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Effect of incorporation of agroforestry crop residues on yield, macro/micronutrients content and uptake by mustard in Alfisol

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ABSTRACT

An experiment study was conducted at AICRP on Agroforestry, Dr. BSKKV Dapoli, Dist. Ratnagiri, Maharashtra during 2020-2021. The experiment was laid out in a Randomized Block Design (RBD) with ten (10) treatments and three (3) replications using agroforestry crop residues. Incorporation of Ain (Terminalia tomentosa) residue @ 5 t ha-1 was significantly influenced the plants nutrients NPK and micronutrients content in grain and straw of mustard crop and its uptake viz. nitrogen uptake (23.92 kg ha-1), phosphorus uptake (6.76 kg ha-1), potassium uptake(14.55 kg ha-1), Zn uptake (53.52 g ha-1), Fe uptake (540.72 g ha-1), Mn uptake (102.50 g ha-1) and Cu uptake (34.93 g ha-1) over control. Application of agroforestry nutritious residues contributed organic matter in soil reflected to improve soil nutrients and crop yield.

INTRODUCTION

Agroforestry residues enables better plant growth and soil health. Furthermore, maintaining carbon inputs through residue recycling for coarse-textured soils is necessary for a long-term agro-ecosystem. Agroforestry crop residues retention combined with minimal tillage has been shown to increase soil hydrology, biological characteristics and fertility. Sharma *et al.*, (2018) locally referred to as Khardal, Indian mustard (Brassica juncea L.) is a member of the Cruciferae family. It is a significant oilseed crop of North India during the Rabi season and is commonly referred to as rai. After soybean (*Glycine max*) and palm (*Elaeisguineensis*) oil, mustard is the third most significant oilseed crop in the world. Mustard production accounts for over 28.6% of all oilseed crops grown in India, making it the second most significant edible oilseed crop after groundnuts. According to Odiwe and Muoghalu (2003), the management of crop residues and the recycling of agroforestry farm waste in soil is the primary route for the return of organic matter and nutrients from aerial parts of the plant community to the soil surface. It has a significant impact on soil formation and fertility as well as fundamental processes in nutrient cycling. Information regarding the impact of managing agricultural residues on soil nutrient availability and carbon mineralization is desperately needed. On the other hand, the majority of farmers in Maharashtra, Konkan Region engage in “rabbing” methods, which contaminate the soil with heavy metals and are detrimental to the ecosystem and soil health. Crop leftovers can be incorporated directly into the soil by farmers as an alternative to “rabbing,” which may aid in the long-term development of soil and crop health. In light of the pressing need to improve agricultural productivity and restore soil fertility using readily accessible agroforestry crop residual sources, which are found in the majority of Konkan region. Therefore, “Effect of incorporation of agroforestry crop residues on yield, nutrient content and uptake by mustard in Alfisol” is the main topic of this study. For the current study, *Terminalia tomentosa, Acacia auriculiformis, Acacia mangium, Glyricidia sepium, Mangifera indica, Anacardium occidentale, Synzygium cumini, Oryza sativa,* and *Eleucine* *coracana* were chosen as readily accessible crop residue species on farmer's fields. High local and regional significance led to the selection of this study. Agroforestry crop residues management will be definitely beneficial in future. With this background, the present study was undertaken to study the effect of incorporation of crop residues on carbon pools and properties of soil.

MATERIALS AND METHODS

The experiment was conducted at AICRP on Agroforestry, Central Experiment Station, Wakawali, Dr. BSKKV Dapoli, Dist. Ratnagiri, Maharashtra during 2020-21. At an elevation of 250 meters above mean sea level, Wakawali is situated in the Konkan area of coastal Maharashtra, bounded to the east by the Sahyadris hills and the Arabian Sea at 170 45' N and 73026' E longitude. With an average annual rainfall of more than 3540.8 mm, the area is known for its humid environment. The district main soils come from "Coastal trap" rock, or basalt, which is abundant in silicon, iron, and aluminum. The reddish colour, lateritic type of Alfisols, especially Kaolinitic and hyperthermic family of *Typic Haplustalf* are characteristics of the experimental soil. The soils are categorized by Keys to soil taxonomy as *Typic Halplustalf* of Wakawali (Kumbhave) series based on the seventh approximation (Soil Survey Staff, 2010). The soil sites status are, pH-5.19, EC-0.10 dS/m at, OC-13.01 g/kg, Avai. N-312.28 kg/ha, Avai. P_2O_5-8.70 kg/ha, Avai. K_2O-404.05 kg/ha, Avai. S- 7.32 kg/ha, DTPA-Zn- 0.98 mg/kg, DTPA-Fe- 18.75 mg/kg, DTPA-Mn- 37.59 mg/kg and DTPA-Cu-3.12 mg/kg. The present investigation was framed in randomized block design with ten treatments and three replications *viz.,* T_1- *Terminalia tomentosa,* T_2- *Acacia auriculiformis,* T_3- *Acacia mangium,* T_4- *Gliricidia sepium,* T_5- *Mangifera indica,* T_6- *Anacardium occidentale,* T_7- *Syzigium cumini,* T_8- *Oryza sativa,* T_9- *Eleucine coracana* and T_{10} -Absolute control. Treatment wise plant samples of mustard were collected. The plant was firstly cleaned by rinsing with detergent followed by 0.02 N HCl and deionised water. After cleaning the plant, they were air dried and oven dried at 70^0C for 12 hours and they were ground in electrically operated stainless steel blades grinder up to maximum fineness. The ground samples were stored in polythene bags with proper labelling for chemical analysis. At harvest, straw and grain yield was recorded and these plant components were further used for chemical analysis (Bhargava and Raghupati, 2001). Plant nitrogen was determined by Micro Kjeldhals method (AOAC, 1990). The plant phosphorus was determined calorimetrically (yellow colour method) as described by Jackson (1973). The potassium content in plant and grain samples were estimated using method described by Piper (1966) on Flame photometer. The total zinc, total iron, total manganese and total copper from plant and grain samples were estimated from diacid extract by wet digestions methods and read on Atomic Absorption Spectrophotometer (Jackson, 1973). The experimental data was subjected to analysis of variances (ANOVA) and treatment means were compared and significant differences were tested at P<0.05 using randomized block design (RBD) (Panse and Sukhatme. 1985).

Uptake of nutrients : Uptake of nutrients i.e. N, P, K, Zn, Fe, Mn and Cu were computed by considering biological yield (i.e. grain and whole plant) and concentration of the particular nutrient.

Nutrient content (%) × Yields of grain/dry matter (kg ha^{-1}) = 100

Crop residues chemical composition : The collected agroforestry residues were analyzed for nutrients (NPK) and lignin content. Overall highly nutritional status viz., N, P, K content in residues were noticed 1.51% (N), 0.73% (P), 0.97% (K) and 61.23% (C) receiving with *Terminalia tomentosa* followed by 2.04% (N), 0.52% (P), 0.80% (K) and 58.94% (C) with *Glyricidia sepium*than other agroforestry residues species. However, less lignin content was observed by *Rice* straw (7.43%) and Finger millet straw (9.17%) but it content lower nutrition status should not be recommended for balances nutrition. Therefore, *Terminalia tomentosa* (12.19) and *Glyricidia sepium* (8.10%) species recorded optimum lignin and its having high nutritional status will be definitely improving the decomposition of soil fertility. The lignin content in various residues was observed and it was ranged 7.43 to 34.17 %. The C: N ratio of crop residues varied from 28.89 to 95.10.

RESULTS AND DISCUSSION

Grain and straw yield of mustard : Application of agroforestry crop residues were significantly enhanced mustard grain and straw yield over control in *Alfisol* (Table 2). The maximum grain yield (384.33 kg ha^{-1}) was given by treatment (T_1) incorporation of *Terminalia tomentosa* residue @ 5 t ha^{-1} followed by *Glyricidia sepium* (378.78 kg ha^{-1}), *Synzigium cumini* (350.18 kg ha^{-1}), *Mangifera indica* (346.21 kg ha^{-1}) residues @ 5 t ha^{-1} of each which were found at par with each other. *Terminalia tomentosa* recorded 172.63 kg ha^{-1} more grain yield of mustard than absolute control. Similar trend was found in case of straw yield of

Table 1: Nutrients, lignin compositions and C: N ratio of agroforestry residues.

Treatments	C (%)	N (%)	P (%)	K (%)	Lignin (%)	C:N ratio
T_1-*Terminalia tomentosa*	61.23	1.58	0.87	0.98	12.29	38.75
T_2-*Acacia auriculiformis*	68.56	1.06	0.11	0.28	34.17	64.68
T_3-*Acacia mangium*	64.71	1.17	0.18	0.39	31.36	55.31
T_4- *Glyricidia sepium*	58.94	2.04	0.52	0.71	8.10	28.89
T_5-*Mangifera indica*	59.86	1.26	0.28	0.68	14.76	47.51
T_{6}-*A. occidentale*)	60.79	0.94	0.17	0.54	21.82	64.67
T_7-*Synzygium cumini*	54.26	0.98	0.23	0.73	18.35	55.37
T_8- Rice straw	37.09	0.39	0.05	0.47	7.43	95.10
T_9- Finger millet straw	35.56	0.38	0.07	0.53	9.17	93.58

Table 2: Effect of incorporation of agroforestry residues on grain and straw yield of mustard.

Treatments	Mustard grain yield (kg ha^{-1})	Mustard straw yield (kg ha^{-1})
T_1- *Terminalia tomentosa*	384.33	1165.06
T_2- *Acacia auriculiformis*	261.16	771.86
T_3- *Acacia mangium*	282.16	870.60
T_4- *Glyricidia sepium*	378.78	1056.11
T_5-*Mangifera indica*	346.21	1018.64
T_6-*Anacardium occidentale*	287.19	690.16
T_7-*Syzygium cumini*	350.18	1030.76
T_8- Rice straw	294.46	950.99
T_9- Finger millet straw	292.33	930.14
T_{10}- Absolute control	211.70	666.67
Mean	308.85	915.10
SE +	33.28	57.31
CD (p= 0.05)	98.89	170.27
CV %	18.66	10.85

mustard. The maximum straw yield (1165.06 kg ha^{-1}) was given by treatment(T_1) incorporation of *Terminalia tomentosa* residue @ 5 t ha^{-1} followed by *Glyricidia sepium*(1056.11 kg ha^{-1}), *Synzigium cumini* (1030.76 kg ha^{-1}), *Mangifera indica* (1018.64 kg ha^{-1}) residues @ 5 t ha^{-1}of each which were found at par with each other. The lowest grain and straw yield was observed in control (211.70 and 666.67 kg ha^{-1}). The similar results were reported by Regar *et al.*(2009) reported that the mustard yield was increased significantly by 25.1, 22.6, 20.8 and 18.6% due to incorporation of 10 t ha^{-1} FYM, FYM 5 t ha^{-1} + mustard straw 5 t ha^{-1}, FYM 5 t ha^{-1} + taramira straw 5 t ha^{-1} and Dhaincha green manuring, respectively. Whereas, Saha *et al.* (2010) reported the application of 3 t ha^{-1} crop residues for mustard have been improved yields of crop

Nitrogen content and uptake by mustard : Significantly maximum nitrogen content (3.23% in grain and 0.99% in straw) was recorded by the treatment *Terminalia tomentosa* residue @ 5 t ha^{-1} which was found at par with *Glyricidia sepium* (3.21% in grain and 0.98 % in straw), and *Mangifera indica (*3.17% grain and 0.97 % straw) residue @ 5 t ha^{-1} of each. The lowest nitrogen content was seen in the absolute control (2.74 % in grain and 0.65 % in straw) treatment. Similar trend was also found in the total uptake of nitrogen by mustard (Table 3). The increase in N uptake on application of quality residues is due to increase in yield, effective root system and increased concentration of nutrients in soil solution as well as better soil physical environment coupled with sufficiency of water and nutrients helped in better uptake of water and nutrients. Similar result recorded by the Jadhav (2018) reported that the application of 5 t ha^{-1} *Glyricidia sepium* residue was noticed significantly higher improvement NPK content and uptake by mustard. However, Regar *et al.* (2009) studied that incorporation of crop residue of mustard and taramira with green manuring improves total nitrogen in plants. Meena *et al.* (2018) revealed that considerably highest N content and uptake by mungbean were noticed with crop residue incorporation. Nurhidayati *et al.* (2018) and Ramesh *et al.* (2009) reported that application of organic residue improved significantly higher (NPK) contents and uptake.

Phosphorus content and uptake by mustard : The higher content (0.74 % in seed and 0.34 % in straw) and uptake (2.84 kg ha^{-1} in seed and 3.93 kg ha^{-1} in straw) of phosphorus as well as total (6.76 kg ha^{-1}) were found in treatment *Terminalia tomentosa* residue @ 5 t ha^{-1} which was at par with *Glyricidia sepium* residue @ 5 t ha^{-1} (0.70% in grain and 0.33 % in straw). The lowest content and uptake of phosphorus were recorded in absolute control (Table 4). The organics also help in enhancing nutrients availability in soil by reducing fixation of phosphorus, which improves the efficient use of added phosphorus. Similar findings were also observed by Jadhav (2018) reported that the application of 5 t ha^{-1} *Glyricidia sepium* residue was noticed significantly

Table 3: Effect of incorporation of agroforestry residues on nitrogen uptake by mustard.

Treatment	Nitrogen content (%)		Nitrogen Uptake (kg ha^{-1})		Total nitrogen Uptake (kg ha^{-1})
	Grain	Straw	Grain	Straw	Grain + Straw
T_1- *Terminalia tomentosa*	3.23	0.99	12.42	11.50	23.92
T_2- *Acacia auriculiformis*	2.81	0.71	8.56	5.45	14.01
T_3- *Acacia mangium*	2.93	0.67	5.61	5.80	11.41
T_4- *Glyricidia sepium*	3.21	0.98	12.22	10.32	22.54
T_5-*Mangifera indica*	3.17	0.97	11.91	10.24	22.15
T_6-*Anacardium occidentale*	2.95	0.87	7.10	5.98	13.08
T_7-*Syzygium cumini*	3.16	0.84	11.84	8.59	20.43
T_8- Rice straw	2.95	0.73	7.74	6.89	14.64
T_9- Finger millet straw	2.94	0.73	6.97	6.65	13.62
T_{10}- Absolute control	2.73	0.65	5.79	3.23	9.02
Mean	3.01	0.81	9.02	7.46	16.48
SE +	0.03	0.01	0.09	0.49	0.48
CD (p= 0.05)	0.09	0.02	0.27	1.46	1.42
CV%	1.79	1.19	1.77	11.42	5.00

Table 4: Effect of incorporation of agroforestry residues on phosphorus uptake by mustard.

Treatment	Phosphorus content (%)		Phosphorus uptake (kg ha^{-1})		Total phosphorus Uptake (kg ha^{-1})
	Grain	Straw	Grain	Straw	Grain+Straw
T_1- *Terminalia tomentosa*	0.74	0.34	2.84	3.93	6.76
T_2- *Acacia auriculiformis*	0.55	0.16	1.43	1.21	2.63
T_3- *Acacia mangium*	0.58	0.20	1.63	1.77	3.40
T_4- *Glyricidia sepium*	0.70	0.33	2.66	3.45	6.12
T_5-*Mangifera indica*	0.63	0.31	2.18	3.13	5.30
T_6-*Anacardium occidentale*	0.58	0.26	1.66	1.77	3.43
T_7-*Syzygium cumini*	0.69	0.27	2.43	2.75	5.17
T_8- Rice straw	0.62	0.26	1.83	2.44	4.27
T_9- Finger millet straw	0.65	0.26	1.89	2.39	4.27
T_{10}- Absolute control	0.43	0.10	0.91	0.68	1.59
Mean	0.62	0.25	1.94	2.35	4.30
SE +	0.02	0.00	0.22	0.16	0.34
CD (p= 0.05)	0.05	0.01	0.66	0.47	1.02
CV%	4.97	2.31	19.93	11.62	13.83

higher improvement NPK content and uptake by mustard. However, Nurhidayati *et al.* (2018) and Ramesh *et al.* (2009) reported that application of crop residue improved s higher (NPK) contents and uptake. Recently, Pandey *et al.* (2018) studied that, integrated effect of organic manure and crop residue also augmented phosphorus uptake by crops.

Potassium content and uptake by mustard: The higher P content (1.19 % in seed and 0.86 % in straw) and total uptake (14.55 kg ha^{-1}) were observed by the treatment *Terminalia tomentosa* residue @ 5 t ha^{-1} followed by *Mangifera indica* residue @ 5 t ha^{-1} (1.17% in grain and 0.82% in straw) and *Glyricidia sepium* residue @ 5 t ha^{-1} (1.18% in grain and 0.85% in straw). The lowest potassium content, uptake and total potassium were recorded in absolute control (0.85% in grain and 0.66 % in straw) (Table 5). The increase in N, P and K uptake owing to residues lies in fact that apart from supply of nutrients, it enhanced the availability of these nutrients to plant. It improved the soil environment, which encourages proliferous root system resulting in better absorption of moisture and nutrients and thus resulting higher biomass production. Similar results were also given by Jadhav (2018) reported that the application of 5 t ha^{-1} *Glyricidia sepium* residue was noticed significantly higher improvement NPK content and uptake by mustard. However, Nurhidayati *et al.* (2018) and Ramesh *et al.* (2009) reported that application of crop residue improved higher (NPK) contents and uptake.

Zinc (Zn) content and uptake by mustard : The maximum total zinc content (42.59 mg kg^{-1} in seed and 31.89 mg kg^{-1} in straw) and total uptake (53.52 g ha^{-1}) were recorded by *Terminalia tomentosa* residue @ 5 t ha^{-1} followed by *Glyricidia sepium* residue @ 5 t ha^{-1}, *Synzygium cumini* residue@ 5 t ha^{-1}), *Mangifera indica* residue@ 5 t ha^{-1}, Rice straw residue @ 5 t ha^{-1}, Finger millet residue@ 5 t ha^{-1} and *Acacia auriculiformis* residue @ 5 t ha^{-1}. The lowest zinc content, uptake and total were recorded in absolute control (37.67 mg kg^{-1}

Table 5: Effect of incorporation of agroforestry residues on potassium uptake in mustard.

Treatment	Potassium content (%)		Uptake (kg ha^{-1})		Total uptake (kg ha^{-1})
	Grain	Straw	Grain	Straw	Grain+Straw
T_1- *Terminalia tomentosa*	1.19	0.86	4.56	9.99	14.55
T_2- *Acacia auriculiformis*	1.09	0.66	2.84	5.07	7.90
T_3- *Acacia mangium*	1.06	0.69	2.98	5.98	8.96
T_4- *Glyricidia sepium*	1.18	0.85	4.46	9.01	13.47
T_5-*Mangifera indica*	1.17	0.82	4.04	8.32	12.36
T_6-*Anacardium occidentale*	1.13	0.78	3.23	5.39	8.62
T_7-*Syzygium cumini*	1.15	0.81	4.03	8.31	12.34
T_8- Rice straw	1.12	0.78	3.30	7.38	10.68
T_9- Finger millet straw	1.15	0.73	3.38	6.82	10.20
T_{10}- Absolute control	0.85	0.66	1.81	4.38	6.19
Mean	1.11	0.76	3.46	7.06	10.53
SE +	0.01	0.01	0.38	0.47	0.72
CD (p= 0.05)	0.03	0.03	1.14	1.38	2.13
CV%	1.59	2.42	19.18	11.42	11.77

Table 6: Effect of incorporation of agroforestry residues on zinc (Zn) uptake in mustard.

Treatment	Zn content (mg kg^{-1})		Zn uptake (g ha^{-1})		Total Zn uptake (g ha^{-1})
	Grain	Straw	Grain	Straw	Grain+Straw
T_1- *Terminaliatomentosa*	42.59	31.89	16.37	37.15	53.52
T_2- *Acacia auriculiformis*	40.85	31.89	10.67	23.72	34.39
T_3- *Acacia mangium*	40.54	30.74	11.44	26.74	38.17
T_4- *Glyricidia sepium*	42.58	30.71	16.12	33.64	49.76
T_5-*Mangifera indica*	42.46	31.85	14.70	32.40	47.10
T_6-*Anacardium occidentale*	38.47	31.81	11.05	20.79	31.84
T_7-*Syzygium cumini*	42.52	30.12	14.89	32.76	47.65
T_8- Rice straw	42.11	31.78	12.40	30.13	42.53
T_9- Finger millet straw	40.45	31.67	11.82	28.49	40.31
T_{10}- Absolute control	37.67	30.62	8.11	18.52	26.63
Mean	41.02	27.52	12.76	28.43	41.19
SE +	1.01	0.46	1.48	1.88	2.56
CD (p= 0.05)	3.00	1.38	4.39	5.60	7.61
CV %	4.26	2.60	20.08	11.47	10.77

in grain, 30.62 mg kg^{-1} in straw and total uptake-26.63 g ha^{-1}). The increase in uptake of micronutrients may be due to the availability of these nutrients from organic sources like quality residues. Kumar *et al.* (2016) noted that the effect of crop residue recorded significantly increases in zinc uptake uptake by rice (205 to 462 g ha^{-1}). Pandey *et al.* (2018) studied that, the integrated effect of organic manure and crop residue also augmented zinc uptake by crops.

Iron (Fe) content and uptake by mustard: The maximum Fe content (560.71 mg kg^{-1} in seed and 279.14 mg kg^{-1} in straw) and total uptake (540.18 g ha^{-1}) were noticed by the treatment *Terminalia tomentosa* residue@ 5 t ha^{-1} followed by *Glyricidia sepium* residue @ 5 t ha^{-1}, *Synzigium cumini* residue @ 5 t ha^{-1} and *Mangifera indica* residue @ 5 t ha^{-}which were found par with each other. The lowest iron content, uptake and total iron uptake were recorded in absolute control. The increase uptake of iron might be due to release of Fe from iron pyrites during oxidation process and release of native iron from soil. Similarly, Kumar *et al.* (2016) noted that the effect of crop residue on nutrient uptake by rice and wheat recorded significantly increases in iron uptake uptake by rice (521 to 936 g ha^{-1}). Pandey *et al.* (2018) studied that, integrated effect of organic manure and crop residue also augmented Fe uptake by crops.

Manganese (Mn) content and uptake by mustard: The higher content (94.84 mg kg^{-1} in seed and 56.71 mg kg^{-1} in straw) and total uptake (102.50 g ha^{-1}) was observed by *Terminalia tomentosa* residue@ 5 t ha^{-1} followed by *Glyricidia sepium* residue@ 5 t ha^{-1} (94.82 mg kg^{-1} in seed and 56.54 mg kg^{-1} in straw), *Synzygium cumini* residue@ 5 t ha^{-1} ,Rice straw residue@ 5 t ha^{-1},Finger millet straw residue@ 5 t ha^{-1} and *Mangifera indica* residue@ 5 t ha^{-1} which were found to be at par with each other (Table 8). The lowest manganese content (63.07 mg kg^{-1} in seed and 49.55 mg kg^{-1} in straw), uptake and total manganese were recorded in absolute control (no residue treatment). Organic based applications released organic acids helps for mineralization of native metals in soil. Similarly, Kumar *et al.* (2016) noted that the effect of crop residue

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Table 7: Effect of incorporation of agroforestry residues on iron (Fe) uptake in mustard.

Treatment	Fe content (mg kg^{-1})		Fe uptake (g ha^{-1})		Total Fe uptake (g ha^{-1})
	Grain	Straw	Grain	Straw	Grain+Straw
T_1- *Terminalia tomentosa*	560.71	279.14	215.50	325.22	540.72
T_2- *Acacia auriculiformis*	548.59	277.47	143.27	214.18	357.44
T_3- *Acacia mangium*	548.51	277.47	154.76	241.58	396.34
T_4- *Glyricidia sepium*	549.53	278.93	208.15	294.58	502.73
T_5-*Mangifera indica*	560.52	278.71	194.06	283.91	477.97
T_6-*Anacardium occidentale*	555.52	277.50	159.53	191.52	351.05
T_7-*Syzygium cumini*	547.36	278.39	191.67	286.95	478.61
T_8- Rice straw	556.41	277.90	163.84	264.29	428.13
T_9- Finger millet straw	547.60	277.63	160.07	258.24	418.31
T_{10}- Absolute control	441.77	264.25	92.77	175.83	268.60
Mean	541.65	276.74	168.36	253.63	421.99
SE +	6.65	2.19	17.82	15.49	27.47
CD (p= 0.05)	19.77	6.52	52.95	46.01	81.60
CV %	2.13	1.37	18.34	10.58	11.27

Table 8: Effect of incorporation of crop residues on manganese (Mn) and uptake in mustard.

Treatment	Mn content (mg kg^{-1})		Mn uptake (g ha^{-1})		Total Mn uptake (g ha^{-1})
	Grain	Straw	Grain	Straw	Grain+Straw
T_1- *Terminaliatomentosa*	94.84	56.71	36.45	66.04	102.50
T_2- *Acacia auriculiformis*	91.75	54.36	23.96	41.97	65.93
T_3- *Acacia mangium*	92.43	54.40	26.08	47.37	73.45
T_4- *Glyricidia sepium*	94.82	56.54	35.92	59.73	95.64
T_5-*Mangifera indica*	94.57	56.16	32.74	57.20	89.93
T_6-*Anacardium occidentale*	93.28	55.35	26.79	38.20	64.99
T_7-*Syzygium cumini*	94.24	56.23	33.00	57.97	90.96
T_8- Rice straw	94.63	55.82	27.86	53.08	80.94
T_9- Finger millet straw	93.40	54.43	27.30	50.63	77.93
T_{10}- Absolute control	63.07	49.57	13.18	32.96	46.14
Mean	90.70	54.96	28.33	50.51	78.84
SE +	1.29	0.41	2.99	3.02	5.02
CD (p= 0.05)	3.84	1.23	8.88	8.98	14.92
CV %	2.47	1.31	18.27	10.36	11.03

on nutrient uptake by rice and wheat recorded significantly increases in manganese uptake uptake by rice (431 to 718 g ha^{-1}).

Copper (Cu) content and uptake by mustard : Significantly higher copper content (30.70 mg kg^{-1} in seed and 19.85 mg kg^{-1} in straw) and total uptake (34.93 g ha^{-1}) were observed by *Terminalia tomentosa* residue @ 5 t ha^{-1} followed by *Glyricidia sepium* residue@ 5 t ha^{-1} (30.69 mg kg^{-1} in seed and 19.83 mg kg^{-1} in straw),*Synzygium cumini* residue@ 5 t ha^{-1}, Rice straw residue@ 5 t ha^{-1}, Finger millet residue@ 5 t ha^{-1} and *Mangifera indica* residue@ 5 t ha^{-1} which were observed at par with each other. The lowest copper content, uptake and total copper were recorded in absolute control. With the increment in supply of essential elements through organic/crop residues, their availability, mobilization and influx in to plant tissue and thus improving content and uptake in the crops. Similarly, Kumar *et al.* (2016) noted that the effect of crop residue on nutrient uptake by rice and wheat recorded significantly increases in copper uptake uptake by rice (44 to 88 g ha^{-1}).

CONCLUSIONS

Application of *Terminalia tomentosa* and *Glyricidia sepium* agroforestry quality residue species was improved plant nutrients content and uptake due to organic matter contribution in soil through residues. These agroforestry quality residues can enhance yield of mustard

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Table 9: Effect of incorporation of crop residues on copper (Cu) uptake in mustard.

Treatment	Cu content (mg kg $^{-1}$)		Cu uptake (g ha^{-1})		Total Cu uptake (g ha^{-1})
	Grain	Straw	Grain	Straw	Grain+Straw
T_1- *Terminalia tomentosa*	30.70	19.85	11.80	23.12	34.93
T_2- *Acacia auriculiformis*	28.43	18.93	7.42	14.61	22.03
T_3- *Acacia mangium*	29.78	18.90	8.41	16.45	24.86
T_4- *Glyricidia sepium*	30.69	19.83	11.62	20.94	32.56
T_5-*Mangifera indica*	30.49	19.77	10.56	20.14	30.70
T_6-*Anacardium occidentale*	29.32	18.81	8.42	12.98	21.40
T_7-*Syzygium cumini*	30.48	19.72	10.67	20.33	31.00
T_8- Rice straw	29.79	18.42	8.78	17.52	26.29
T_9- Finger millet straw	29.42	18.42	8.60	17.13	25.73
T_{10}- Absolute control	25.67	15.22	5.42	10.31	15.73
Mean	29.48	18.79	9.17	17.35	1.77
SE +	0.71	0.38	0.99	1.17	5.25
CD (p= 0.05)	2.10	1.12	2.95	3.47	2.39
CV %	4.15	3.48	18.72	11.66	11.54

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