Soil fertility under Asana (*Bridelia retusa*) based agroforestry systems in lateritic soil of Konkan

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ABSTRACT: *An experimental study was conducted during 2019-20 at the Research Farm of AICRP on Agroforestry, Dr. BSKKV, Dapoli, Maharashtra. The results indicated that, significantly high soil fertility of Asana based agroforestry was recorded by T6>T5>T7 than other. The soil fertility status was noted slightly improvement in pH (5.94 to 5.97) and EC (0.232 to 0.254 dSm^{-1}) by T6 during the years of 2019 and 2020. The maximum organic carbon (2.18 to 2.27 %), N (343.66 kg ha^{-1}), and (351.33 kg ha^{-1}), available P2O5 (22.30 to 25.20 kg ha^{-1}) and available K2O (439.08 to 455.84 kg ha^{-1}) was recorded in T6 in the year of 2019 and 2020, respectively. Overall, it can be concluded that the improving soil fertility were recorded significantly by T6>T5>T7 than other, it may be due to presence of high amount biomass contribution and addition organic matter in the soil. Thus, T6 –Asana + Jam is the best treatment under asana based agroforestry systems seem to be increased the soil fertility in lateritic soils of Konkan.*

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1. INTRODUCTION

Agroforestry, the practice of introducing trees in farming system has played a significant role in enhancing land productivity and improving livelihood in both developed and developing countries. The planting of tree along with crops improves soil fertility, controls and prevents soil erosion, controls water logging, checks acidification and eutrophication of stream and rivers, increases local biodiversity, decreases pressure on natural forests for fuel and provides fodder for livestock (Mukundi and Sathaye, 2004). Soil fertility is the main factor affecting crop productivity. *Bridelia retusa* (L.) A. Juss., locally known as Asana belongs to Euphorbiaceae family. Normally asana was found in Konkan region of Maharashtra. It is an indigenous species in Konkan widely use farmers as a fodder and multipurpose tree species. It is found throughout India up to an altitude of 1000 m, except in very dry regions. Bark is grey to brown exfoliating in irregular flakes. By Asana based agroforestry systems removing carbon from the atmosphere and developing soil fertility and also helps to improved productivity of plants and crops. In contrast to selected forest tree along with some crop species for soil improvement naturally in the bio-diverse condition. This system used for bund plantation, block plantation, as a source of nutrient etc. easily in Konkan region. Therefore, considering that there is an increasing need to reforest the expanding areas of degraded land by easily available agroforestry sources that occurs in most parts of the Konkan region of Maharashtra, The present study focuses on "Soil Fertility under Asana based Agroforestry Systems in Rainfed Lateritic Soil. "Arial yam (*Dioscorea bulbifera*), Pineapple (*Ananas comosus*), Elephant foot yam (*Amorphophallus paeonifolins*), Mulberry (*Morus alba*), Karonda (*Carissa carandas*), Jam (*Syzygium samarangense*), Seedless lemon (*Citrus latifolia*), are being selected as intercrops in agroforestry system.

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2. MATERIALS AND METHODS

The experiment was conducted at Research Farm of All India Co-ordinated Research Project on Agroforestry, Central Experimental Station, Wakavali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra during 2019-2020.The experimental soil is characterized by reddish colour; Lateritic type of Alfisols. The 15 years old block plantation of Asana tree species and framed in a randomized block design (RBD) with eight treatments and three replications. The treatment comprises *viz.* T1- Asana + Arial yam (*Dioscorea bulbifera*), T2- Asana + Pine apple (*Ananas comosus*), ,T3- Asana + Elephant foot, T4- Asana + Mulberry (*Morus alba*), T5- Asana + Karonda (*Carissa carandas*), T6- Asana + Jam (*Syzygium samarangense*), T7- Asana + Seedless Lemon (*Citrus latifolia*), T8- Only Asana (*Bridelia retusa*).Plot wise soil samples were collected at initial and after 1 year

period of soil analyzing for physicochemical properties of soil. Soil samples were collected at the depth of 0-30 cm and it was air dried, powdered and passed through <2 mm sieve for determination of physico-chemical properties. Bulk density was determine by Blake and Hartge (1986), Maximum water holding capacity determined by Piper (1966), electrical conductivity (EC), soil reaction (pH), were determined by Jackson (1973), organic carbon (OC) was determine by Piper (1966), available N determined by Subbiah and Asija, 1956, available P determined by Bray and Kurtz (1945) and available K determined by Piper (1966).

3. RESULTS AND DISSCUSION

Bulk density of soil: The improved bulk density of soil was observed under T6- Asana+ Jam (*Bridelia retusa* + *Syzygium samarangense*) 1.36 Mg m^{-3} in 2019 and 1.38 Mg m^{-3} in 2020. The less improvement of bulk density of soil was noted under T8 - only Asana (*Bridelia retusa*) 1.48 Mg m^{-3} in 2019 and 1.50 Mg m^{-3} in 2020, respectively. It is given in (Table 1). Less improvement in bulk density of soil was recorded in T8 - only Asana (*Bridelia retusa*) as compare to other species may be due to high compactions rate and less aggregations comparably to other. The maximum improvement in bulk density of soil might be due to the addition of plant and root biomass in soil and high builds up carbon in the soil helps to improved water stable in soil aggregates and microspores ultimately improved bulk density of soil (Meshram *et al.* 2020). Similar finding were observed by Hirmas *et al.* (2005), Ramesh *et al.* (2009) and Choudhury *et al.* (2013) the application of organic influenced the soil fertility and increased bulk density of soil.

Maximum water holding capacity of soil: The perusal data of maximum water holding capacity (MWHC) of soil are given in (Table 1). The maximum water holding capacity of soil was noted significantly high in T6 – Asana+ Jam (*Bridelia retusa* + *Syzygium samarangense*) 57.07% in 2019 and increased up to 60.27% in the year of 2020. Lowest MWHC of soil was noted in T8- only Asana (*Bridelia retusa*) 49.16% and 51.61% in the year of 2019 and 2020 respectively. The higher water holding capacity may be due to addition of organic matter in the soil helps to maintain high pore spaces (increases micro-capillary and macro-capillary pores in soil) resulted, it filled the high amount of water (Meshram *et al.* 2020). Moreover, Zou *et al.* (2001) also observed that increased rooting depth of different forest species significantly influenced bulk density and porosity of soil due to higher addition of root biomass ultimately greater formation of macro and micro pores inside which held high amount of water.

pH of soil: The study revealed that the T6– Asana+ Jam (*Bridelia retusa* + *Syzygium samarangense*) was noted highest pH 5.94 in 2019 and increased up to 5.97 in 2020 and T8– Only Asana (*Bridelia retusa*) had the lowest pH 5.27 in 2019 and 5.31 in 2020. The soil reaction like pH of soil had significant under different land use system and the data is given in (Table 2). The improvement in pH of soil may be attributed to several mechanisms that release H+ ions such as soil-based cation uptake and decomposition of organic matter to organic acid (Meshram *et al.* 2020). Similar findings were reported by Emma (2005) also observed that the addition of agroforestry litter and some phyto-remidial effect cause to increase soil pH particularly in

Table 1. Physical properties of soil under asana based agroforestry systems

Treatments	Bulk density (Mg m^{-3})		Water holding capacity (%)	
	2019	2020	2019	2020
T_1-Asana + Arial yam (*Dioscorea bulbifera*)	1.44	1.45	52.74	54.88
T_2- Asana + Pine apple (*Ananas comosus*)	1.47	1.47	53.49	55.08
T_3- Asana + Elephant foot yam (*Amorphophallus paeonifolins*)	1.40	1.42	52.92	54.62
T_4- Asana + Mulberry (*Morus alba*)	1.42	1.44	54.03	56.77
T_5- Asana + Karonda (*Carissa carandas*)	1.39	1.41	54.92	57.43
T_6- Asana + Jam (*Syzygium samarangense*)	1.36	1.38	57.07	60.27
T_7- Asana + Seedless Lemon (*Citrus latifolia*)	1.41	1.42	54.08	57.07
T_8- Only Asana (*Bridelia retusa*)	1.48	1.50	49.16	51.61
Mean	1.42	1.44	53.55	55.97
S.Em.±	0.009	0.012	1.32	1.22
C.D. at 5 %	0.028	0.036	4.01	3.71
C.V. %	1.11	1.43	4.27	3.79

acid soils. Singh *et al.* (2017) observed that after seven year plantation of Prosopis juliflora agroforestry systems were significantly influenced improvement in pH, EC, organic carbon of soil and productivity and also recorded the reclamation capacity in Alkali soil.

Electrical conductivity (EC): The maximum electrical conductivity of soil was found significantly in T6– Asana + Jam (*Bridelia retusa* + *Syzygium samarangense*) 0.232 in 2019 dS m^{-1} and increased up to 0.254 dS m^{-1} in the year of 2020. While less in T8 – Only Asana (*Bridelia retusa*) 0.076 in 2019 and 0.09 dS m^{-1} in 2020. Data of electrical conductivity of soil of asana-based agroforestry system shown in (Table 2). The higher improvement of electrical conductivity was recorded in T6 – Asana + Jam (*Bridelia retusa* + *Syzygium samarangense*). The low electrical conductivity could be due to the leaching of soluble salts due to heavy precipitation resulting into less concentration of soluble salts in the soil. Ekhuya *et al.*, (2015) recorded that the soils under Grevillea robusta have significantly higher pH, EC, Organic carbon and total organic carbon due high addition of agroforestry biomass in acidic soils. Singh *et al.* (2017) observed that after seven-year plantation of Prosopis juliflora agroforestry systems are significantly influenced improvement in pH, EC, Organic carbon of soil and productivity and also recorded the reclamation capacity in Alkali soil.

Organic carbon: The maximum organic carbon of soil was recorded by T6 – Asana + Jam (*Bridelia retusa* + *Syzygium samarangense*) 2.18% and 2.27. While lowest organic carbon was found in T8 – Only Asana (*Bridelia retusa*) 1.68% and 1.71% in the year of 2019 and 2020, respectively. The data of soil organic carbon under asana-based agroforestry systems is given in (Table 2). Similarly, Chakravarty *et al.* (2011) recorded that the soil organic carbon (SOC) per cent was highest in natural forest of Shorea robusta which as significantly higher than rest of the land use systems. Bhavya *et al.* (2017) observed that the soil organic carbon under Mango orchard has significantly higher than other land use systems.

Available Nitrogen of soil: Significantly higher available nitrogen of soil was recorded in T6 – Asana + Jam (*Bridelia retusa* + *Syzygium samarangense*) 343.66 kg ha^{-1} in 2019 and increased up to 351.33 kg ha^{-1} in 2020 whereas lowest in T8– Only Asana (*Bridelia retusa*) 298.07 kg ha^{-1} in 2019 and 303.92 kg ha^{-1} in 2020. The data on available nitrogen of soil is given in (Table 3). It might be attributed due to the available N status although showed increased under the organic matter, it has not been increased much due to the prevailing climatic condition accelerating oxidation of organic matter as well as the nature of nitrogen forms in the soil in the form of its losses through volatilization and leaching (Meshram *et al.* 2020). Similarly, Sing *et al.* (2010) observed that available N, P, K under poplar-based agroforestry system. They found available nitrogen were statistically significant. Available N, P, K improved the soil fertility due to deposition of litter. Moreover, Zeng *et al.* (2010) and Basak *et al.* (2018) reported that the increases in NPK status due to the addition nutrients through agroforestry litters may be contributed to the sustainability of crop and improved soil fertility.

Table 2. Chemical properties of soil under asana based agroforestry systems

Treatments	pH (1:2.5)		EC (dS m^{-1})		Organic carbon (%)	
	2019	2020	2019	2020	2019	2020
T_1-Asana + Arial yam (*Dioscorea bulbifera*)	5.83	5.87	0.096	0.108	1.81	1.91
T_2- Asana + Pine apple (*Ananas comosus*)	5.82	5.84	0.084	0.097	1.79	1.88
T_3- Asana + Elephant foot yam (*Amorphophallus paeonifolins*)	5.34	5.44	0.108	0.120	1.85	1.91
T_4- Asana + Mulberry (*Morus alba*)	5.82	5.85	0.099	0.115	1.87	1.95
T_5- Asana + Karonda (*Carissa carandas*)	5.85	5.88	0.137	0.150	1.89	1.99
T_6- Asana + Jam (*Syzygium samarangense*)	5.94	5.97	0.232	0.254	2.18	2.27
T_7- Asana + Seedless Lemon (Citrus latifolia)	5.92	5.95	0.132	0.149	1.87	1.96
T_8- Only Asana (*Bridelia retusa*)	5.27	5.31	0.076	0.090	1.68	1.71
Mean	5.72	5.762	0.120	0.135	1.87	1.95
S.Em.±	0.059	0.047	0.003	0.004	0.008	0.012
C.D. at 5 %	0.179	0.143	0.009	0.011	0.024	0.035
C.V. %	1.78	1.42	4.55	4.6	0.73	1.04

Available phosphorus of soil: The available phosphorus of soil was noted highest in T6 – Asana + Jam (*Bridelia retusa* + *Syzygium samarangense*) 22.30 kg ha^{-1} in 2019 and increased up to 25.20 kg ha^{-1} in the year of 2020. While lowest in T8 – Only Asana (*Bridelia retusa*) 14.63 kg ha^{-1} and 15.21 kg ha^{-1}, respectively in the years of experiment. The perusal data pertaining to available phosphorus in the soil is specified in (Table 3).Highest available phosphorus was recorded in T6 – Asana + Jam (*Bridelia retusa* + *Syzygium samarangense*) followed by T5–Asana + Karonda (*Bridelia retusa* + *Carissa carandas*), T7– Asana + Seedless lemon (*Bridelia retusa* + *Citrus latifolia*), this might have also solubilized the native phosphorus in the soil through the release of various organic acids which had the chelating effect that reduced phosphorus fixation (Meshram *et al.* 2020). Similar findings were also recorded by Finzi *et al.* (2001) during decomposition study maximum availability of the soil phosphorus in deciduous forest than pine forest due to optimum amount of moisture and decomposition of agroforestry litters in soil. Moreover, Kumar *et al.* (2017) showed the addition of litters contributed highest soil organic carbon and manganese was positively correlated with plant nutrients like (NPK).

Available potassium of soil: Among various land use system under asana-based agroforestry systems, data were found to be statistically significant and given in (Table 3). The available potassium of soil uppermost in T6–Asana + Jam (*Bridelia retusa* + *Syzygium samarangense*) 439.08 kg ha^{-1} and 455.84 kg ha^{-1} followed by T5 – Asana + Karonda (*Bridelia retusa* + *Carissa carandas*) 426.23 kg ha^{-1} and 440.57 kg ha^{-1} whereas lowest in T8 – Only Asana (*Bridelia retusa*) 338.56 kg ha-1 and 345.69 kg ha-1 during 2019 and 2020 respectively. The higher potassium in the soils might be due to greater degree of weathering of potash minerals in the region and higher amount of nitrogen content in the leaves of T6 – Asana + Jam which leads to synergistic effect through plant and root biomass contribution in soil or apply decomposition which increased the potassium content of the soil (Meshram *et al.* 2020). Potassium enhanced cellulose decomposition; one or more micronutrients enhanced leaf litter and crop residues (fine roots and straw). However, Alfaia *et al.* (2003) and Singh *et al.* (2010) recorded observed that the decomposition rate and higher amount of C, N, P, K (nutrients) returned in the soil under agroforestry systems.

4. CONCLUSION

It can be concluded that the improvement of soil fertility was recorded significantly by T6-Asana + Jam (*Syzygium samarangense*) followed by T5- Asana + Karonda (*Carissa carandas*) than other systems. Build up soil carbon was found due to addition of more amount of plant biomass in soil, fine roots of T6 – Asana + Jam, T5 – Asana + Karonda, T7 – Asana + Seedless lemon, T4 – Asana + Mulberry and also developed bio- stability in soil which helps to maintain soil health. The improvement of available macronutrients of soil were recorded maximum by addition of organic matter in T6 – Asana + Jam, followed by T5 – Asana + Karonda, T7 – Asana + Seedless lemon and T4 – Asana + Mulberry which helps to determining carbon, nitrogen, phosphorus, potassium mineralization in soil for development of

Table 3. Chemical properties of soil under asana based agroforestry systems

Treatments	Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	2019	2020	2019	2020	2019	2020
T_1-Asana + Arial yam (*Dioscorea bulbifera*)	321.86	328.20	17.33	18.64	370.03	394.79
T_2- Asana + Pine apple (*Ananas comosus*)	314.57	319.61	15.66	16.08	367.97	390.73
T_3- Asana + Elephant foot yam (*Amorphophallus paeonifolins*)	326.40	331.36	18.65	19.81	374.16	400.66
T_4- Asana + Mulberry (*Morus alba*)	325.49	330.13	17.84	19.17	371.58	398.40
T_5- Asana + Karonda (*Carissa carandas*)	332.36	339.34	19.09	21.40	426.23	440.57
T_6- Asana + Jam (*Syzygium samarangense*)	343.66	351.33	22.30	25.20	439.08	455.84
T_7- Asana + Seedless Lemon (*Citrus latifolia*)	329.61	335.51	18.92	20.54	418.92	431.35
T_8- Only Asana (*Bridelia retusa*)	298.07	303.92	14.63	15.21	338.56	345.69
Mean	324.00	329.93	18.05	19.50	388.32	407.26
S.E. m.±	1.64	1.61	0.50	0.56	1.57	1.56
C.D. at 5 %	4.97	4.87	1.53	1.69	4.76	4.73
C.V. %	0.88	0.84	4.84	4.96	0.7	0.66

soil fertility. T6 – Asana + Jam is the best treatment under asana based agroforestry systems seem to be increased the soil fertility.

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