (4.70)	331.45 (387.78)	18.09 (19.22)	480.07 (536.04)	21.31 (22.44)	160.02	07.03	33.33	32.98
G. optiva	65.33	0.88	55.37 (120.70)	02.62 (3.50)	283.56 (348.89)	14.34 (15.22)	431.67 (497.00)	15.90 (16.78)	143.89	05.30	33.33	33.33
Spacing 6mx8m												
B. variegata	62.11	0.99	39.59 (101.70)	01.31 (2.30)	285.6 ((347.78)	17.01 (18.00)	455.01 (518.00)	20.57 (21.56)	151.67	06.86	33.33	33.34
G. optiva	57.55	0.83	38.15 (112.10)	00.94 (2.37)	292.45 (350.00)	15.72 (16.55)	504.46 (562.01)	19.39 (20.22)	168.15	06.46	33.33	33.32

Note: Figures indicated in parenthesis in above table are growth data

Table 2. Canopy measurement of Kachnar and Bhimal from 2018 to 2021 in cm

Spacing 6mX6m									
year		**Site-I. Dhaluwala majbata**				**Site-II. Dhaluwala kalan**			
		B. variegata		***G. optiva***		***B. variegata***		***G. optiva***	
		NxS	**ExW**	**NxS**	**ExW**	**NxS**	**ExW**	**NxS**	**ExW**
2018	Av.	33.2	31.2	32.6	31.1	29.6	31.2	16.2	16.1
	±SD	2.59	0.91	1.82	1.56	3.21	2.56	1.30	1.14
2019	Av.	93.0	80.6	71.6	68.4	95	88.6	74.6	78.2
	±SD	13.96	11.48	20.13	5.77	8.69	9.61	20.37	6.06
2020	Av.	130.60	114.80	104.80	111.90	117.80	110.80	107.60	114.00
	±SD	136.72	115.36	105.76	113.28	119.36	112.96	109.12	114.40
2021	Av.	189.20	190.80	209.60	186.20	186.00	196.00	184.20	201.40
	±SD	8.11	11.88	8.79	6.50	29.45	24.85	8.11	7.16
Spacing 6mX8m									
year		**Site-I. Dhaluwala majbata**				**Site-II. Dhaluwala kalan**			
		B. variegata		***G. optiva***		***B. variegata***		***G. optiva***	
		NxS	**ExW**	**NxS**	**ExW**	**NxS**	**ExW**	**NxS**	**ExW**
2018	Av.	35.00	32.60	34.20	34.80	35.20	35.80	25.80	31.30
	±SD	1.41	0.58	1.47	1.03	3.43	0.51	1.72	4.71
2019	Av.	115.00	122.00	100.80	115.00	112.00	117.00	81.00	83.80
	±SD	8.94	11.66	0.75	4.47	7.48	6.23	14.91	6.14
2020	Av.	134.60	128.40	113.00	119.70	125.40	117.60	115.80	123.60
	±SD	19.54	11.06	2.28	4.24	7.06	7.50	9.02	4.13
2021	Av.	220.00	227.00	223.80	186.20	204.20	212.00	195.00	213.00
	±SD	5.48	3.52	3.43	5.81	26.58	19.13	8.74	4.00

Table 3. Recorded green weight of leaves in 4th year

Fodder production (Kg/tree)					
Name of species	Site-I. Dhaluwala majbata			Site-II. Dhaluwala kalan	
	Spacing			Spacing	
	6mx6m		6mx8m	6mx6m	6mx8m
B. variegata	Average	0.94	0.73	1.56	1.28
	±SD	0.02	0.02	0.01	0.01
B. variegata	Average	0.89	0.66	1.45	1.20
	±SD	0.01	0.02	0.01	0.01

Table 4. Fodder estimation in 4th year 2021 (Quintal/ha)

Fodder production (Qtl/ha)				
Name of species	Site-I. Dhaluwala majbata		Site-II. Dhaluwala kalan	
	Spacing		Spacing	
	6mx6m	6mx8m	6mx6m	6mx8m
B. variegata	9.38	7.24	15.68	12.18
G. optiva	8.98	6.61	14.26	11.97
Calculation of fodder (Trees/ha at spacing 6mx6m = 280 and at spacing of 6mx8m =210**)** **Calculation in quintal/ha =** weight in kg/tree X Number of trees/ha / 100				

In spacing of 6mx8m, *B. variegata* gained height of 101.89cm with girth 12.38cm while *G. optiva* gained height 136.69cm and girth 11.50cm in third year. At site-II, in spacing of 6mx6m, *B. variegata* showed height of 480.07cm with girth 21.31cm while *G. optiva* gained height of 431.67cm with girth 15.90cm. Likewise, in spacing of 6mx8m, *G. optiva* gained height of 504.46cm with girth 19.39cm and *B. variegata* showed height of 455.01cm but in girth performance *B. variegata* i.e. 20.57cm was found better than *G. optiva* i.e. 15.72cm. As well as annual increment concerns at site-I, in the spacing of 6mx6m, the mean annual increment (MAI) in four year duration. *B. variegata*, showed annual increment of 32.00cm and 4.60cm in height and girth respectively while in *G. optiva*, it was 50.20cm in height and 3.81cm in girth. In spacing of 6mx8m at same site, the mean annual increment (MAI) in in *B. variegata* was 33.96cm and 4.13cm in height and girth respectively while in *G. optiva*, it was 45.56cm in height and 3.83cm in girth.

At site-II, in the spacing of 6mx6m, the mean annual increment (MAI) in *B. variegata* was 160.02cm and 7.03cm in height and girth respectively while in *G. optiva*, it was 143.89cm in height and 5.30cm in girth. In spacing of 6mx8m at same site, the mean annual increment (MAI) in *B. variegata* 151.67cm and 6.86cm in height and girth respectively while in *G. optiva*, it was 168.15cm in height and 6.46cm in girth.

Canopy measurement of Kachnar and Bhimal: The canopy measurement data in north-south and east-west directions from initial stage to 3 years old plantation are given in Table-2. In the year 2018 at site-I with 6mx6m spacing, the canopy of *B. variegata* in north-south and east-west directions was 33.2cm and 31.2cm and canopy of *G. optiva* in same directions was 32.6cm and 31.1cm. At site-II with same spacing of plantation, the canopy of of *B. variegata* was 29.6cm and 31.2cm while canopy of *G. optiva* was 16.2cm and 16.1cm. In the year 2019, at site-I with 6mx6m spacing, the canopy of *B. variegata* was 93.0cm and 80.6cm and canopy of *G. optiva* was 71.6cm and 68.4cm. At site-II with same spacing of plantation, the canopy of *B. variegata* was 95.0cm and 88.6cm while canopy of *G. optiva* was 74.6cm and 78.2cm. In the year 2020, at site-I with 6mx6m spacing, the canopy of *B. variegata* was 130.60cm and 114.8cm and canopy of *G. optiva* was 104.8cm and 111.90cm. At site-II with same spacing of plantation, the canopy of *B. variegata* was 117.80cm and 110.8cm while canopy of *G. optiva* was 107.60cm and 114.0cm. In the year 2021, at site-I with 6mx6m spacing, the canopy of the canopy of *B. variegata* was 189.20cm and 190.80cm and canopy of *G. optiva* was 209.60cm and 186.20cm. At site-II with same spacing of plantation, the canopy *B. variegata* was 186.0cm and 196.0cm while canopy of *G. optiva* was 184.20cm and 201.40cm. Similarly, In the year 2018 at site-I with 6mx8m spacing, the canopy of *B. variegata* in north-south and east-west directions was 35.0cm and 32.6cm and canopy of *G. optiva* in same directions was 34.2cm and 34.80cm. At site-II with same spacing of plantation, the canopy of of *B. variegata* was 35.2cm and 35.8cm while canopy of *G. optiva* was 25.8cm and 31.3cm. In the year 2019, at site-I with 6mx8m spacing, the canopy of *B. variegata* was 115.0cm and 122.0cm and canopy of *G. optiva* was 100.8cm and 115.0cm. At site-II with same spacing of plantation, the canopy of *B. variegata* was 112.0cm and 117.0cm while canopy of *G. optiva* was 81.0cm and 83.8cm. In the year 2020, at site-I with 6mx8m spacing, the canopy of *B. variegata* was 134.6cm and 128.4cm and canopy of *G. optiva* was 113.0cm and 119.7cm. At site-II with same spacing of plantation, the canopy of *B. variegata* was 125.4cm and 117.6cm while canopy of *G. optiva* was 115.8cm and 123.6cm. In the year 2021, at site-I with 6mx8m spacing, the canopy of the canopy of *B. variegata* was 220.0cm and 227.0cm and canopy of *G. optiva* was 223.8cm and 186.2cm. At site-II with same spacing of plantation, the canopy *B. variegata* was 204.2cm and 212.0cm while canopy of *G. optiva* was 195.0cm and 213.0cm.

Fodder production from *B. variegata* and *G. optiva*

Recorded green weight of leaves in 4th year (Kg/tree): The trees of *B. variegata* and *G. optiva* were found to provide fodder initially in 4th year. The average weight of leaves in *B. variegata* with spacing of 6mx6m was 0.94kg/tree at site-I and 1.56kg/tree at site-II. The weight of leaves in *B. variegata* was recorded as 0.73Kg and 1.28Kg/tree in plantation of 6mx8m spacing at site-I and II respectively. Likewise, the weight of leaves/tree in *G. optiva* with spacing of 6mx6m at site-I and II was 0.89Kg and 1.45Kg respectively. Similarly, in plantation of 6mx8m spacing at site-I and II the weight of leaves in *G. optiva* was recorded as 0.66Kg and 1.20Kg/tree. The production of fodder was found more at site-II as compare to site-I as the soil of that site was porous and more fertile.

Calculated fodder production in 4th year: The fodder production in plantation of *B. variegata* with spacing of 6mx6m at site-I and II was 9.38quintal and 15.68quintal/ha respectively. Likewise, in plantation of 6mx8m spacing at site-I and II, the production of fodder in *B. variegata* was recorded as 7.24 quintal and 12.18 quintal/ha respectively. Likewise, the fodder production in plantation of *G. optiva* with spacing of 6mx6m at site-I and II was 8.98quintal and 14.26quintal/ha respectively. In plantation of 6mx8m spacing at site-I and II, the production of fodder in *G. optiva* was recorded respectively as 6.61quintal and 11.97quintal/ha (Table-4). The production of fodder was also found more at site-II as compare to the site-I as trees were healthy due to the soil more porous, fertile and free from pebbles and gravels.

DISCUSSION

It is well known that the fodder and fuel based farm forestry is very common in hilly tract in Uttarakhand but in lower hills and tarai region of the state, farmers are under adoption of commercial farm forestry with plantation of Poplar and Eucalyptus. Fodder yielding trees are rarely seen on farmland of the farmers of the tarai region. Farmers harvest their Rabi crops in the month of April and May and there is no fodder production from agricultural crops from April to June month and during that period there is a dire need of fodder trees on farmland to fulfillment of green fodder for livestock. In this direction, Bhimal (*G. optiva*) is a wonder tree having many qualities which make it valuable for the local people. Leaves of the tree are very good fodder. The soft bark of *G. optiva* contains saponin which is used in shampoo and conditioner for hair wash (Luna, 2005). The bark of the tree is also used as good fiber in making ropes and other fiber based items. Bhimal based feeding packages for goat have been suitable, sustainable and beneficial to farmers of mid and far Western Hill region of Nepal (Pandey *et al.,* 2017).

The species is one of the important fodder trees of the North-Western and central Himalaya and is found distributed throughout sub-Himalayan tract. Besides, providing fodder, the tree also gives small timber for making wooden artifacts and fuel for local community. As multipurpose tree species for farmland, *G. optiva* is considered by many researchers as one of the most important fodder tree species in Uttarakhand (Toky *et al*, 1989, Tewari *et al*., 2007). It is a general trend that farmers with small land holdings plant or retain a larger number of trees than those of larger land holdings. The trees are lopped during lean period of winter and summer when there is no other fodder or grass available. Although, very low systematic studies have been conducted regarding the economic value of the produce obtained from *G. optiva* as the produce is generally used domestically at local level. *G. optiva* has its potential to survive under rainfed conditions and hence a suitable species of dry regions of Uttarakhand including its tarai area. Under traditional farm forestry, the species is known as boon for the region by several workers (Nautiyal *et al*., 1998; Bhatt and Pathak, 2003; Bijalwan and Dobriyal, 2014).

Information on multipurpose uses of *G. optiva* with its biological and ecological characteristics was given by Joshi and Narayan (1992). According to the study, this species can be grown with both crops as well as grasses. The study showed that *G. optiva* grows better with gorda grass (*Chrysopogon fulvus*). Considering its benefits, Prasad and Arya (1997) mentioned *G. optiva* and crops as an example of traditional agroforestry in Himalyan zone of India. Mehta *et al.* (2022) in a study concluded that growth parameters of *G. optiva* viz., collar diameter, diameter at breast height and productivity traits viz., fresh fodder weight and dry fodder weight showed direct positive correlation with each other. The study conducted by them revealed that these early generation traits can be used for early generation selection of genotypes for higher fodder and fuel wood productivity. The study also informed that based on correlation analysis, diameter at breast height, collar diameter and fodder dry weight can be used as selection criteria for breeding programs of high fodder yielding clones in *G. optiva*. Furthermore, presence of genetic variability in a species is an utmost requirement for the improvement of economically important traits. Crossing between genotypes may provide good chance for obtaining transgressive segregates in the segregating generations and may end up in some promising genotypes of the species. Overall, *G. optiva* is an important agroforestry species primarily grown for green fodder, fiber and small timber in North-West Himalaya.

Likewise, *B. variegata* is popular tree of farmers localized in sub-Himalayan tract for its fodder and fiber (Luna, 2005). The tree has a potential to grow in a variety of soils under irrigated and rainfed conditions with a supply of good growth. Alongwith other tree species, *Bauhina* is a suitable species under agri-silivi-pastoral agroforestry system in sub-tropical and sub-temperate region of lower Himalayan tract and fulfills the demand of fodder (Patnayak, 2019). Traditionally, *B. variegata* is also popular for small timber, fuel, fodder and medicinal importance and gained a focus of tree grower under agroforestry.

CONCLUSION

G. optiva and *B. variegata* are good fodder yielding trees and categorized under multipurpose trees in Uttarakhand. These are found naturally on farm boundaries in hilly tract in Sub-Tropical and Sub-Temperate zone of the state. Both tree species showed a remarkable growth performance under rainfed conditions and also started to produce fodder in tarai region of Uttarakhand after completion of three years from their initial age. Hence, these species may be promising to fulfill the demand of fodder in lean period from April to June when green fodder is not available from agricultural crops in the said area.

REFERENCES

Bhatt, R. K. and Pathak, P. S. 2003. Upscalling quality fodder production in semi arid tropics by *Grewia optiva, ICAR News*, 9 (1): January to March, 2003.

Bijalwan, A. and Dobriyal, M. J. R. 2014. Productivity of wheat (*Triticum aestivum*) as intercrop in *Grewia optiva* based traditional agroforestry system along altitudinal gradient and aspect in midl hills of Garhwal Himalaya, India, *American Journal of Environmental Protection*, 2 (5): 89 – 94.

Gupta, R. K. 1993. *Multipurpose trees Agroforestry and Wasteland utilization*, Oxford &IBH Publication company: 1-580.

Joshi, P. and Narayan, P. 1992. Bhimal: A multipurpose tree for agroforestry, *Indian Farming*, 41(12):14 – 15.

Luna, R. K. 2005. *Plantation tree,* International Book Distributors, Publisher and distributer, 9/3 Rajpur Road, Dehradun-248001: 1 – 975.

Mehta, H.; Kumar, P.; Rathore, A. C.; Kaushal, R. and Gupta, A. K. 2022. Evaluation of *Grewia Optiva* Clones for Fodder Yield under North Western Himalayas Conditions, *Journal of Sustainable Forestry*, 42(4): 441–452. https://doi.org/10.1080/10549811.2022.2045502

Nautiyal, S.; Maikhuri, R. K.; Semwal, R.L.; Rao, K. S. and Saxena K. G. 1998. Agroforestry systems in rural landscape: A case study in Garhwal Himalaya, India". *Agroforestry Systems*, 41(2): 151-165.

Orwa, C.; Mutua, A.; Kindt, R.; Jamnadass, R. and Simons A. 2009. *Agroforestree Database*: a tree reference and selection guide verson 4.0., World Agroforestry Centre, Kenya. (https://www.worldagroforestry. org/output/ agroforestree-database)

Pandey, L. N.; Tewary, M.R.; Vishnu, B. K. C.; Baskota, N. and Banjade, J,N, 2017. Feeding response of tree fodder Bhimal (*Grewia optiva*) on growth performance of castrated male goats, *Journal of Nepal Agricultural research Council* Vol. 3:01-05, May 2017. ISSN 2392-4535 (Print), 2392-454:3 (Online) DOI: http://dx.doi.org/10.3126/jnarcv3i1:1.17268

Patnayak, A; Bisht, J. K.; Yadav, R. P. and Pandey, B. 2019. Fodder Tree based Agroforestry Systems in Hills of Uttarakhand, Chapter in Book: *Agroforestry for Climate Resilience and Rural Livelihood*, Scientific Publishers: 65 – 81.

Prasad, R. N. and Arya, S. L. 1997. Indigenous technical knowledge of soil and water conservation in India - Indigenous technical knowledge for land management in Asia, (IBSRAM). Paper presented in assembly of the management of soil erosion Consortium, Nan, Thailand: 28 Jan – 2 Feb 1997.

Tewari, S.; Kaushal, R. and Purohit, R. 2007. Agroforestry in Uttaranchal", [In: *AGROFORESTRY SYSTEMS AND PRACTICES*, edited by Prof. Sunil Puri and Dr. Pankaj Panwar], New India Publishing Agency, Pitam Pura, New Delhi-110088: 1- 643.

Thakur, N. S.; Gupta, N. K. and Gupta, B. 2004. Phytosociological analysis of woody and non woody-components under some agroforestry systems in Western Hymalaya – a case study", *Indian Journal of Agroforestry*, 6(1): 65-71.

Thakur, N.S.; Gupta, N. K. and Gupta, B. 2005. An appraisal of biological diversity in agroforestry systems in North-Western Himalaya", *Indian Journal of Ecology*, 32(1):7-12.

Toky, O. P.; Kumar, P. and Khosla, P. K.1989. Structure and function of traditional agroforestry systems in the Western Himalaya. II. Nutrient cycling *Agrofrestry Systems*, 9(10):71 - 89.

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