Environment Pollution and Climate Change

Sharma. Environ Pollut Climate Change 2020, 4:4

Research Article Open Access

Accumulation of Carbon Stock through Fodder Crops in Alluvial Soils of Gwalior, MP

Amita Sharma*

Department of Environmental Sciences, College Of Agriculture, Gwalior, India

Abstract

The was conducted at the Farm of Environmental sciences, College of Agriculture, RVSKVV, Gwalior during rabi (2017-18). The experiment comprised of two fodder crops and 6 nutrient levels which came up to twelve treatment combinations and laid out in randomized block design with three replications. All agronomic practices were kept normal and uniform in all treatments. Oat + maize + 25 gm urea + 38.125 gm ssp +7.5 kg VC (T_6) was found significantly superior for the morphological growth parameters *viz.*, plant height & tillers. The same treatment combination of Oat + maize + 25 gm urea + 38.125 gm ssp +7.5 kg VC (T_6) showed significantly superior results in case of green fodder yield as well as dry fodder yield ,carbon stock and carbon dioxide sequestration in soil which may be due to higher biomass. The next best crop and nutrient level was under the treatment combination Oat + maize + 25 gm urea + 37.5 gm SSP +7.5 kg FYM (T_{10}). So for better carbon stock and in turn higher carbon sequestration potential in long duration time can be achieved by the oat fodder crop along with these two nutrient levels in alluvial soils of Gwalior region of Madhya Pradesh

Keywords: Fodder crops; Growth parameter; Intercrop; Carbon accumulation (stock) and Carbon dioxide sequestration

Introduction

Soil acts as a major sink and source of atmospheric CO_2 and has a huge role to play in carbon capture and storage activity. Judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints [1]. Combined organic and inorganic fertilization could enhance carbon storage in soils and reduce emission from N fertilizer use, while contributing to high productivity in agriculture [2]. Sustaining soil health through inclusion of manure in the fertilization schedule is important since it can improve the organic carbon status and available N, P, K and S in soil [3]. To improve soil physical properties, addition of various organic materials could be undertaken and combined use of NPK and FYM increases soil organic matter compared to application of NPK through inorganic fertilizers [4].

Mitigation of CO_2 emission from agriculture can be achieved by increasing carbon sequestration in soil which implies storage of carbon as soil organic matter. An increase of 1 ton of soil carbon pool of degraded cropland soils may increase crop yield by 20 to 40 kg/ha for Wheat, 10 to 20 kg /ha for Maize and 0.5 to 1 kg/ha for Cowpea. The potential of soil carbon sequestration in India was estimated at 7 to 10 Tg C/yr for restoration of degraded soils and ecosystems, 5 to 7 Tg C/yr for erosion control, 6 to 10 Tg C/yr for adoption of recommended practices on agricultural soils and 22 to 26 Tg C/yr for secondary carbonates [5]. Adequate supply of nutrients can enhance biomass production and soil organic carbon content. Application of organic manure in combination with chemical fertilizer for crop is more useful to obtain high yields. It has been stated that the atmosphere is annually absorbing 3.4 gigatons of carbon more than it's releasing. Judicious nutrient management is crucial to soil organic carbon (SOC) sequestration in tropical soils [6]. It has been estimated that global potential scale of carbon sequestration in soils used for agricultural purposes is around 0.3 t C ha^{-1} Y^{-1} on arable lands and around 0.5 – 0.7 t C ha^{-1} Y^{-1} on grasslands [7]. Promoting soil carbon sequestration is an effective strategy for reducing atmospheric CO_2 and improving soil quality. Moreover, quantification of soil organic carbon in relation to various crop management practices is of importance in identifying sustainable systems for carbon sequestration in soils and subtropical environments.

Carbon sequestration (CS) is the process of removal of carbon dioxide (CO_2) from atmosphere in to green plants where it can be stored indefinitely. The rate of carbon sequestration depends on the net balance between carbon inputs and carbon losses per unit time. Climate change, together with other megatrends population growth, rapid urbanization, food insecurity and water scarcity increases competition for resources and heightens tensions and instability. Global climate change has already manifested itself through increase in global temperature by 0.6 to 0.8°C during the 20th century and increase in frequency of extreme events like very high intensity precipitation, frequent drought, heat waves etc. carbon in the form of methane (CH_4) and CO_2 is the major player in contributing to this global climatic shift. Global warming potential, methane (25), nitrous oxide (298) and Chlorofluorocarbons (10,900) are equivalent to units of CO_2 (ISA, 2017). Mitigation of CO_2 emission from agriculture can be achieved by increasing carbon sequestration in soil which implies storage of carbon as soil organic matter as minimum soil disturbance (i.e. tillage), increasing the mass and quality of plant and animal inputs to soils, improving soil microbial diversity and abundance and maintaining continuous living plant cover on soils year-round.

By means of various practices and technologies, sequestration needs to be enhanced and in turn the storage ability of all potential sinks and expand the number and type of sinks in which carbon storage is possible. The research is conducted to find the carbon uptake by fodder crops to finally analyse the total carbon sequestration in alluvial soils.

Materials and Method

The experiment was conducted in field of Department of Environmental Sciences, Centre for College of Agriculture (RVSKVV),

***Corresponding author:** Amita Sharma, Department of Environmental Sciences, College Of Agriculture, Rvskvv, Gwalior, India; Tel: 9131461034; E-mail: jaiamitsharma@gmail.com

Received June 18, 2020; **Accepted** July 23, 2020; **Published** August 18, 2020

Citation: Sharma A (2020) Accumulation of Carbon Stock through Fodder Crops in Alluvial Soils of Gwalior, MP. Environ Pollut Climate Change. 4: 181.

Gwalior (M.P.). The topography of the field was uniform with proper drainage with sandy clay loam & pre-sowing irrigation was given. Oat seed was sown @ 100 kg /ha and maize seed was sown @ 50 kg/ha by funnel attached with desi plough, keeping row to row distance of 22.5 cm. The sowing was done on 18th November, 2017. Among the growth parameters, only plant-height and tiller counts were recorded at each cutting (3 cuts) of fodder crops. Total four irrigations (7.00 cm each) were given to the crop as scheduled. Ten plants were tagged randomly for taking observations at equal intervals from all the 36 plots. The crop spacing was 20 × 20 cm. The experiment was conducted in randomized block design with three replications and 12 treatments. Two fodder crops: Oat & maize and 6 fertilizer levels: 20 kg vermi compost (VC), 32.55 gm urea +37.5 gm ssp, 25 gm urea + 28.125 gm ssp +7.5 kg VC, 20 kg FYM, 25 gm urea + 37.5 gm SSP + 7.5 kg FYM, & 25 gm urea + 38.125 gm ssp +7.5 kg VC were taken along with plots having Oat as control & Oat + maize as control.

Plant-height (cm) was measured on the main culm from the ground level to the base of well emerged last leaf with the help of meter scale at each cutting.

The total number of tillers (m^{-2}) were counted and further it was converted to number of tillers m-2 basis by multiplying tiller population per tussock with mean number of observed tussock per meter square.

Green forage yield was recorded from crops when cut from about 5 cm above the ground level and a border of 50 cm from all sides of a plot was first cut and removed immediately. Thereafter, the crops growing within the net plot area was cut and forage yield was recorded with the help of spring balance. In all 3 cuttings were taken from all plots at 60, 100 and 140 DAS in oat including intercrop.

In Oat the biomass production was measured manually by harvesting the aboveground biomass by cutting at the ground level and belowground biomass (Root) by excavation method. Dry biomass is determined by drying the freshly harvested crops in hot air oven at 700 C for 24 hours.

On the basis of plant dry biomass conversion into carbon, is natural reservoir of carbon that accumulates and stores some carbon-containing chemical compound for an identifiable period and the process by which carbon stock removes carbon dioxide from the atmosphere was determined as formula used by Rajput [8].

Carbon stock was determined by using dry biomass converted into carbon by Ash method. Dry biomass was multiplied by carbon content to give carbon stock as per the formulae used by Rajput [8].

Carbon stock = Dry biomass × Carbon content

Carbon dioxide sequestration potential (t ha^{-1}) by forage crops was determined by multiplying biomass carbon stock with a factor of 3.67 for all species a formulae used by Rajput [8].

C sequestered = Carbon stock × 3.67

The atomic weight of Carbon & Oxygen is 12 & 15.9 respectively.

The weight of CO_2 is C + 2 O (O+O) = 43.9

The ratio of CO_2 to C is 43.9/12=3.67

Organic carbon (%) was determined by Walkey and Black method [9]. It is expressed in percentage. Composite soil samples were collected from different soil depths (0-15 cm) with the help of soil augur.

Soil organic carbon stocks (t ha^{-1}) was calculated by multiplying the organic carbon with weight of the soil (bulk density and depth) for a particular depth and expressed as tonne per ha^{-1} (t ha^{-1}) as the equation given by Pearson et al. [10].

C (t ha^{-1}) = [(soil bulk density, (g/cc^{-1}) × soil depth (cm) × % C)] ×100

Results and discussion

Growth Parameters

Data pertaining to plant population m^{-2} was recorded at 20 DAS and final cutting (Table 1) and found that plant population was non-significant at both the stages under all the treatments. The plant height of oat at each cutting was significantly influenced by the maize intercrop and nutrient level on height on fodder Oat (Table 2) During vegetative stage, maximum average plant height observed under Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) 119.7, 90.2, 78.0 and 96.0 cm at first, second, third and mean of cutting respectively with at par Oat + maize + 25 gm urea + 37.5 gm SSP +7.5 kg FYM (T_{10}) over the treatment Oat + maize control (T_{12}). Number of tillers (Table 3) of fodder oat as influenced by different maize intercrop and nutrient level. Maximum tillers were observed under Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) 293.3, 289.4 and 72.3 at first, second and third cutting respectively which was at par with Oat + maize + 25 gm urea + 37.5 gm SSP +7.5 kg FYM (T_{10}) over the treatment Oat + maize control (T_{12}).

	Name of treatment	Plant population (M^{-2})	
		Initial	Final
T_1	Oat +20kg VC	25.0	25.0
T_2	Oat +maize +20kg VC	25.0	25.0
T_3	Oat +32.55gm urea +37.5gm ssp	25.0	25.0
T_4	Oat + maize +32.55gm urea +37.5gm ssp	25.0	25.0
T_5	Oat + 25gm urea + 28.125 gm ssp +7.5 kg VC	25.0	25.0
T_6	Oat + maize + 25gm urea + 38.125 gmssp +7.5 kg VC	25.0	25.0
T_7	Oat + 20 kg FYM	25.0	25.0
T_8	Oat + maize + 20kg FYM	25.0	25.0
T_9	Oat + 25gm urea + 37.5gm SSP + 7.5 kg FYM	25.0	25.0
T_{10}	Oat + maize + 25gm urea + 37.5 gm SSP +7.5 kg FYM	25.0	25.0
T_{11}	Oat control	25.0	25.0
T_{12}	Oat + maize control	25.0	25.0
SE(m) ±		0.00	0.00
C.D. at 5%		0.00	0.00

Table 1: Effect of maize intercrop and nutrient levels on green fodder by Oat and soil and total at different cutting interval.

Green fodder yield

Maize intercrop and fertilizer level on fodder Oat significantly affected the green fodder yield (Table 4). Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) exhibited significantly higher green fodder yield (44.2, 47.8, 60.2 and 152.2 t ha^{-1}) at first, second and third cutting respectively & at par with Oat + maize + 25 gm urea + 37.5 gm SSP +7.5 kg FYM (T_{10}) over the treatment Oat + maize control (T_{12}).

Dry fodder yield

Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) exhibited significantly higher dry fodder yield (9635.6, 10320.0 and 14000.3 kg ha^{-1}) at first, second & third cutting respectively which was at par with Oat + maize + 25 gm urea + 37.5 gm SSP +7.5 kg FYM (T_{10}) over the treatment Oat + maize control (T_{12}) (Table 5).

	Name of treatment	1st cut	2nd cut	3rd cut	Mean
T_1	Oat +20kg VC	85.8	68.2	59.2	71.1
T_2	Oat +maize +20kg VC	106.3	83.0	70.0	86.4
T_3	Oat +32.55gm urea +37.5 gm ssp	88.5	70.0	62.0	73.5
T_4	Oat + maize +32.55gm urea +37.5gm ssp	109.0	85.3	72.4	88.9
T_5	Oat + 25gm urea + 28.125 g ssp +7.5 kg VC	96.8	77.4	63.7	79.3
T_6	Oat + maize + 25gm urea + 38.125 g ssp +7.5 kg VC	119.7	90.2	78.0	96.0
T_7	Oat + 20 kg FYM	82.0	65.2	59.1	68.8
T_8	Oat + maize + 20kg FYM	103.9	80.6	67.5	84.0
T_9	Oat + 25gm urea + 37.5gm SSP + 7.5 kg FYM	93.4	75.2	61.8	76.8
T_{10}	Oat + maize + 25gm urea + 37.5 gm SSP +7.5 kg FYM	112.7	86.9	75.9	91.8
T_{11}	Oat control	78.9	61.3	56.0	65.4
T_{12}	Oat + maize control	74.1	58.8	53.4	62.1
	SE(m) ±	0.37	0.27	0.55	0.21
	C.D. at 5%	1.09	0.81	1.62	0.60

Table 2: Effect of maize intercrop and nutrient levels on height on fodder Oat at different cutting interval.

	Name of treatment	1st cut	2nd cut	3rd cut	Mean
T_1	Oat +20kg VC	274.5	266.1	58.0	199.5
T_2	Oat +maize +20kg VC	285.2	280.2	64.7	210.0
T_3	Oat +32.55gm urea +37.5gm ssp	277.9	268.5	63.2	203.2
T_4	Oat + maize +32.55gm urea +37.5gm ssp	286.8	282.5	68.2	212.5
T_5	Oat + 25gm urea + 28.125 gmssp +7.5 kg VC	283.8	274.9	65.3	208.0
T_6	Oat + maize + 25gm urea + 38.125 gmssp +7.5 kg VC	293.3	289.4	72.3	218.3
T_7	Oat + 20 kg FYM	268.5	263.1	64.9	198.8
T_8	Oat + maize + 20kg FYM	285.5	102.7	65.7	151.3
T_9	Oat + 25gm urea + 37.5gm SSP + 7.5 kg FYM	281.7	271.7	63.1	205.5
T_{10}	Oat + maize + 25gm urea + 37.5 gm SSP +7.5 kg FYM	288.8	286.3	70.2	215.1
T_{11}	Oat control	264.8	259.1	61.8	195.2
T_{12}	Oat + maize control	256.2	224.1	56.1	178.8
	SE(m) ±	1.30	25.2	2.19	8.4
	C.D. at 5%	3.81	74.0	6.42	24.7

Table 3: Effect of maize intercrop and nutrient levels on tillers of fodder Oat at different cutting interval.

	Name of treatment	1st cut	2nd cut	3rd cut	Total
T_1	Oat +20kg VC	36.2	41.2	52.5	129.9
T_2	Oat +maize +20kg VC	40.4	43.4	55.7	139.6
T_3	Oat + 32.55gm urea +37.5gm ssp	37.9	42.1	54.1	134.2
T_4	Oat + maize +32.55gm urea +37.5gm ssp	42.3	44.3	57.2	143.8
T_5	Oat + 25gm urea + 28.125 gmssp +7.5 kg VC	39.6	43.3	55.5	138.4
T_6	Oat + maize + 25gm urea + 38.125 gmssp +7.5 kg VC	44.2	47.8	60.2	152.2
T_7	Oat + 20 kg FYM	34.9	40.8	52.8	128.5
T_8	Oat + maize + 20kg FYM	40.2	42.8	55.1	138.1
T_9	Oat + 25gm urea + 37.5gm SSP + 7.5 kg FYM	38.2	42.8	54.6	135.6
T_{10}	Oat + maize + 25gm urea + 37.5 gm SSP +7.5 kg FYM	43.3	46.3	58.8	148.3
T_{11}	Oat control	35.0	40.1	51.4	126.4
T_{12}	Oat + maize control	34.7	38.3	47.2	120.2
	SE(m) ±	0.31	0.44	0.96	1.10
	C.D. at 5%	0.89	1.29	2.81	3.24

Table 4: Effect of maize intercrop and nutrient levels on green fodder yield t/ha on Oat at different cutting interval.

Citation: Sharma A (2020) Accumulation of Carbon Stock through Fodder Crops in Alluvial Soils of Gwalior, MP. Environ Pollut Climate Change. 4: 181.

Carbon accumulation (Stock)

There was a significant variation (Table 6) under different maize intercrop and nutrient level on fodder Oat for aboveground carbon accumulation (stock). Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) exhibited significantly higher carbon (34.0, 1012.5 and 1046.5 t ha^{-1}) plant, soil and total which was at par with Oat + maize + 25 gm urea + 37.5 gm SSP +7.5 kg FYM (T_{10}) over the treatment Oat + maize control (T_{12}).

CO_2 sequestration potential

The carbon stock of crops were converted into carbon dioxide sequestration potential (CSP) under different treatments maize

	Name of treatment	1st cut	2nd cut	3rd cut	Total
T_1	Oat +20kg VC	8217.8	9235.6	9544.4	26997.8
T_2	Oat +maize +20kg VC	9124.4	9800.0	12333.3	31257.8
T_3	Oat + 32.55gm urea +37.5gm ssp	8431.1	9360.0	10611.1	28402.2
T_4	Oat + maize +32.55gm urea +37.5gm ssp	9266.7	9911.1	13111.1	32288.9
T_5	Oat + 25gm urea + 28.125 gmssp +7.5 kg VC	8800.0	9542.2	10666.7	29008.9
T_6	Oat + maize + 25gm urea + 38.125 gmssp +7.5 kg VC	9635.6	10320.0	14000.3	33955.9
T_7	Oat + 20 kg FYM	7946.7	9137.8	9000.0	26084.4
T_8	Oat + maize + 20kg FYM	8937.8	2924.4	11000.0	22862.2
T_9	Oat + 25gm urea + 37.5gm SSP + 7.5 kg FYM	8555.6	9520.0	10600.0	28675.6
T_{10}	Oat + maize + 25gm urea + 37.5 gm SSP +7.5 kg FYM	9488.9	10062.2	14000.0	33551.1
T_{11}	Oat control	7831.1	8968.9	8533.3	25333.3
T_{12}	Oat + maize control	7560.0	8640.0	8755.6	24955.6
	SE(m) ±	52.5	43.0	413.7	397.7
	C.D. at 5%	154.1	126.3	1213.4	1166.5

Table 5: Effect of maize intercrop and nutrient levels on dry fodder yield kg/ha on Oat at different cutting interval.

	Name of treatment	C t/ha by fodder	C t/ha by soil	Total C t/ha
T_1	Oat +20kg VC	27.0	917.0	944.0
T_2	Oat +maize +20kg VC	30.6	960.5	991.8
T_3	Oat +32.55gm urea +37.5gm ssp	28.1	924.0	952.4
T_4	Oat + maize +32.55gm urea +37.5gm ssp	31.6	967.5	999.8
T_5	Oat + 25gm urea + 28.125 gmssp +7.5 kg VC	29.0	938.0	967.0
T_6	Oat + maize + 25gm urea + 38.125 gmssp +7.5 kg VC	34.0	1012.5	1046.5
T_7	Oat + 20 kg FYM	26.1	908.5	934.6
T_8	Oat + maize + 20kg FYM	29.9	945.0	967.9
T_9	Oat + 25gm urea + 37.5gm SSP + 7.5 kg FYM	28.7	931.0	959.7
T_{10}	Oat + maize + 25gm urea + 37.5 gm SSP +7.5 kg FYM	32.4	983.0	1016.6
T_{11}	Oat control	25.3	868.0	893.3
T_{12}	Oat + maize control	25.0	853.0	878.5
	SE(m) ±	0.52	16.78	16.81
	C.D. at 5%	1.52	49.22	49.31

Table 6: Effect of maize intercrop and nutrient levels on c accumulation by fodder Oat and soil and total at different cutting interval.

	Name of treatment	CO_2 t/ha by fodder	CO_2 t/ha by soil	Total CO_2 t/ha
T_1	Oat +20kg VC	99.1	3365.4	3464.5
T_2	Oat +maize +20kg VC	114.7	3525.0	3639.8
T_3	Oat +32.55gm urea +37.5gm ssp	104.2	3391.1	3495.3
T_4	Oat + maize +32.55gm urea +37.5gm ssp	118.5	3550.7	3669.2
T_5	Oat + 25gm urea + 28.125 gmssp +7.5 kg VC	108.7	3442.5	3548.9
T_6	Oat + maize + 25gm urea + 38.125 gmssp +7.5 kg VC	124.6	3715.9	3840.5
T_7	Oat + 20 kg FYM	95.7	3334.2	3429.9
T_8	Oat + maize + 20kg FYM	113.1	3468.2	3552.1
T_9	Oat + 25gm urea + 37.5gm SSP + 7.5 kg FYM	105.2	3416.8	3522.0
T_{10}	Oat + maize + 25gm urea + 37.5 gm SSP +7.5 kg FYM	123.1	3607.6	3730.7
T_{11}	Oat control	93.0	3185.6	3278.5
T_{12}	Oat + maize control	91.6	3132.3	3223.9
	SE(m) ±	1.82	61.59	61.71
	C.D. at 5%	5.34	180.64	180.98

Table 7: Effect of maize intercrop and nutrient level on CO_2 sequestration potential by fodder Oat and soil and total at different cutting interval.

intercrop and nutrient level on fodder Oat, which were presented in (Table 7). Significant variation was observed under different treatments, maize intercrop and nutrient levels on fodder Oat for carbon dioxide sequestration potential.

During the experimentation, the fodder oat CSP was found significantly maximum under Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) exhibited significantly carbon dioxide sequestration (124.6, 3715.9 and 840.5 t ha^{-1}) plant, soil and total which was at par with Oat + maize + 25 gm urea + 37.5 gm SSP +7.5 kg FYM (T_{10}) over the treatment Oat + maize control (T_{12}).

Discussion

The growth parameters of fodder oat under different maize intercrop and fertilizer level vary considerably, which is primarily controlled by factors such as growth habit, climatic and edaphic attributes, age, genetic makeup, management practices *viz*., fertilizer, irrigation and cultural practices applied to the fodder oat. Present study also showed a wide variation in height under different land use systems. Significantly highest height was found under Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) 119.7, 90.2, 78.0 and 96.0 cm at first, second, third and mean of cutting respectively due to due to positive interaction between for sharing the resources like light, nutrient, water as well as the cultural practices applied to it. Similar results revealed by Kumar [11], Bhattacharya et al. [4], Kaur et al. (2008), Thornton and Herrero [12], Yadava et al. [13], Ghannoum et al. [14], Panchal [15], Rajkumar et al. [16], Thennarasu et al. [17] and Gupta et al. (2017).

Biomass production under different land use systems depends on number of factors *viz*., choice of crops, growth habit, site quality, soil type, age of crop, management practice applied, frequent intercultural operations, moisture conservation and their interaction with belowground crops have also contributed towards the increasing aboveground biomass production. In the present study, the highest aboveground biomass production may be due to growth habit of fodder oat. Results supported by Kaisi and Grote [19], Ahadiyat and Ranamukhaarachchi [20], Chimento et al. [21], Javanmard et al. [22], Anita et al. [23], Sharma [24], Chaplot [25], Ram , Sathiya and Babu, Meena et al. [26] and Jha and Tiwari [27].

The variation in total biomass production may be due to crop compatibility, genetic makeup of crop, management practice applied, frequent intercultural operations, presence of hard pan in subsoil layers and the above and belowground interaction of crop for sharing of nutrient, water, light and space as also reported by In the present experiment, the maximum total biomass was observed by Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) system may be due to genetic makeup of fodder oat and also may due to positive interaction between them for sharing the resources *viz*., nutrient, water, light and space. Similar results found by Mohammed and Bekele [28], Meena et al. [26] and Jha and Tiwari [27].

The variation in total carbon stock under different fodder oat depends primarily upon the ash content and the ash content depends upon the amount of structural components of respective crops. Variability may also depend on nature of components, crop density, growth habit, genetic makeup, age, structure, functional components and their number, soil type and intensity of management. Similar results revealed by Kumar [11], and Nishanth et al. [17].

Significantly highest total CO_2 sequestration potential was observed under Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6). Total CO_2 sequestration potential by plant is directly related to biomass production of the different plant components. Highest CO_2 sequestration potential in Oat + maize + 25 gm urea + 38.125 g ssp +7.5 kg VC (T_6) may due to more biomass and more carbon stock was observed. Higher carbon sequestration in intercropping system compared to sole cropping system. Similar results found by Mohammed and Bekele [28-31], and Nishanth et al. [17].

Conclusions

Based on the foregoing discussion, the study comes to the conclusions that Oat + maize + 25 gm urea + 38.125 gm ssp +7.5 kg VC (T_6) found significantly superior for the morphological growth parameters *viz*., plant height, tillers, green fodder yield, dry fodder yield, carbon accumulation and carbon dioxide sequestration. The next best crop and nutrient level was under the treatment combination Oat + maize + 25 gm urea + 37.5 gm SSP +7.5 kg FYM (T_{10}). So for better carbon stock and in turn higher carbon sequestration in long duration time can be achieved by the oat fodder crop along with these two nutrient levels in alluvial soils of Gwalior region of Madhya Pradesh.

References

1. Abedi T, Alemzadeh A, Kazemelni SA (2010) Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. Aust J Crop Sci, 4:384-389.
2. Pan G, Zhou P, Li Z, Pete S, Li L, et al. (2009) Combined inorganic/organic fertilization enhances N efficiency and increased rice productivity through organic cabon accumulation in a rice paddy from the Tai Lake region, China. Agri Ecosys Environ, 131:274-280.
3. Tiwari RK, Baghel RPS, Singh SK (2002) Inclusion of niger and sesame cake replacing soybean meal in coarse cereals based starter chicken ration. Indian J Poult Sci, 40(3):241-244.
4. Bhattacharya R, Chandra S, Singh RD, Kundu S, Srivastava AK, et al. (2007) Long term farmyard manure application effects on properties of a silty clay loam soil under irrigated wheat-soybean rotation. Soil Tillage Res, 94:386-396.
5. Lal R (2004). Carbon emission from farm operations. Environ Int, 30:981– 990.
6. Bhattacharyya R, Kundu S, Praksh V, Gupta HS (2008) Sustainability under combined application of mineral and organic fertilizers in a rainfed soybean-wheat system of the Indian Himalayas. Eur J Agron, 28:33-46.
7. IPCC, (2014). IPCC special report on Impacts. Adaptation and vulnerability.
8. Rajput BS (2010) Bio-economic appraisal and carbon sequestration potential of different land use systems in temperate north-western Himalayas. Ph.D. Thesis, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). India.
9. Black CA (1965) Method of Plant and Soil Analysis part 11. Publishing American Society Agronomy, Madison wiscorsin, USA, pop. 1367-1373.
10. Pearson, Timothy RH, Brown, Sandra L, Birdsey, et al. (2007). Measurement guidelines for the sequestration of forest carbon. Gen Tech Rep, 42
11. Kumar S (2003). Carbon dynamics studies in agroforestry systems of Western Himalaya. M.Sc. Thesis. Dr. Y. S. Parmar University of Horticulture andForestry, Nauni, Solan (H.P.) India. 80p.
12. Kaur S, Samant GV, Pramanik K, Philip WL, Michael LP, et al. (2008) Silencing of directional migration in roundabout4 knockdown endothelial cells. BMC Cell Biol, 9:61.
13. Thornton PK and Herrero M (2010) Potential for reduced methane and carbon dioxide emissions from livestock and pasture management in the tropics. Proc Natl Acad Sci U S A, 107(46):19667-19672.
14. Yadava AK (2010) Biomass production and carbon sequestration in different agro-forestry systems in Tairaregion of Central Himalaya. Ind For, 136(2):234-244
15. Ghannoum (2011) Nitrogen & water use efficiency of C2S plant in raghavendra A.S & Sage R.S (Eds) C4 Photosynthesis and related CO2 Concentrating Machanism, Springer Science + Business media B.V., Dordrecht, The Netherland, 129-146.

16. Panchal J, Thakur NS, Jha SK, Kumar V (2017). Productivity and carbon sequestration of prevalent agroforestry systems in Navsari district, Gujarat, India. Int J Curr Microbiol App Sci, 6(9):3405-3422.

17. Nishanth B, Rajkumar JSI, Meenakshi SS, Sivakumar T, Sankaran VM (2013) Sequestration of Atmospheric Carbon through Forage Crops Cultivated in Ramayanpatti, Tirunelveli District, Tamilnadu, India. Res J Agri Fores Sci, 1(3):11-14.

18. Thennarasu A, Sivakumar T, Meenakshi SS (2017). Comparative Carbon Sequestration Potential of Fodder Maize (Zea mays L.) and Influenced by Different Organic Manure. Ind Vet J. 94 (6): 25-26.

19. Kaisi MMA, Grote JB (2007) Cropping Systems effects on improving soil carbon stocks of exposed subsoil. Soil Sci Soc Am J, 71(4):1381-1388.

20. Ahadiyat YR, Ranamukhaarachchi SL (2008) Effects of tillage and intercropping with grass on soil properties and yield of rainfed maize. Int J Agri Biol, 10(2):133-139.

21. Chimento C, Almagro M, Amaducci S (2014) Carbon sequestration potential in perennial mixtures on the yield and quality of forages. Int J Fores Crop Imp, 6(1):85-89.

22. Javanmard A, Shekari F, Dehghanian H (2014) Evaluation of forage yield and competition indices for intercropped barley and legumes. Int J Agri Bio Sys Eng, 8(2):193-196.

23. Anita MR, Lakshmi S, Sajitharani T (2015) Effects of row ratios of grass fodder cowpea bioenergy crops the importance of organic matter inputs and its physical protection. Internat J Forestry & Crop Improv, 6 (2):85-89.

24. Sharma KC (2014) Productivity of different fodder crops sequences grown in association of Ber (zizyphus mauritiana lamk.) plantation under agri-horticulture system in hot arid region of Western India. Forage Res, 39(4):159-164.

25. Chaplot PC (2014) Introduction of different grasses mixed with legume on wastelands. Forage Res. 40 (3):199-200.

26. Meena LR, Meena LK, Meena AL, Singh SP (2017) Effect of organic nutrient management on intercropping systems of Cenchrus and Dolichoslab lab for quality fodder production and for improving soil health under semi-arid conditions of Rajasthan. Forage Res, 43(3):202-207.

27. Jha SK, Tiwari N (2018) Evaluation of intensive fodder cropping systems for round the year green fodder production in Chhattisgarh. Forage Res, 44(2):115-118.

28. Mohammed A, Bekele L (2014) Changes in Carbon Stocks and Sequestration Potential under Native Forest and Adjacent Land use Systems at Gera,South-Western Ethiopia. Glob J Sci Front Res: D Agri Vet, 14(10):11-19.

29. Nishanth R, Sundaramm S, Sankaranv M, Sivakumar T (2014). Scope of popular fodder crops in carbon sequestration for mitigating carbon emissions. Bioinfo Environ & Pollution, 4(1):42-45.

30. Thennarasu A, Shivakumar T (2016) Carbon sequestration potential of fodder maize (Zea mays L.) influenced by manure treatment techniques. Intl Conf on food Agri & Biology.

31. Yadava DK, Singh L (2010) Community structure and floristic diversity of tree stratum of deciduous forest of Achanakmar-Amarkantak Biosphere Reserve. Indian For, 136(6):725-735.