

Results

Results

4. RESULTS

4.1. *MENTHA*

4.1.1. Morphological traits

The UPGMA tree based on the variation in morphological traits is shown in figure 2. In this tree, the three accession of the cultivated *Mentha spicata* (MS03, MS04 and MS05) were clustered in one group, while all accessions with erect stem (wild and cultivated *Mentha*) were clustered in another major group. This major group has two subgroups; a small one that includes two cultivated accessions *Mentha spicata* (MS01) and *Mentha piperita* (MP) and two wild accessions of *Mentha longifolia* (ML09 and ML30), and a large group that is diverged into two clusters, the large one includes a smaller cluster of the two accessions *Mentha spicata* (MS02) and *Mentha longifolia* (ML29), while the large number of accessions in both clusters is comprised the remaining wild accessions of *Mentha longifolia*. The mean values of the examined morphological traits are given in table 2.

The proximity (genetic distances) matrix among the samples included in the tree based on cluster analysis of morphological data is shown in table 3. Small distance values are scored among accessions of the same species, for example 0.003 between ML31 and ML32, 0.005 between ML02 and ML03. On the other hand higher values were recorded for accessions of different species. The highest value 0.97 was found between *M. longifolia* subsp. *schemperi* (ML01) and *M. piperita* (MP).

Table 2: Mean values and standard deviation of the morphological traits of the studied accessions of *Menha*.

Access.	Stem Length	Stem Width	Stem Diam.	Internode No	Internode L.	Leaf Length	Leaf Width	InfL Length	InfL Width	No of flower	Root Width	Root Diam.	Root Length	Germin. Per.	Stem
ML01	147.65 ± 4.71	1.56 ± 0.15	0.55 ± 0.06	35.40 ± 3.27	8.22 ± 1.02	7.13 ± 0.41	0.74 ± 0.1	5.55 ± 2.83	0.69 ± 0.14	45.40 ± 3.53	1.87 ± 0.13	0.60 ± 0.04	40.89 ± 2.17	8.20 ± 0.92	erect
ML02	138.25 ± 13.32	1.58 ± 0.29	0.56 ± 0.11	23.60 ± 3.10	8.37 ± 2.07	5.95 ± 1.43	2.59 ± 1.14	4.82 ± 2.02	0.81 ± 0.13	44.60 ± 6.04	1.58 ± 0.39	0.50 ± 0.12	35.18 ± 6.06	4.40 ± 1.08	erect
ML03	136.35 ± 23.57	1.57 ± 0.3	0.56 ± 0.11	23.80 ± 3.33	7.28 ± 1.28	6.62 ± 0.83	2.16 ± 0.27	5.51 ± 1.83	0.95 ± 0.14	42.60 ± 5.50	1.45 ± 0.29	0.46 ± 0.09	25.18 ± 4.61	4.90 ± 0.99	erect
ML04	91.01 ± 41.79	1.75 ± 0.25	0.62 ± 0.09	32.80 ± 3.74	7.19 ± 0.9	2.57 ± 0.57	1.0 ± 0.29	3.12 ± 1.67	0.83 ± 0.23	43.80 ± 5.90	1.48 ± 0.37	0.47 ± 0.12	26.83 ± 4.49	3.20 ± 0.42	erect
ML05	78.57 ± 27.74	2.00 ± 0.33	0.71 ± 0.11	32.80 ± 5.71	3.75 ± 0.84	2.22 ± 0.48	1.09 ± 0.36	8.23 ± 3.76	1.18 ± 0.2	39.60 ± 6.4	2.07 ± 0.18	0.66 ± 0.06	34.73 ± 5.35	3.60 ± 1.26	erect
ML06	83.36 ± 36.66	1.79 ± 0.5	0.63 ± 0.17	23.50 ± 3.98	4.43 ± 0.91	3.22 ± 1.5	1.53 ± 0.82	3.14 ± 1.04	0.73 ± 0.11	40.30 ± 1.64	1.56 ± 0.37	0.50 ± 0.12	27.56 ± 6.05	4.80 ± 1.69	erect
ML07	87.40 ± 28.54	1.56 ± 0.57	0.55 ± 0.20	22.50 ± 3.98	4.99 ± 0.92	2.82 ± 0.50	1.09 ± 0.20	3.64 ± 2.15	0.88 ± 0.26	41.50 ± 6.96	1.21 ± 0.5	0.39 ± 0.16	28.01 ± 7.78	3.00 ± 0.00	erect
ML08	84.00 ± 29.05	1.02 ± 0.20	0.36 ± 0.07	24.00 ± 3.65	2.93 ± 0.54	2.94 ± 0.53	1.03 ± 0.16	3.24 ± 1.41	0.98 ± 0.20	40.50 ± 6.06	1.87 ± 0.16	0.59 ± 0.05	24.38 ± 1.44	4.10 ± 0.99	erect
ML09	49.90 ± 8.20	0.90 ± 0.12	0.31 ± 0.05	18.60 ± 2.37	3.43 ± 0.58	2.94 ± 0.54	1.40 ± 0.24	3.75 ± 1.4	1.05 ± 0.17	42.00 ± 5.33	0.83 ± 0.11	0.26 ± 0.03	19.95 ± 2.81	3.70 ± 0.48	erect
ML10	76.15 ± 8.60	1.34 ± 0.41	0.47 ± 0.15	25.20 ± 3.68	3.79 ± 0.72	2.33 ± 0.61	1.05 ± 0.18	7.52 ± 3.63	0.69 ± 0.32	40.50 ± 4.45	1.88 ± 0.21	0.60 ± 0.07	25.98 ± 3.30	3.60 ± 0.97	erect
ML11	100.90 ± 38.10	1.19 ± 0.4	0.42 ± 0.14	28.30 ± 4.57	5.90 ± 1.66	3.08 ± 1.03	1.30 ± 0.39	3.29 ± 1.13	0.75 ± 0.11	41.00 ± 4.55	1.50 ± 0.47	0.48 ± 0.15	30.01 ± 6.91	3.20 ± 0.42	erect
ML12	73.25 ± 29.31	1.48 ± 0.42	0.52 ± 0.15	28.20 ± 5.59	4.86 ± 1.88	3.54 ± 0.49	1.58 ± 0.46	5.38 ± 3.31	0.97 ± 0.23	40.60 ± 3.27	1.59 ± 0.46	0.49 ± 0.14	29.90 ± 4.93	3.30 ± 0.48	erect
ML13	97.10 ± 27.35	1.56 ± 0.57	0.55 ± 0.20	27.30 ± 1.89	4.86 ± 0.68	3.03 ± 0.63	1.31 ± 0.28	6.53 ± 1.76	1.11 ± 0.23	38.50 ± 2.46	1.69 ± 0.31	0.54 ± 0.10	29.05 ± 3.78	4.20 ± 1.23	erect
ML14	81.05 ± 17.24	1.60 ± 0.18	0.570 ± 0.07	22.60 ± 4.14	5.21 ± 1.61	5.64 ± 1.78	2.05 ± 0.50	5.96 ± 3.34	0.91 ± 0.33	41.80 ± 7.79	1.72 ± 0.33	0.55 ± 0.11	16.58 ± 2.99	3.80 ± 0.79	erect
ML15	84.50 ± 35.15	1.13 ± 0.16	0.40 ± 0.06	22.70 ± 3.68	5.20 ± 1.25	4.37 ± 0.81	1.74 ± 0.48	3.16 ± 2.15	1.00 ± 0.27	44.50 ± 6.84	1.59 ± 0.40	0.51 ± 0.13	26.60 ± 6.53	4.60 ± 0.70	erect
ML16	67.25 ± 12.61	1.75 ± 0.34	0.62 ± 0.12	24.20 ± 4.83	8.64 ± 1.72	5.37 ± 1.30	1.99 ± 0.24	3.92 ± 1.64	0.95 ± 0.3	40.80 ± 5.67	1.97 ± 0.19	0.63 ± 0.06	34.27 ± 4.18	4.80 ± 0.92	erect
ML17	87.20 ± 29.84	1.02 ± 0.39	0.36 ± 0.14	29.00 ± 3.4	6.48 ± 1.34	4.47 ± 0.94	1.73 ± 0.31	4.67 ± 3.55	1.03 ± 0.28	42.50 ± 5.08	1.66 ± 0.48	0.53 ± 0.15	19.31 ± 3.93	4.80 ± 0.79	erect
ML18	101.34 ± 36.09	1.60 ± 0.18	0.57 ± 0.07	22.60 ± 4.14	5.21 ± 1.61	5.18 ± 2.25	2.28 ± 1.12	4.35 ± 2.51	1.00 ± 0.22	54.20 ± 14.48	1.74 ± 0.44	0.55 ± 0.14	32.51 ± 5.10	5.20 ± 0.63	erect
ML19	74.10 ± 24.81	1.46 ± 0.28	0.52 ± 0.1	32.30 ± 5.25	6.55 ± 2.14	3.60 ± 0.93	1.25 ± 0.4	4.35 ± 2.51	1.00 ± 0.18	42.20 ± 6.05	1.41 ± 0.45	0.45 ± 0.14	29.15 ± 6.48	4.80 ± 1.03	erect
ML20	77.73 ± 30.16	1.34 ± 0.44	0.47 ± 0.16	28.50 ± 5.66	5.30 ± 1.77	3.03 ± 0.64	1.19 ± 0.43	3.20 ± 1.54	0.40 ± 0.14	39.90 ± 5.00	1.26 ± 0.32	0.40 ± 0.10	23.04 ± 3.89	4.70 ± 0.82	erect
ML21	67.60 ± 13.17	1.38 ± 0.23	0.49 ± 0.08	23.80 ± 4.18	4.18 ± 0.83	3.04 ± 1.27	1.19 ± 0.43	3.20 ± 1.54	1.09 ± 0.18	40.20 ± 3.99	1.42 ± 0.33	0.45 ± 0.10	26.29 ± 4.00	5.00 ± 0.82	erect
ML22	80.90 ± 20.17	1.31 ± 0.28	0.46 ± 0.10	25.40 ± 4.3	4.31 ± 0.78	3.42 ± 1.07	1.47 ± 0.44	5.50 ± 3.41	1.09 ± 0.18	40.20 ± 3.99	1.42 ± 0.33	0.45 ± 0.10	26.29 ± 4.00	5.00 ± 0.82	erect
ML23	56.70 ± 22.84	1.84 ± 0.26	0.65 ± 0.09	24.00 ± 4.14	4.16 ± 0.53	2.81 ± 0.74	1.23 ± 0.32	6.93 ± 3.20	1.20 ± 0.17	43.10 ± 4.28	1.56 ± 0.46	0.50 ± 0.15	27.89 ± 5.59	3.60 ± 0.70	erect
ML24	98.65 ± 26.47	1.47 ± 0.34	0.55 ± 0.12	24.70 ± 3.65	5.10 ± 0.82	2.62 ± 0.83	1.18 ± 0.42	6.86 ± 2.45	0.99 ± 0.23	38.00 ± 3.77	1.50 ± 0.48	0.48 ± 0.15	27.95 ± 5.91	4.40 ± 0.52	erect
ML25	101.80 ± 41.40	1.26 ± 0.31	0.44 ± 0.11	23.10 ± 3.84	6.51 ± 1.36	3.92 ± 1.91	1.20 ± 0.61	5.68 ± 2.58	1.03 ± 0.18	40.40 ± 6.00	1.80 ± 0.27	0.58 ± 0.08	31.17 ± 4.69	4.00 ± 0.67	erect
ML26	58.17 ± 8.58	1.69 ± 0.33	0.60 ± 0.12	29.60 ± 6.19	7.50 ± 2.1	2.86 ± 0.31	0.86 ± 0.13	2.64 ± 1.45	0.67 ± 0.18	43.50 ± 3.97	1.75 ± 0.26	0.56 ± 0.08	31.17 ± 4.69	4.00 ± 0.67	erect
ML27	86.60 ± 19.62	1.41 ± 0.43	0.50 ± 0.15	24.50 ± 3.63	4.88 ± 0.92	5.16 ± 0.47	1.21 ± 0.52	5.11 ± 2.33	0.87 ± 0.23	43.60 ± 5.52	1.51 ± 0.37	0.48 ± 0.11	25.56 ± 4.39	5.00 ± 0.82	erect
ML28	106.95 ± 23.49	1.56 ± 0.32	0.55 ± 0.12	24.60 ± 4.99	5.33 ± 1.64	2.76 ± 1.03	1.09 ± 0.31	5.56 ± 2.12	1.05 ± 0.13	45.10 ± 5.40	1.48 ± 0.38	0.47 ± 0.11	28.03 ± 5.59	4.50 ± 0.53	erect
ML29	66.60 ± 17.82	0.96 ± 0.21	0.34 ± 0.07	18.60 ± 3.3	4.61 ± 1.11	3.46 ± 0.5	1.30 ± 0.21	4.89 ± 2.07	0.93 ± 0.20	42.80 ± 6.94	1.48 ± 0.41	0.47 ± 0.13	19.02 ± 3.26	4.60 ± 0.70	erect
ML30	52.20 ± 8.53	1.00 ± 0.19	0.35 ± 0.07	17.70 ± 2.58	4.98 ± 1.37	2.67 ± 0.58	1.58 ± 0.34	8.13 ± 3.36	1.10 ± 0.31	45.00 ± 4.92	1.17 ± 0.35	0.37 ± 0.11	17.87 ± 4.09	4.70 ± 0.67	erect
ML31	59.35 ± 7.93	1.33 ± 0.45	0.47 ± 0.16	24.50 ± 4.74	5.23 ± 1.33	3.89 ± 0.76	1.71 ± 0.41	4.70 ± 2.45	0.88 ± 0.27	43.20 ± 5.45	1.80 ± 0.25	0.57 ± 0.08	25.38 ± 5.51	4.40 ± 0.52	erect
ML32	54.65 ± 10.51	1.40 ± 0.36	0.49 ± 0.13	22.70 ± 3.56	4.79 ± 0.65	3.42 ± 0.7	1.31 ± 0.30	2.67 ± 0.99	0.74 ± 0.12	38.50 ± 5.08	1.42 ± 0.30	0.45 ± 0.09	22.21 ± 3.56	5.30 ± 1.16	erect
MS01	75.4 ± 20.68	0.89 ± 0.17	0.31 ± 0.06	26.5 ± 3.50	8.79 ± 1.76	3.92 ± 0.66	1.89 ± 0.42	9.35 ± 4.61	0.94 ± 0.28	49.2 ± 3.61	0.52 ± 0.11	0.17 ± 0.03	16.63 ± 2.97	5.9 ± 1.45	erect
MS02	85.81 ± 17.98	0.89 ± 0.13	0.32 ± 0.05	31.4 ± 4.03	11.26 ± 1.65	4.11 ± 0.3	1.9 ± 0.45	7.28 ± 2.8	1.08 ± 0.13	42.6 ± 5.34	0.61 ± 0.09	0.2 ± 0.03	12.31 ± 1.49	4.9 ± 0.99	prostrate
MS03	18.4 ± 3.48	0.61 ± 0.10	0.21 ± 0.04	10.4 ± 1.17	2.1 ± 0.21	2.95 ± 0.47	1.52 ± 0.3	7.24 ± 2.8	1.08 ± 0.13	42.6 ± 5.34	0.61 ± 0.09	0.2 ± 0.03	12.31 ± 1.49	4.9 ± 0.99	prostrate
MS04	64.38 ± 25.41	0.94 ± 0.21	0.33 ± 0.07	19.0 ± 2.49	3.75 ± 0.66	2.74 ± 0.34	1.65 ± 0.23	3.63 ± 0.47	0.84 ± 0.14	32.4 ± 2.07	0.71 ± 0.06	0.23 ± 0.02	10.5 ± 1.38	14 ± 0.94	prostrate
MS05	27.83 ± 1.81	0.90 ± 0.11	0.32 ± 0.04	8.5 ± 0.85	3.57 ± 0.47	2.74 ± 0.34	1.65 ± 0.23	3.63 ± 0.47	0.84 ± 0.14	32.4 ± 2.07	0.71 ± 0.06	0.23 ± 0.02	10.5 ± 1.38	14 ± 0.94	prostrate
MP	19.97 ± 2.24	0.80 ± 0.07	0.28 ± 0.02	10.1 ± 1.52	1.99 ± 0.20	2.72 ± 0.40	1.64 ± 0.25	3.44 ± 0.67	0.88 ± 0.09	41.7 ± 5.12	0.7 ± 0.07	0.22 ± 0.02	10.15 ± 1.28	16.2 ± 0.63	erect

Table 3: The values of genetic distances among *Mentha* accessions based on morphological data.

Accession	ML01	ML02	ML03	ML04	ML05	ML06	ML07	ML08	ML09	ML10	ML11	ML12	ML13	ML14	ML15	ML16	ML17	ML18	ML19	ML20	ML21	ML22	ML23	ML24	ML25	ML26	ML27	ML28	ML29	ML30	ML31	ML32	MS01	MS02	MS03	MS04	MS05	MP		
ML01																																								
ML02	0.015																																							
ML03	0.028	0.005																																						
ML04	0.190	0.125	0.112																																					
ML05	0.284	0.280	0.181	0.016																																				
ML06	0.243	0.167	0.153	0.005	0.010																																			
ML07	0.217	0.144	0.131	0.002	0.013	0.001																																		
ML08	0.243	0.186	0.180	0.004	0.012	0.002	0.001																																	
ML09	0.556	0.438	0.467	0.068	0.088	0.085	0.000	0.005																																
ML10	0.287	0.215	0.197	0.014	0.007	0.004	0.008	0.004	0.042																															
ML11	0.130	0.078	0.071	0.008	0.030	0.018	0.011	0.018	0.151	0.035																														
ML12	0.133	0.087	0.088	0.004	0.022	0.011	0.007	0.011	0.132	0.024	0.001	0.031																												
ML13	0.281	0.185	0.198	0.013	0.020	0.009	0.005	0.004	0.064	0.007	0.033	0.014	0.024																											
ML14	0.238	0.180	0.145	0.003	0.014	0.001	0.001	0.008	0.006	0.017	0.010	0.012	0.008	0.008																										
ML15	0.225	0.272	0.285	0.008	0.013	0.004	0.007	0.022	0.030	0.010	0.083	0.004	0.051	0.028	0.005																									
ML16	0.225	0.186	0.133	0.004	0.018	0.008	0.008	0.004	0.081	0.011	0.016	0.018	0.011	0.004	0.005	0.035																								
ML17	0.197	0.082	0.070	0.013	0.053	0.026	0.018	0.021	0.145	0.041	0.012	0.054	0.011	0.044	0.028	0.021	0.013																							
ML18	0.301	0.221	0.222	0.024	0.014	0.003	0.024	0.023	0.080	0.018	0.048	0.011	0.042	0.035	0.017	0.016	0.028	0.043																						
ML19	0.275	0.282	0.188	0.010	0.004	0.003	0.007	0.004	0.061	0.002	0.028	0.001	0.042	0.011	0.004	0.009	0.010	0.041	0.010																					
ML20	0.373	0.278	0.258	0.002	0.018	0.014	0.022	0.014	0.018	0.005	0.083	0.005	0.065	0.013	0.017	0.008	0.073	0.068	0.022	0.002																				
ML21	0.256	0.183	0.167	0.007	0.000	0.003	0.001	0.006	0.001	0.023	0.004	0.014	0.005	0.005	0.002	0.014	0.005	0.028	0.017	0.026	0.010																			
ML22	0.464	0.383	0.343	0.008	0.033	0.038	0.051	0.041	0.006	0.021	0.107	0.018	0.048	0.038	0.042	0.010	0.066	0.114	0.028	0.028	0.008	0.032																		
ML23	0.148	0.081	0.078	0.008	0.028	0.013	0.004	0.013	0.135	0.027	0.002	0.038	0.001	0.025	0.014	0.057	0.013	0.010	0.051	0.038	0.054	0.017	0.008	---																
ML24	0.148	0.086	0.086	0.011	0.047	0.022	0.015	0.019	0.147	0.038	0.007	0.051	0.001	0.024	0.020	0.016	0.013	0.001	0.065	0.021	0.064	0.026	0.114	0.082																
ML25	0.440	0.348	0.334	0.059	0.008	0.037	0.049	0.041	0.018	0.022	0.088	0.013	0.084	0.043	0.043	0.007	0.053	0.115	0.020	0.047	0.005	0.011	0.031	0.003	0.008	0.015	0.047													
ML26	0.108	0.056	0.046	0.014	0.051	0.031	0.021	0.030	0.181	0.052	0.004	0.083	0.006	0.006	0.004	0.027	0.088	0.008	0.008	0.007	0.018	0.006	0.035	0.136	0.063	0.008	0.130	0.022												
ML27	0.221	0.148	0.134	0.002	0.013	0.001	0.001	0.018	0.022	0.088	0.013	0.011	0.006	0.006	0.006	0.005	0.003	0.016	0.020	0.047	0.018	0.006	0.035	0.136	0.063	0.008	0.130	0.022												
ML28	0.387	0.283	0.286	0.040	0.034	0.021	0.029	0.020	0.015	0.011	0.076	0.014	0.061	0.013	0.021	0.015	0.028	0.068	0.031	0.050	0.003	0.017	0.011	0.127	0.068	0.130	0.022													
ML29	0.538	0.418	0.384	0.062	0.068	0.081	0.073	0.081	0.002	0.038	0.144	0.038	0.122	0.047	0.083	0.031	0.074	0.132	0.054	0.020	0.018	0.082	0.008	0.085	0.135	0.021	0.088	0.180	0.012											
ML30	0.441	0.341	0.320	0.054	0.059	0.051	0.043	0.033	0.004	0.018	0.088	0.012	0.078	0.030	0.034	0.008	0.044	0.089	0.024	0.033	0.004	0.025	0.001	0.107	0.088	0.003	0.040	0.182	0.007	0.009										
ML31	0.487	0.385	0.362	0.075	0.048	0.048	0.060	0.047	0.003	0.027	0.120	0.024	0.101	0.040	0.051	0.017	0.080	0.121	0.044	0.014	0.009	0.028	0.004	0.044	0.120	0.005	0.057	0.152	0.010	0.008	0.008									
ML32	0.350	0.224	0.208	0.023	0.027	0.017	0.021	0.015	0.045	0.010	0.051	0.015	0.041	0.007	0.014	0.028	0.012	0.038	0.018	0.021	0.013	0.012	0.028	0.028	0.043	0.032	0.014	0.083	0.032	0.035	0.022	0.035								
MS01	0.244	0.174	0.180	0.018	0.003	0.021	0.021	0.018	0.088	0.020	0.032	0.027	0.048	0.012	0.018	0.046	0.007	0.022	0.008	0.025	0.035	0.018	0.082	0.380	0.028	0.090	0.013	0.093	0.037	0.075	0.051	0.071	0.007							
MS02	0.400	0.330	0.330	0.034	0.063	0.021	0.021	0.038	0.088	0.030	0.043	0.037	0.073	0.027	0.018	0.040	0.007	0.022	0.044	0.030	0.031	0.014	0.014	0.078	0.283	0.140	0.282	0.481	0.138	0.075	0.121	0.091	0.208	0.480						
MS03	0.434	0.328	0.380	0.054	0.084	0.024	0.043	0.031	0.015	0.019	0.084	0.028	0.077	0.017	0.034	0.030	0.037	0.044	0.035	0.008	0.027	0.017	0.014	0.380	0.080	0.028	0.038	0.113	0.083	0.070	0.012	0.015	0.014	0.122						
MS04	0.400	0.330	0.380	0.054	0.084	0.024	0.043	0.031	0.015	0.019	0.084	0.028	0.077	0.017	0.034	0.030	0.037	0.044	0.035	0.008	0.027	0.017	0.014	0.380	0.080	0.028	0.038	0.113	0.083	0.070	0.012	0.015	0.014	0.122						
MS05	0.400	0.330	0.380	0.054	0.084	0.024	0.043	0.031	0.015	0.019	0.084	0.028	0.077	0.017	0.034	0.030	0.037	0.044	0.035	0.008	0.027	0.017	0.014	0.380	0.080	0.028	0.038	0.113	0.083	0.070	0.012	0.015	0.014	0.122						
MP	0.370	0.309	0.315	0.313	0.255	0.248	0.280	0.085	0.205	0.401	0.201	0.285	0.221	0.285	0.172	0.275	0.378	0.227	0.225	0.146	0.234	0.108	0.371	0.385	0.132	0.270	0.445	0.132	0.071	0.115	0.088	0.158	0.278	0.010	0.118	0.154				

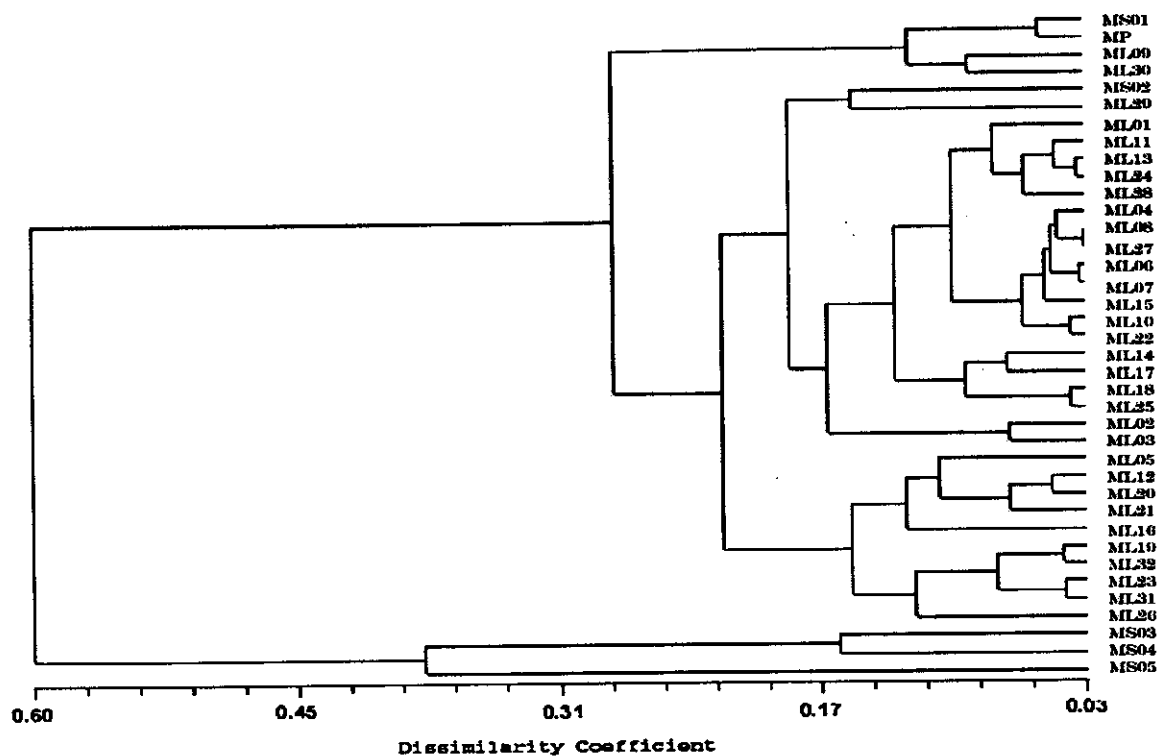


Figure 2: A UPGMA tree illustrating the relationships among *Mentha* accessions based on the analysis morphological data.

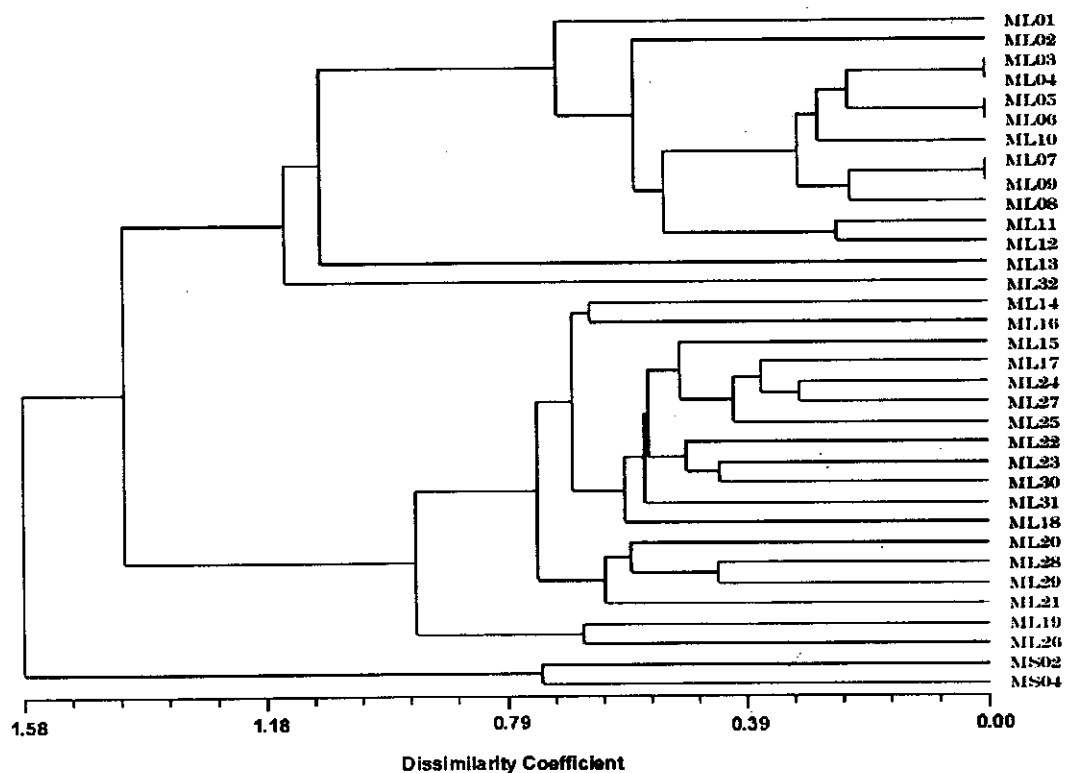


Figure 4: A UPGMA tree illustrating the relationships among *Mentha* accessions based on the analysis of seed protein electrophoretic data.