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## Growth and yield of mustard under Gamhar (*Gmelina arborea*) based Agrisilvicultural system

**Abhay Kumar, MS Malik, PR Oraon, Rakesh Kumar, Sheela Barla, Swati Shabnam, SS Das and Kerobim Lakra**

### Abstract

A field experiment on mustard in *rabi* season of 2016-2017 and 2017-2018 was carried out at experimental site near Faculty of Forestry in main campus of Birsa Agricultural University, Ranchi, Jharkhand, India. The experimental plots were laid out in randomized block design, sole farming and Gamhar based Agrisilvicultural system. Growth and yield attributes of like plant population, number of leaves, plant height, root length, numbers of root hairs, crop growth rate, days to 50% flowering, days to 80% siliqua maturity, number of primary branches, number of siliqua per plant, siliqua length, number of seeds per siliqua, weight of seeds per siliqua and test weight were found higher in sole farming than when intercropped with Gamhar in *rabi* season of 2016-17, 2017-18 and in pooled data. The yield characters of mustard, such as grain yield, straw yield, biological yield and harvest index in Sole Cowpea-Mustard was 5.52, 8.48 and 7.16 percent, 2.44, 4.53 and 3.53 percent, 3.29, 5.71 and 4.56 percent and 2.24, 3.21 and 2.73 percent higher than Gamhar+Cowpea-Mustard in 2016-17, 2017-18 and in pooled data respectively, while in Sole Greengram-Mustard, it was 5.24, 10.24 and 7.83 percent, 1.19, 9.04 and 5.18 percent, 2.38, 9.42 and 5.99 percent, and 2.45, 1.20 and 1.80 percent higher than Gamhar+Greengram-Mustard in 2016-17, 2017-18 and in pooled data respectively.

**Keywords:** Gamhar, mustard, Intercropping, agroforestry system

### 1. Introduction

Agroforestry is a land use system, which integrates trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. Agroforestry not only provides environmental services, but also economic gains, as about 65 percent of the country's timber requirement is met from the trees grown outside forests [16]. At present agroforestry meets almost half of the demand of fuel wood, two third of small timber, 70-80% plywood, 60% paper and 9-11% green fodder requirement of livestock, besides meeting the subsistence needs of households for food, fruit, fibre, medicine, timber etc. [8]. Agroforestry can also reduce risks by having appropriate trees (species, age, diversity, management) at strategic locations at hillslope and landscape scale [17].

*Gmelina arborea*, commonly known as Gamhar, is fast growing deciduous tree, light demander, tolerate excessive drought, tolerant to temperatures between 18-35 °C, precipitation of up to 2286 mm (easy adaptation) and the multiple uses of its wood, it is highly appreciated in forest markets, which has encouraged its introduction in much of the world [14, 6]. The species Gamhar (*Gmelina arborea*) in current scenario is in great demand and is good alternative of teak. Among the MPTs, Gamhar offers many possibilities in supplementing a part of N-requirement of the associated crops through enrichment of the site, providing fuel wood, small timber to cater basic needs of rural people for their sustenance in dry areas [9]. Research work carried out in India and abroad reveals that Gamhar tree could be a promising tree species in the agroforestry system particularly in red and lateritic tract of Jharkhand.

Mustard is the main *rabi* crop of semi-arid tract of the Central India which are susceptible to the implications of climate change scenarios. Development of a feasible agroforestry system taking this crop would be more profitable to the farmer. Towards this direction, it is essential to know the limitations of the crops as it would be posed in agroforestry system mainly due to heterogeneity of incident light.

### 2. Materials and Methods

A two year field experiment was conducted during *kharif* and *rabi* season of 2016-17 and 2017-18 at experimental site near Faculty of Forestry in main campus of Birsa Agricultural

University, Ranchi, Jharkhand, India. Birsa Agricultural University is located between 23°26'54.6" N to 23°26'55.0" N Latitude and 85°18'53.0" E to 85°18'53.7" E longitudes and at an altitude of 625 meters above mean sea level, in the southern part of the Chota Nagpur plateau in India. It is the eastern section of the Deccan plateau and comes under Central and North-Eastern Plateau (Sub Zone-IV), a part of agro-climatic (Zone VII) of the country known as Eastern Plateau and Hill Region.

The whole field was laid out as per plan to show the four different crops (arhar, cowpea, greengram and mustard) under gamhar based agrisilvicultural system and sole farming systems. The experiment design adopted was randomized block design (RBD) with seven treatments and three replications. They were: T<sub>1</sub>: Gamhar+ Arhar, T<sub>2</sub>: Gamhar+ Cowpea-Mustard, T<sub>3</sub>: Gamhar+ Greengram-Mustard, T<sub>4</sub>: Sole Gamhar, T<sub>5</sub>: Sole Arhar, T<sub>6</sub>: Sole Cowpea-Mustard, T<sub>7</sub>: Sole Greengram-Mustard. Plot size was 24m x 7.5m and the spacing of gamhar was 8m X 2.5m. Gamhar seedlings were transplanted in the experimental field on June, 2016 and intercropping conducted during *kharif* and *rabi* season of 2016-2017 and 2017-2018.

**3. Results**

Data on plant population per m<sup>2</sup> recorded at 15 days after sowing (DAS) and number of leaves per plant at 30 and 60 days after sowing of mustard is presented in Table 1.

Plant population of mustard in Sole Cowpea-Mustard was 16.00, 9.10 and 12.26 percent higher than Gamhar+Cowpea-Mustard while in Sole Greengram-Mustard was 10.98, 7.52 and 9.12 percent higher than Gamhar+Greengram-Mustard in 2016-17, 2017-18 and in pooled data respectively.

Number of leaves of mustard in Sole Cowpea-Mustard was 5.42, 6.13 and 5.79 percent, and 11.07, 4.34 and 7.45 percent higher than Gamhar+Cowpea-Mustard at 30 DAS and 60 DAS respectively, while in Sole Greengram-Mustard, it was 4.63, 5.41 and 5.03 percent higher than Gamhar+Greengram-Mustard at 30 DAS and 12.12, 11.81 and 12.07 percent higher at 60 DAS, in 2016-17, 2017-18 and in pooled data

respectively.

Plant height of mustard in Sole Cowpea-Mustard was 27.38, 34.05 and 30.76 percent higher than Gamhar+Cowpea-Mustard at 30 DAS, 31.43, 27.46 and 29.40 percent higher at 60 DAS, and 9.72, 10.90 and 10.31 percent higher at harvest, while in Sole Greengram-Mustard, it was 2.90, 4.70 and 3.80 percent higher than in Gamhar+Greengram-Mustard at 30 DAS, 18.34, 16.74 and 17.53 percent higher at 60 DAS, and 8.92, 10.02 and 9.48 percent higher at harvest, in 2016-17, 2017-18 and in pooled data respectively, showed in Table 2.

Root length of mustard in Sole Cowpea-Mustard was 24.24, 24.81 and 24.44 percent, 42.84, 42.52 and 42.68 percent, and 17.55, 17.90 and 17.72 percent higher than Gamhar+Cowpea-Mustard at 30 DAS, 60 DAS and at harvest respectively, while in Sole Greengram-Mustard, it was 35.69, 31.87 and 20.29 percent higher than Gamhar+Greengram-Mustard at 30 DAS, 20.29, 18.93 and 19.61 percent higher at 60 DAS, and 28.39, 24.23 and 26.23 percent higher at harvest, in 2016-17, 2017-18 and in pooled data respectively (Table 3).

Number of root hairs of mustard in Sole Cowpea-Mustard was 34.30, 23.64 and 28.54 percent, 33.90, 25.72 and 29.69 percent, and 23.77, 33.66 and 28.67 percent higher than Gamhar+Cowpea-Mustard at 30 DAS, 60 DAS and at harvest respectively, while in Sole Greengram-Mustard, it was 25.67, 21.26 and 23.40 percent higher than Gamhar+Greengram-Mustard at 30 DAS, 15.26, 15.44 and 15.39 percent higher at 60 DAS, and 27.89, 37.19 and 32.45 percent higher at harvest, in 2016-17, 2017-18 and in pooled data respectively (Table 4).

Crop growth rate of mustard in Sole Cowpea-Mustard was 9.97, 6.57 and 8.31 percent, and 22.68, 13.36 and 17.19 percent higher than Gamhar+Cowpea-Mustard between 30 to 60 DAS and between 60 DAS to harvest respectively, while in Sole Greengram-Mustard, it was 1.48, 2.44 and 1.80 percent higher than Gamhar+Greengram-Mustard between 30 DAS to 60 DAS, and 20.00, 19.58 and 20.00 percent higher between 60 DAS to at harvest, in 2016-17, 2017-18 and in pooled data respectively (Table 5).

**Table 1:** Plant population and number of leaves of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	Plant population (m <sup>2</sup> )			No. of Leaves					
				30 DAS			60 DAS		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	25.00	29.33	27.17	5.53	5.87	5.70	8.40	10.13	9.26
Gamhar +Greengram-Mustard	27.33	31.00	29.17	5.83	6.10	5.97	8.50	9.57	9.03
*Sole Gamhar	-	-	-	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-	-	-	-
Sole Cowpea- Mustard	29.00	32.00	30.50	5.83	6.23	6.03	9.33	10.57	9.95
Sole Greengram-Mustard	30.33	33.33	31.83	6.10	6.43	6.27	9.53	10.70	10.12
S.Em±	1.75	1.34	1.10	0.32	0.23	0.19	0.44	0.65	0.39
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	10.86	7.37	9.10	9.61	6.54	8.14	8.62	11.10	10.13

**Table 2:** Plant height of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	Plant height (cm)								
	30 DAS			60 DAS			At Harvest		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	12.27	12.63	12.45	63.53	66.87	65.20	92.17	94.20	93.19
Gamhar +Greengram-Mustard	16.23	16.40	16.32	72.73	74.87	73.80	93.77	96.77	95.27
*Sole Gamhar	-	-	-	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-	-	-	-
Sole Cowpea- Mustard	15.63	16.93	16.28	83.50	85.23	84.37	101.13	104.47	102.80

Sole Greengram-Mustard	16.70	17.17	16.94	86.07	87.40	86.74	102.13	106.47	104.30
S.Em±	0.81	0.91	0.60	2.34	2.80	1.82	2.57	2.15	1.67
CD (p=0.05)	2.79	3.15	1.87	8.10	9.68	5.61	NS	7.45	5.16
CV (%)	9.18	10.00	9.62	5.30	6.16	5.76	4.58	3.71	4.15

**Table 3:** Root length of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	Root length (cm)								
	30 DAS			60 DAS			At Harvest		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	6.60	6.73	6.67	8.87	9.03	8.95	14.42	14.69	14.56
Gamhar +Greengram – Mustard	7.20	7.53	7.37	11.53	11.83	11.68	16.13	16.80	16.47
*Sole Gamhar	-	-	-	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-	-	-	-
Sole Cowpea- Mustard	8.20	8.40	8.30	12.67	12.87	12.77	16.95	17.32	17.14
Sole Greengram-Mustard	9.77	9.93	9.85	13.87	14.07	13.97	20.71	20.87	20.79
S.Em±	0.29	0.25	0.19	0.61	0.54	0.40	0.48	0.60	0.38
CD (p=0.05)	0.99	0.86	0.58	2.11	1.89	1.26	1.67	2.07	1.18
CV (%)	6.26	5.26	5.77	9.02	7.90	8.47	4.90	5.95	5.46

**Table 4:** Number of root hairs of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	Number of root hairs plant <sup>-1</sup>								
	30 DAS			60 DAS			At Harvest		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	9.33	10.70	10.02	10.53	11.43	10.98	13.63	13.37	13.50
Gamhar +Greengram – Mustard	10.90	11.57	11.24	13.30	13.60	13.45	14.70	13.90	14.30
*Sole Gamhar	-	-	-	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-	-	-	-
Sole Cowpea- Mustard	12.53	13.23	12.88	14.10	14.37	14.24	16.87	17.87	17.37
Sole Greengram-Mustard	13.70	14.03	13.87	15.33	15.70	15.52	18.80	19.07	18.94
S.Em±	0.26	0.64	0.34	0.36	0.60	0.35	0.36	0.32	0.24
CD (p=0.05)	0.92	2.22	1.06	1.26	2.07	1.07	1.25	1.11	0.74
CV (%)	3.95	8.96	7.08	4.73	7.52	6.33	3.92	3.47	3.70

**Table 5:** Crop growth rate (CGR) of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	Crop growth rate (CGR)					
	CGR gm <sup>2</sup> day <sup>-1</sup> (30-60 DAS)			CGR gm <sup>2</sup> day <sup>-1</sup> (60 DAS-Harvesting)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	3.71	3.50	3.61	1.94	2.47	2.21
Gamhar +Greengram – Mustard	4.06	3.69	3.88	2.00	2.40	2.20
*Sole Gamhar	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-
Sole Cowpea- Mustard	4.08	3.73	3.91	2.38	2.80	2.59
Sole Greengram-Mustard	4.12	3.78	3.95	2.40	2.87	2.64
S.Em±	0.14	0.14	0.10	0.25	0.22	0.16
CD (p=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	6.26	6.65	6.45	19.56	14.35	16.74

Data on crop days to 50% flowering and 80% siliqua maturity of mustard is presented in Table 6. Days to 50% flowering was significantly affected by different treatments, while days to 80% siliqua maturity was not found to be statistically significant. Results revealed that days to 50% flowering and 80% siliqua maturity of mustard was recorded higher in gamhar based agrisilviculture system than in sole cropping in *rabi* season of 2016-17, 2017-18 and in pooled data. Number of primary branches per plant at harvest and number

of siliquas per plant of mustard in Sole Cowpea-Mustard was 13.94, 6.07 and 10.00 percent and 1.97, 6.34 and 4.21 percent higher than Gamhar+Cowpea-Mustard in 2016-17, 2017-18 and in pooled data respectively, while in Sole Greengram-Mustard, it was 29.70, 18.75 and 24.04 percent and 6.71, 6.17 and 6.43 percent higher than Gamhar+Greengram-Mustard in 2016-17, 2017-18 and in pooled data respectively, showed in Table 7.

**Table 6:** Days to 50% flowering and 80% siliqua maturity of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	Days to 50% flowering			Days to 80% siliqua maturity		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	50.67	51.67	51.17	96.00	96.67	96.34

Gamhar +Greengram – Mustard	54.67	55.00	54.84	97.33	97.67	97.50
*Sole Gamhar	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-
Sole Cowpea- Mustard	50.33	51.00	50.67	95.33	95.67	95.50
Sole Greengram-Mustard	51.00	51.33	51.17	95.00	95.33	95.17
S.Em±	0.84	0.52	0.49	0.79	0.86	0.58
CD (p=0.05)	2.92	1.79	1.52	NS	NS	NS
CV (%)	5.83	6.72	6.33	11.42	8.56	7.49

**Table 7:** Number of primary branches and siliquas per plant of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	No. of primary branches plant <sup>-1</sup> at harvest			No. of siliquas plant <sup>-1</sup>		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	2.87	3.13	3.00	367.90	388.30	378.10
Gamhar +Greengram – Mustard	3.03	3.20	3.12	389.80	423.20	406.50
*Sole Gamhar	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-
Sole Cowpea- Mustard	3.27	3.32	3.30	375.13	412.93	394.03
Sole Greengram-Mustard	3.93	3.80	3.87	415.97	449.30	432.64
S.Em±	0.09	0.20	0.10	28.13	24.04	18.50
CD (p=0.05)	0.33	NS	0.33	NS	NS	NS
CV (%)	5.01	10.08	8.02	12.58	9.95	11.25

Yield attribute data on length of siliqua (cm), number of seeds per siliqua and test weight (g) of mustard is presented in Table 8. The treatments significantly affected length of siliqua and test weight. The results revealed that length of siliqua, number of seeds per siliqua and test weight were more in sole cropping than when intercropped with gamhar in *rabi* season of 2016-17, 2017-18 and in pooled data. Length of siliqua, number of seeds per siliqua and test weight of mustard in Sole

Cowpea-Mustard was 13.25, 21.46 and 17.51 percent, 6.70, 8.11 and 7.43 percent, and 3.60, 1.65 and 2.61 percent higher than Gamhar+Cowpea-Mustard in 2016-17, 2017-18 and in pooled data respectively, while in Sole Greengram-Mustard, it was 12.35, 14.20 and 13.29 percent, 16.17, 5.15, 10.03 percent, and 1.41, 1.63 and 1.40 percent higher than Gamhar+Greengram-Mustard in 2016-17, 2017-18 and in pooled data respectively.

**Table 8:** Length of siliqua, number of seeds per siliqua and test weight of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	Yield attributes								
	Length of siliqua (cm)			Number of seeds siliqua <sup>-1</sup>			Test weight (g)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	4.68	4.80	4.74	10.00	12.33	11.17	4.17	4.25	4.21
Gamhar +Greengram – Mustard	4.94	5.14	5.04	10.33	13.00	11.67	4.27	4.30	4.29
*Sole Gamhar	-	-	-	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-	-	-	-
Sole Cowpea- Mustard	5.30	5.83	5.57	10.67	13.33	12.00	4.32	4.32	4.32
Sole Greengram-Mustard	5.55	5.87	5.71	12.00	13.67	12.84	4.33	4.37	4.35
S.Em±	0.18	0.19	0.13	1.05	1.28	0.83	0.02	0.01	0.01
CD (p=0.05)	0.63	0.65	0.40	NS	NS	NS	0.06	0.03	0.03
CV (%)	6.12	6.06	6.09	16.91	17.15	17.13	7.79	5.32	6.58

Yield data on grain yield (kg ha<sup>-1</sup>), straw yield (kg ha<sup>-1</sup>), biological yield (kg ha<sup>-1</sup>) and harvest index (%) of mustard is presented in Table 9. The treatments significantly affected straw yield and biological yield in pooled data only. The results revealed that grain yield, straw yield, biological yield and harvest index were more in sole cropping than when intercropped with gamhar in *rabi* season of 2016-17, 2017-18 and in pooled data.

Grain yield, straw yield, biological yield and harvest index of

mustard in Sole Cowpea-Mustard was 5.52, 8.48 and 7.16 percent, 2.44, 4.53 and 3.53 percent, 3.29, 5.71 and 4.56 percent and 2.24, 3.21 and 2.73 percent higher than Gamhar+Cowpea-Mustard in 2016-17, 2017-18 and in pooled data respectively, while in Sole Greengram-Mustard, it was 5.24, 10.24 and 7.83 percent, 1.19, 9.04 and 5.18 percent, 2.38, 9.42 and 5.99 percent, and 2.45, 1.20 and 1.80 percent higher than Gamhar+Greengram-Mustard in 2016-17, 2017-18 and in pooled data respectively.

**Table 9:** Grain, straw, biological yield and harvest index (HI) of mustard under sole farming and gamhar based agrisilviculture system in *rabi* season.

Treatments	Yield											
	Grain yield (kg ha <sup>-1</sup> )			Straw yield (kg ha <sup>-1</sup> )			Biological yield (kg ha <sup>-1</sup> )			HI (%)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
*Gamhar+ Arhar	-	-	-	-	-	-	-	-	-	-	-	-
Gamhar + Cowpea- Mustard	616	696	656	1478	1635	1557	2095	2331	2213	29.41	29.95	29.68



Gamhar +Greengram – Mustard	630	723	677	1516	1570	1543	2146	2293	2220	29.42	31.71	30.57
*Sole Gamhar	-	-	-	-	-	-	-	-	-	-	-	-
*Sole Arhar	-	-	-	-	-	-	-	-	-	-	-	-
Sole Cowpea- Mustard	650	755	703	1514	1709	1612	2164	2464	2314	30.07	30.91	30.49
Sole Greengram-Mustard	663	797	730	1534	1712	1623	2197	2509	2353	30.14	32.09	31.12
S.Em±	17	41	22	47	57	37	44	58	36	1.04	1.57	0.94
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	112.94	NS	NS	NS
CV (%)	4.75	9.70	7.99	6.26	5.75	5.78	19.56	4.91	3.95	5.48	7.23	7.57

#### 4. Discussion

The results presented in above section, the plant population, plant height as well as number of leaves of mustard under sole farming system was higher than gamhar based agrisilviculture system. Pervin *et al.* (2015) [15] reported that the plant height of mustard in association with Kalokoroi tree, gradually decreased toward the tree base which may be due to competition for nutrient and water between the root system of mustard and Kalokoroi tree. Root length and root hairs were affected by gamhar trees at all the growth stages of mustard and among different treatments, longer root length was observed under sole farming system. Thus there was reduction in root length in agrisilviculture system as compared to sole farming system. Bibyan *et al.* (2020) [3] reported that the root length, stem diameter, root weight and number of plants per m<sup>2</sup> of Indian mustard increased significantly at 4 meters away from the Khejri tree. Crop growth rate (CGR) was affected by gamhar trees at all the growth stages of mustard, and maximum CGR was observed under sole farming system as compared to gamhar based agrisilviculture system. Mirjha (2016) [12] reported that the Mango+Cowpea-Mustard cropping system exhibited significantly higher CGR between different growth duration over rest of cropping systems. Similarly results also found that by Mohsin *et al.* (2021) [13] reported that in mustard primary branches per plant and seeds per siliqua were at par under Eucalyptus, Poplar, and sole cropping.

Yield attribute *viz.* length of siliqua, number of seeds per siliqua and test weight of mustard was affected by gamhar trees at all the growth stages of mustard, and the maximum was observed under sole farming system as compared to gamhar based agrisilviculture system. This may be attributed to cumulative effect of partial shade and competition for moisture and different nutrients between the root system of mustard and gamhar tree. Similar results were reported by a number of other researchers (Basak *et al.*, 2011; Farhana *et al.*, 2013; Kundu *et al.*, 2014; Divya *et al.*, 2018; Bibyan *et al.*, 2020) [2, 7, 11, 5, 3].

Yield of mustard like grain yield, straw yield, biological yield and harvest index affected by gamhar tree and maximum was observed under sole farming system as compared to gamhar based agrisilviculture system. This may be attributed to cumulative effect of partial shade and competition for moisture and nutrients between the mustard and gamhar tree. Similar results were found by a number of other researchers (Kumar and Nandal, 2004; Dhara and Sharma, 2015; Pervin *et al.*, 2015; Divya *et al.*, 2018; Ahlawat *et al.*, 2019; Mohsin *et al.*, 2021) [10, 4, 15, 5, 1, 13].

#### 5. Conclusion

All the growth parameters, yield attribute and yield approximately were found better in sole farming system as compared to gamhar based agrisilvicultural system in both the year (2016-17 & 2017-18). Among all the treatment, Sole Cowpea-Mustard was found better in term of productivity and lower in Gamhar+Cowpea-Mustard due to cumulative effect

of partial shade and competition for moisture and nutrients between the mustard and gamhar tree in 2016-17, 2017-18 and in pooled data respectively,

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