Original Research Article

Impression of different agroforestry system on Physical properties of soil

ABSTRACT

This study associated with the difference between agroforestry system and impact over to soil in long duration. This investigation interpreted the changes between two years. This study analyzed by the RBD (Randomized Block Design) with 5 treatments (agroforestry systems ~~***i.e.***~~) and 4 replications. This investigation run in the existing systems planted at Forestry Research Farm, Department of Forestry, JNKVV, Jabalpur and conducted during *Rabi* season of 2021-22 and 2022-23. The soil collection done in the 0-15 cm depth of soil under different agroforestry systems after that soil have tested in department of agricultural chemistry and soil science under different methodology. The result revealed that the data of sand silt percentage maximum was obtained in the *Acacia nilotica*- wheat agroforestry system, and the sand value was found in the *Dalbergia sissoo*- wheat- based system. *A. nilotica*- wheat based intercropping agroforestry system shows highest bulk density and lowest water holding capacity. The pH of soil under investigation was found slightly acidic ~~soi~~l ranges from 6.20 to 6.51 and EC obtained from 0.20 to 0.26 dsm^{-1} in the two years of experiment with Cation exchange capacity (CEC) noted from 22.55 to 35.57 C mol kg^{-1} between 2021-22 and 2022-23 respectively. The above investigation *D. sissoo* – wheat-based agroforestry system was found best treatment.

Keywords: Bulk density, pH, D. sissoo, A. nilotica, G.arborea, M. indica, M. pinnata Agroforestry systems etc.

1. INTRODUCTION

Physical properties of soil include color, texture, structure, porosity, density, consistence, aggregate stability, and temperature. These properties affect processes such as infiltration, erosion, nutrient cycling, and biologic activity. Different factors affecting physical properties of matter, are the solubility, boiling point, density, melting point, reactivity, and temperature of soil. Soil physical properties define movement of air and water/dissolved chemicals through soil, as well as conditions affecting germination, root growth, and erosion processes. Soil physical properties form the foundation of several chemical and biological processes, which may be further governed by climate, landscape position, and land use. Thus, a range of soil physical properties when altered by climate change can trigger a chain reaction that leads to soil environment, which may greatly influence growth and production of crops including wheat. Some key soil physical indicators in relation to climate change include soil structure, water infiltration rate, bulk density, rooting depth, and soil surface cover (Mangi *et al.,* 2018). The physical properties are main point to effect the cropping pattern of crops. Agroforestry system (AFS) is a land use system in which perennial trees/ plants are integrated with arable crops (grasses, other crops) with or without livestock either in rotation or not

associated with ecological and environmental benefits among tree and non-tree components (Lundgren and Raintree, 1982).

Agroforestry systems contribute to the physical properties of the soil by improving soil aggregates, bulk density, water holding capacity, etc. Manures applied in these systems provide soil surface coverage while minimizing evaporation, runoff, soil loss, soil compaction, etc. improving water infiltration and moisture retention. Soil aggregate stability is a powerful indicator of soil degradation. Agroforestry systems improve soil compaction through fallen debris and renewal of root biomass. The addition of organic matter to the soil thus provides better soil structural stability, improves the distribution of soil aggregates and water-resistant aggregates, thereby reducing soil erosion. Tree-based agroforestry systems help retain more moisture in the soil profile. Perennial tree crops improve the supply of organic matter, reduce soil moisture loss, and prevent erosion in the agroecosystem. Another important physical property is bulk density, an indicator of soil health, influenced by management practices. Bulk density affects soil moisture content, infiltration, porosity, and directly affects biochemical processes in the soil. Planting trees at high densities increases litter supply and organic matter content, thereby reducing bulk density. Thus, the inclusion of various multipurpose tree species (MPT) in the agroecosystem improves various hydro-physical properties of the soil, thus acting as a barrier against soil erosion rates, improving macro-aggregation and infiltration capacity, reducing losses. Furthermore, the agroforestry system practiced with reduced or no-till reduces soil erosion, provides additional soil surface cover with litter fall, minimal disturbance and crop diversification.

2. MATERIAL AND METHODS

The experimental trail carried out in agroforestry field of Forestry Research Farm, Department of Forestry, JNKVV, Jabalpur. These studies conducted during *Rabi* season of 2021-22 and 2022-23. ~~The experiments~~ (detailed description about geographical location)

Table 1. Physical, chemical ~~and biological properties~~ of experimental soil (0-20 cm) (Where is biological properties??)

A. Physical Properties	
Sand (%), Silt (%), and Clay (%)	International pipette method (Piper, 1967)
Bulk density (g cm^{-3})	Oven dry method (Black, 1995)
Water holding capacity (%)	Oven dry method (Black, 1995)
Soil pH	Solo-bridge method (Black, 1996)
Electrical conductivity (dS m^{-1})	Solo-bridge method (Black, 1996)

2.1 Physical analysis

2.1.1 Bulk density

Soil bulk density is the ratio of dry soil mass to bulk soil volume (including pore spaces). The unit for density is mega grams per cubic meter (Mg/m^3), which is numerically equivalent to grams per cubic centimeter.

$$\text{Soil bulk density (g cm}^{-1}) = \frac{\text{Weight of Oven dry soil (g)}}{\text{Volume of the soil in the core sampler(cm}^3)}$$

2.1.2 Water Holding Capability (%)

Water holding capacity is the ability of a certain soil texture tp physically hold water against the force of gravity. It is important to know the WHC of the soil to determine how much water storage. The texture, composition, and volume of organic materials in grow medium determine how much water it can hold. Keen boxes were used to measure the

water holding capacity. To allow soil to absorb water to the point of saturation, keen boxes were entirely filled with air-dried soil samples and placed in plastic trays that had some water in them. The formula below is used to estimate water holding capacity:

$$\% \text{ WHC} = \frac{\text{Wet weight} - \text{Oven Dry weight}}{\text{Wet weight}} \times 100$$

2.1.3 Soil pH

In order to determine of soil pH, 1:2.5 soil water extract was prepared by taking 20 g soil and 50 ml of distilled water in 100 ml of beaker. Subsequently the extract was mixed with a glass rod. The pH meter was calibrated by Immersing the electrodes in different buffer solution of pH 4.0, 7.0 and 9.2 Electrodes were placed into beaker containing the soil extract and recorded the reading displayed by the pH meter. After each determination, the electrodes were thoroughly washed by distilled water and wiped out by ordinary tissue paper.

2.1.4 Electrical conductivity

Soil water extract was prepared by 20 g soil sample and 50 ml distilled water (1:2.5 ratio) beaker cup of 100 ml and extract was mixed with the help of glass rod. The electrical conductivity meter was adjusted conductivity 1.41 dSm^{-1} at 25^0C at temperature and calibrated with the standard solution 0.01 N KCl. Before proceeding the samples, washed the conductivity cell for avoiding error.

3. RESULTS AND DISCUSSION

The data present in Table 2 *i.e.* sand, silt and clay of soil were the data in table sand and clay percent significantly differ in agroforestry systems soil but in case of silt per cent was found non-significantly under different systems.

3.1 Sand, silt and clay (%)

The sand percent T_4 – *A. nilotica*- wheat (23.50, 23.74 and 23.62 %) and T_5- *M. indica* - linseed (24.47, 25.30 and 24.89 %) were significantly maximum to T_1- *D.sissoo*- wheat (20.44, 20.72 and 20.58 %), T_2- *G. arborea* - mustard (20.13, 20.30 and 20.21 %) and T_3 - *M. Pinnata*- wheat (21.10, 20.72 and 20.91 %) In the 2021-22, 2022-23 and pooled data respectively. Whereas, T_4 – *A. nilotica*- wheat was at par with T_5- *M. indica* – linseed in both year as well as pooled mean. Moreover, between the year sand percent was found non significantly.

The silt per cent in soil was non-significantly found. The maximum silt percentage was estimated in T_4 – *A. nilotica*- wheat (23.99, 21.28 and 22.64 %) followed by T_2- *G. arborea* - mustard (21.32, 20.88 and 21.10 %) and the minimum under T_5- *M. indica* - linseed (18.74, 19.76 and 19.25 %) in the first year, second year and pooled data respectively. moreover the data in respective year not significant variation found.

The clay per cent in soil under different agroforestry systems was noted minimum and maximum range 52.51 to 60.16 % in first year (2021-22). During second year (2022-23) it was recorded minimum and maximum range 54.54 to 59.53%. There cumulative effect (pooled) minimum to maximum varies from 53.74 to 59.84 %. Whereas the data in first year second year were fond non-significant difference but cumulative effect founds significant *i.e.* T_1- *D.sissoo*- wheat (59.30 %), T_2- *G. arborea* - mustard (58.69 %) and T_3 - *M. Pinnata*- wheat (59.84 %) were significant to T_4 – *A. nilotica*- wheat (53.74%) and T_5- *M. indica* - linseed (55.25 %), however the data was found partly between T_1 T_2 and T_3. The above result highly correlated with Kinyili *et. al.*,2024 *i.e.* found that sand was significantly higher among non-adopters compared to adopters while silt and bulk density was significantly higher among the adopters compared to the non-adopters. Sand levels decreased while silt and bulk density significantly increased with increasing agroforestry stand age. The result was similar, the decline in sand proportion in *Acacia nilotica* agroforestry was attributed to protection of soil from the impact of rain drops which would otherwise increase the deflocculating effects (Refrences?)(Pandey *et al*., 2000). The increased proportion of silt in soil where agroforestry

is practiced has been widely reported (Bhaduri *et al*., 2017; Deng *et al.,* 2017; Dhaliwal *et al.,* 2019).

Table 2. Sand, silt and clay percentage of soil under different agroforestry systems

Treatments	Sand %			Silt %			Clay %		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1- D.Sissoo-Wheat	20.44	20.72	20.58	20.49	19.75	20.12	59.07	59.53	59.30
T_2- G. arborea-Mustard	20.13	20.30	20.21	21.32	20.88	21.10	58.55	58.83	58.69
T_3-M. Pinnata-Wheat	21.10	20.72	20.91	18.74	19.76	19.25	60.16	59.53	59.84
T_4-A. nilotica-Wheat	23.50	23.74	23.62	23.99	21.28	22.64	52.51	54.98	53.74
T_5-M. Indica-Linseed	24.47	25.30	24.89	19.57	20.16	19.86	55.96	54.54	55.25
Mean	**21.93**	**22.15**	**22.04**	**20.82**	**20.36**	**20.59**	**57.25**	**57.48**	**57.37**
SEm±	0.41	0.51	0.29	1.93	1.50	1.09	1.99	1.45	1.10
CD(P<0.05)	1.52	1.88	1.14	7.19	5.57	4.29	7.40	5.38	4.32
SEm±(Year)	0.21			0.77			0.78		
CD(Year) (P<0.05)	0.81			3.04			3.05		
SEm±(YXT)	0.46			1.73			1.74		
CD(YXT) (P<0.05)	1.81			6.79			6.83		

The data revealed that bulk density and water holding capacity (WHC) of soil under different agroforestry systems are presented in Table 3 the data was non-significantly found in the both year and pooled.

3.2 Bulk density

The data revealed that bulk density are presented in Table 3 the data was non-significantly found in the both year and pooled. The bulk density was noted minimum and maximum range 1.25 to 1.41 g cm^3 during 2021-22 while in the year of 2022-23 minimum and maximum between 1.26 to 1.41 g cm^3 and the pooled minimum and maximum range 1.25 to 1.41 g cm^3. Whereas, the maximum T_4 – *A. nilotica*- wheat (1.41, 1.41 and 1.41 g cm^3) and T_1- *D.Sissoo* - wheat (1.25, 1.26 and 1.25 g cm^3) both the year and pooled. Moreover in year data was found non – significant differences. There was a significant difference in mass density according to the age of agroforestry practice. The result of bulk density Soil density was higher in adopters than in non-adopters and increased with the age of agroforestry adoption. These studies are consistent with those of (Silva *et al.,* 2011; Chaudhari *et al.,* 2013) The parameter needs detailed discussion & reason with others finding. Thus, add other appropriate research work.

3.3 Water Holding Capacity (WHC)

The data shown in Table 3 found that In 2021-22 the water holding capacity (WHC) was found non –significant. The maximum water holding capacity found in T_3 - *M. Pinnata*- wheat (84.39 %) and minimum was found in T_4 – *A. nilotica*- wheat (70.51%) based agroforestry system. In 2022-23 WHC in the T_1- *D. Sissoo* – wheat (82.88 %) and T_3 - *M. Pinnata*- wheat (82.86 %) were significantly higher to T_2- *G. arborea* - mustard (81.18 %), T_4 – *A. nilotica*- wheat (71.21 %) and T_5- *M. indica* - linseed (75.89 %). Whereas, the T_1 was at par with T_3. While in the cumulative (pooled) data T_1- *D. Sissoo* – wheat (82.32 %) and T_3 - *M. Pinnata*- wheat (83.85 %) T_2- *G. arborea* - mustard (80.85 %) were significantly maximum to T_4 – *A. nilotica*- wheat (70.86 %) and T_5- *M. indica* - linseed (74.64 %) whereas, T_1, T_2, T_3 found partly in the different agroforestry systems. This effect was produced due to bulk density and the clay percent in soil increase (Ferrant *et al.,*2016 and Ferrant *et al.,*2011) (Follow same pattern everywhere)

The parameter needs detailed discussion with others finding. Thus, add other appropriate research work.

Table 3 Bulk density and water holding capacity of soil in different agroforestry system

Treatments	Bulk density (g cm^3)			Water Holding Capacity(%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1- D.Sissoo-Wheat	1.25	1.26	1.25	81.77	82.88	82.32
T_2- G. arborea-Mustard	1.27	1.27	1.27	80.52	81.18	80.85
T_3-M. Pinnata-Wheat	1.30	1.27	1.29	84.39	82.86	83.62
T_4-A. nilotica-Wheat	1.41	1.41	1.41	70.51	71.21	70.86
T_5-M. Indica-Linseed	1.36	1.35	1.35	73.40	75.89	74.64
Mean	**1.32**	**1.31**	**1.31**	**78.12**	**78.80**	**78.46**
SEm±	0.07	0.06	0.04	3.83	2.81	2.13
CD(P<0.05)	0.27	0.21	0.16	14.25	10.46	8.35
SEm±(Year)	0.03			1.50		
CD(Year) (P<0.05)	0.11			5.90		
SEm(YXT)	0.06			3.36		
CD(YXT) (P<0.05)	0.25			13.20		

3.4 pH

The data Table 4 revealed that pH and EC found non-significant in the different agroforestry systems in the both year as well as pooled data. The maximum to minimum pH was found in the T_4 – *A. nilotica*- wheat (6.49, 6.51 and 6.50) followed by T_5- *M. indica* – linseed (6.48, 6.45 and 6.46) after that T_1- *D.Sissoo* – wheat (6.47,6.41 and 6.44) than T_2- *G. arborea* – mustard (6.23, 6.23 and 6.23) and the minimum pH was found in the T_3 - *M. Pinnata*- wheat (6.20, 6.23 and 6.21) in the 2021-22 (first year) ,2022-23 (second year) and pooled data respectively.

The parameter needs detailed discussion with others finding. Thus, add other appropriate research work.

3.5 Electrical conductivity (EC)

The Table 4 presented that EC found non-significant in the different agroforestry systems in the both year as well as pooled data. the result noted that electrical conductivity was minimum and maximum ranged 0.20 to 0.25 dSm^{-1} during 2021-22 where maximum EC found in T_4 – *A. nilotica*- wheat and T_3 - *M. Pinnata*- wheat. While minimum and maximum ranged 0.21 to 0.26 dSm^{-1} during 2022-23. Their maximum observed into T_6 and T_1 treatments and minimum found in T_3. Moreover, the pooled data ranged from 0.20 to 0.25 dSm^{-1}. Tomar *et al.* 2004 and Tomar *et al.* 1986 reported the soil amelioration in terms of reduction in soil pH, improvement in organic matter and available nitrogen contents under agri-horticultual system. The result of pH and EC obtained in this title was like to Fahad *et al.*,2022.

The parameter needs detailed discussion with others finding. Thus, add other appropriate research work.

Table 4 pH and EC of soil under different agroforestry systems

Treatments	pH			EC (dSm^{-1})		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled

T_1- D.Sissoo-Wheat	6.47	6.41	6.44	0.24	0.26	0.25
T_2- G. arborea-Mustard	6.23	6.23	6.23	0.23	0.24	0.23
T_3-M. Pinnata-Wheat	6.20	6.23	6.21	0.20	0.21	0.20
T_4-A. nilotica-Wheat	6.49	6.51	6.50	0.25	0.25	0.25
T_5-M. Indica-Linseed	6.48	6.45	6.46	0.25	0.26	0.25
Mean	**6.37**	**6.36**	**6.37**	**0.23**	**0.24**	**0.24**
SEm±	0.10	0.11	0.07	0.01	0.01	0.01
CD(P<0.05)	0.37	0.40	0.26	0.05	0.05	0.03
SEm± (Year)	0.05			0.01		
CD(Year) (P<0.05)	0.18			0.02		
SEm± (YXT)	0.10			0.01		
CD(YXT) (P<0.05)	0.41			0.05		

3.6 Cation exchange capacity (CEC) of soil under different agroforestry systems

The observation of revealed that in Table 5 and ~~Fig 1~~. the cation exchange capacity was recorded T_1- *D.Sissoo* – wheat (35.37, 35.47 and 35.42 C mol kg^{-1}) and T_2- *G. arborea* – mustard (34.95, 35.57 and 35.26 C mol kg^{-1}) were highly significant to T_3 - *M. Pinnata*- wheat (28.05, 28.56 and 28.30 C mol kg^{-1}), T_5- *M. indica* – linseed (29.70, 29.90 and 29.80 C mol kg^{-1}) and T_4 – *A. nilotica*- wheat (22.55, 22.56 and 22.55 C mol kg^{-1}) in first year (2021-22), second year (2022-23) and pooled data respectively. Whereas, T_1 was at par with T_2. While T_3 - *M. Pinnata*- wheat and T_5- *M. indica* – linseed were significant to T_4 – *A. nilotica*- wheat in the both year and pooled data respectively. Between the years the data was found non-significant. The CEC of agroforestry systems shoes non –significant difference between the year but in long term basis it was continuously changes year to year. The CEC depends on the pH, EC as well as and bulk density.

The parameter needs detailed discussion with others finding. Thus, add other appropriate research work.

Table 5 Cation exchange capacity (CEC) of soil under different agroforestry systems

Treatments	CEC (C mol kg^{-1})		
	2021-22	**2022-23**	**Pooled**
T_1- D.Sissoo-Wheat	35.37	35.47	35.42
T_2- G. arborea-Mustard	34.95	35.57	35.26
T_3-M. Pinnata-Wheat	28.05	28.56	28.30
T_4-A. nilotica-Wheat	22.55	22.56	22.55
T_5-M. Indica-Linseed	29.70	29.90	29.80
Mean	**30.12**	**30.41**	**30.27**
SEm±	1.28	1.47	0.87
CD (P<0.05)	4.76	5.48	3.43
SEm± (Year)	0.62	**SEm± (YXT)**	1.38
CD(Year)	2.42	**CD(YXT)**	5.42

4. CONCLUSION

From the above investigation it may be concluded that Sand and Clay percentage under different agroforestry systems were shows significantly another the data on bulk density water holding capacity, pH, EC, and CEC between year (2021-22 to 2022-23) were found non-significant difference. Under different agroforestry systems. The best treatments under agroforestry system was noted that on the basis of percentage of sand, silt and clay (20.58, 20.12 and 59.30 respectively), bulk density (1.25 g cm^3), pH (6.44),EC (0.25 dsm^{-1}) and CEC

(35.42 C mol kg^{-1}) and water holding capacity (82.32%) in *D.sissoo*- wheat based agroforestry system behalf of pooled analysis (P<0.05). ~~I bow my head great reverence before the God, whose ideologies have always been an inspiring source in my life and has enabled me achieve this seemingly invincible task.~~

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ABBREVIATIONS

Dalbergia sissoo = D. sissoo, Millettia pinnata = M. pinnata, Gmelina arborea = G. arborea, Acacia nilotica = A. nilotica, CEC = Cation exchange capacity

SUGGESTION:

1. **Follow APA style format in references. (you can also help with google for citation writing).**
2. **Check Grammarly error. (very much error).**
3. **Spacing, font is not well managed.**
4. **All parameter needs detailed discussion with others finding. Thus, add other appropriate research work.**
5. **Figure also included for easy & graphical understanding.**