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Research Article

YIELD PERFORMANCE OF *Chlorophytum borivilianum* SANT. & FERN AND ACCESSIONS IN MORINGA BASED AGROFORESTRY SYSTEM

MEHTA A.A., TANDEL M.B., PATEL D.P., BEHERA L.K., PRAJAPATI D.H.* AND JADEJA D.B.

College of Forestry, Navsari Agricultural University, Navsari, 396450, Gujarat, India
*Corresponding Author: Email-prajapatidharamshi@gmail.com, aamehta@nau.in

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Abstract- The field investigation on *Chlorophytum borivilianum* Sant. & Fernand germplasm for yield attributes and suitability in Agroforestry system was carried out at ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India during 2014-2015. For the study 10 accessions collected from different parts of India were evaluated. Significantly higher fresh weight of leaves (24.20 g/plant) and dry weight of leaves (5.58 g/plant) were noted in safed musli accession C_2. Fresh weight of single tuber/finger (1.88 g) and dry weight of single tuber/finger (0.49 g) were higher in safed musli accession C_4. Significantly higher tuber yield was observed in safed musli accession C_5 (11.85 g/plant). The interaction effect of various land use systems and accessions of safed musli was found non-significant for all yield parameters under study in respective years of investigation. However, in pooled analysis fresh weight of single tuber and dry weight of single tuber were found significant. BCR was recorded maximum in safed musli accession C_5 when it was grown in open condition (1:2.69) as well as under moringa based Agroforestry system (1:2.76).

Keywords- Safed Musli, Moringa, Intercrop, Yield

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Introduction

For millennia, herbal drugs have been recognized and are now in great demand all over the world as a rich source of therapeutic agents for the remedy of various diseases and ailments. About 12.5% of the 4,22,000 plant species documented worldwide are reported to have medicinal values; but only a few hundred are known to be in cultivation[1].

C. borivilianum, a medicinal plant is known for its use from ancient age. The Indian Pharmacopoeia has recognized safed musli as one of the 85 drug plants, whose ingredients are used in various pharmaceutical preparations. The National Medicinal Plants Board (NMPB), set up by the Government of India has ranked safed musli as the 6th among the 28 selected priority medicinal plants for cultivation and export [2,3].

Dried roots of *C. borivilianum* popularly known as safed musli in India, because of its aphrodisiac and sex tonic properties is considered as wonder drug in Indian system of medicine (Ayurveda, Unani and Siddha). Safed musli roots are the major constituents of more than 100 Ayurvedic formulations because of its great therapeutic importance [4]. *C. borivilianum* possess the highest economic value owing to its highest saponin content in genus Chlorophytum. [5].

On an average, 2000–3000 kg of wet musli (fresh harvested tubers) can be harvested from *C. borivilianum* per acre [6]. According to other report, nearly ten quintals of fleshy root (wet) per hectare collected is reduced to 200 kg (about 20% of wet root wt) after processing and drying [7] and after drying up to 20% (400–450 kg) dry musli is finally obtained. In indigenous Indian market, rate of dry musli is around Rs. 800 to 1,800 per kg in whereas in the international market, it is about Rs. 3,000 per kg [6].

Performance of the safed musli accessions and its yield under the moringa based agroforestry system is very essential to know the suitability of different accessions under intercropping with moringa in South Gujarat condition and getting the maximum benefit from its cultivation.

Materials and Method

Field experiments were conducted under support irrigation conditions during monsoon season 2014 and 2015 at Navsari Agricultural University, Navsari, Gujarat to study the yielding ability of safedmusli (*Chlorophytum borivilianum* Santapau & Fernandes) under *Moringa* based Agroforestry systems in South Gujarat. One year old plantation of drumstick tree (*Moringa oleifera* Lam)cv. PKM-1 at 3.0 x 3.0 m spacing was used for intercropping study. From different parts of India, 10 accessions of Safedmusli (*Chlorophytum borivilianum*) *viz*., C_1- Kalam khet (Dang, Gujarat), C_2- Melghat (Maharashtra), C_3- JNKVV (Jabalpur, Madhya Pradesh), C_4- Satpuda (Maharastra), C_5- Sahyadri (Maharashtra), C_6- Bhuvadi (Dang, Gujarat), C_7- Rambhas chikar (Dang, Gujarat), C_8- Pratapgarh (Rajasthan), C_9- SFRI (Madhya Pradesh) and C_{10}- Dhar (Madhya Pradesh) were selected for the present study.

The experimental data were subjected to the statistical analysis as per the procedure suggested by Gomez and Gomez (1984) [8]. Experimental design was adopted for the study was Factorial Randomized Block Design (FRBD) with 3 replications. Land use system i.e. safed musli as a sole crop (A_0) and safed musli intercropped under the moringa trees (A_1) were considered as two factors.

The land was prepared before the receipt of early monsoon. Soil was brought to a fine tilth by giving about two deep ploughing (cultivator, disc plough, rotary plough). Weeds stubbles, roots *etc*. were removed. Before the receipt of monsoon showers, raised beds of 15 cm height and 2 m length and 2 m width were prepared. Farm yard manure was applied @10 tha^{-1} (for safed musli) to all the plots uniformly and was incorporated into the soil at the time of land preparation.

No other forms of fertilizers were applied in the soil. Planting of tubers were done in the second week of June. The observations on yield and its attributes in safed musli plant were recorded during the course of investigation. Above ground parameters i.e. fresh weight of leaves (g/plant) and dry weight of leaves (g/ plant) were taken at 60 DAP whereas, other parameters like fresh weight of single tuber (g), dry weight of single tuber (g) and tuber yield (g/plant) were observed after harvesting of safed musli. The yield was extrapolated into kg/ha unit and by consideration of the all expenditure and benefits, economics of the cultivation of safed musli as sole crop and as intercrop under moringa based AF system was also worked out.

Results and Discussion

The mean data pertaining to variation in fresh and dry weight of leaves of *safed musli* accessions in Moringa based agro-forestry systems as well as sole crop for the years 2014 and 2015 and their pooled analysis are presented in [Table–1]. Among all the accessions, fresh weight of leaves was found significantly higher in C_2 (22.60 g/plant) which was statistically at par with C_5 (22.34 g) and C_6 (21.17 g) in first year of investigation while minimum fresh weight of leaves was noticed in the accession C_1 (13.03 g/plant). Similar trend of results was observed in second year of investigation as well as in pooled analysis. With regard to different accessions, the results of dry weight of leaves was found significant in 2014, 2015 and in pooled analysis. It was found significantly higher in C_2 (5.37 g/plant) which was on same bar with C_6 (5.14 g/plant), C_5 (4.95 g/plant) and C_{10} (4.78 g/plant) whereas minimum dry weight of leaves was noted in accession C_3 (3.13 g/plant) in first year of investigation. Same trend was observed during second year of study and the pooled analysis.

Table-1 *Fresh and dry weight of leaves (g/plant) of safedmusli as influenced by moringa based AF system*

Treatments	Fresh weight of leaves (g/plant)			Dry weight of leaves (g/ plant)		
	2014	2015	Pooled	2014	2015	Pooled
Accessions (C)						
C_1	13.03	13.81	13.42	3.17	2.86	3.01
C_2	22.60	25.79	24.20	5.37	5.79	5.58
C_3	14.40	14.21	14.30	3.13	3.55	3.34
C_4	16.02	15.93	15.97	3.64	4.09	3.86
C_5	22.34	22.70	22.52	4.95	5.63	5.29
C_6	21.17	22.41	21.79	5.14	5.24	5.19
C_7	18.55	20.54	19.54	4.63	4.90	4.76
C_8	17.50	17.96	17.73	4.31	4.46	4.38
C_9	16.34	17.96	17.15	3.74	4.09	3.91
C_{10}	19.13	20.39	19.76	4.78	4.91	4.84
S. Em±	0.886	0.863	0.608	0.232	0.227	0.160
C.D. @ 5%	2.54	2.47	1.71	0.67	0.65	0.45
Landuse Systems (A)						
A_0	18.45	19.69	19.07	4.41	4.69	4.55
A_1	17.76	18.65	18.21	4.16	4.41	4.29
S. Em±	0.396	0.386	0.275	0.104	0.101	0.072
C.D. @ 5%	NS	NS	0.78	NS	NS	0.20
Interaction (A X C)						
S. Em±	1.253	1.221	0.882	0.329	0.321	0.222
C.D. @ 5%	NS	NS	NS	NS	NS	NS
CV %	11.98	11.03	11.50	13.28	12.20	12.72

With context to intercrop effect, the effect of both land use system was found non-significant however, maximum fresh weight of leaves was observed in sole crop (19.69) as compared to intercropping with Moringa (18.65). In context of intercrop effect, it was found non- significant during the both year but was significant in the pooled analysis. It was significantly higher in safed musli grown as sole crop (4.55 g/plant) as compared to safed musli grown as intercrop.

Table-2 *Fresh and Dry weight of single tuber (finger) (g) of safedmusli as influenced by moringa based AF system.*

Treatments	Fresh weight of single tuber (g)			Dry weight of single tuber (g)		
	2014	2015	Pooled	2014	2015	Pooled
Accessions (C)						
C_1	1.67	1.72	1.69	0.43	0.43	0.43
C_2	1.42	1.51	1.46	0.35	0.37	0.36
C_3	1.74	1.83	1.78	0.46	0.46	0.46
C_4	1.83	1.93	1.88	0.50	0.48	0.49
C_5	1.49	1.58	1.54	0.39	0.40	0.39
C_6	1.46	1.55	1.51	0.38	0.39	0.38
C_7	1.43	1.53	1.47	0.36	0.38	0.37
C_8	1.45	1.53	1.49	0.38	0.39	0.39
C_9	1.52	1.61	1.56	0.40	0.41	0.40
C_{10}	1.56	1.65	1.60	0.42	0.41	0.41
S. Em±	0.040	0.048	0.030	0.014	0.012	0.009
C.D. @ 5%	0.12	0.14	0.08	0.04	0.03	0.02
Landuse Systems (A)						
A_0	1.57	1.66	1.61	0.41	0.42	0.41
A_1	1.55	1.62	1.58	0.40	0.41	0.40
S. Em±	0.018	0.022	0.014	0.006	0.005	0.004
C.D. @ 5%	NS	NS	NS	NS	NS	NS
Interaction (A X C)						
S. Em±	0.057	0.068	0.043	0.020	0.017	0.013
C.D. @ 5%	NS	NS	0.12	NS	NS	0.03
CV %	6.36	7.20	6.82	8.39	7.15	7.79

The mean data pertaining to variation in fresh and dry weight of single tuber of *safed musli* accessions are presented in [Table-2 and 2a]. Among various accessions, significantly higher fresh and dry weight of single tuber was found in C_4 (1.83 g and 0.50 g, respectively) which was statistically at par with C_3 (1.74 g, and 0.46 g, respectively) while minimum fresh and dry weight of single tuber was noticed in the accession C_2 (1.42 g and 0.35 g, respectively) in first year of investigation. Similar trend of results was observed in second year of investigation as well as in pooled analysis. The effect of different land use system was found non-significant during the both years of study as well as in pooled analysis. However, maximum fresh and dry weight of single tuber (1.61 g and 0.41 g) was observed in sole crop. For interaction effect, C_4 accession grown under moringa based agroforestry system registered maximum fresh wet of single tuber (1.94 g) and dry weight of single tuber(0.51 g) in pooled analysis whereas in both the year it was non-significant.

Table-2a *Fresh and Dry weight of single tuber (finger) (g) of safed musli as influenced by moringa based AF system (Interaction)*

Treatments	Fresh weight of single tuber (finger) (g)		Dry weight of single tuber (finger) (g)	
	A_0	A_1	A_0	A_1
C_1	1.68	1.70	0.43	0.43
C_2	1.51	1.41	0.38	0.33
C_3	1.86	1.70	0.47	0.45
C_4	1.82	1.94	0.47	0.51
C_5	1.58	1.49	0.40	0.38
C_6	1.56	1.45	0.40	0.37
C_7	1.47	1.48	0.36	0.38
C_8	1.46	1.52	0.38	0.39
C_9	1.57	1.56	0.41	0.39
C_{10}	1.62	1.59	0.42	0.41
S. Em±	0.043		0.013	
C.D. @ 5%	0.12		0.03	
CV %	6.82		7.79	

During the year 2014, significantly higher tuber yield was noted in C_5 (12.36 g/plant) which was on same bar with C_2 (11.93 g/plant) and C_7 (11.93 g/plant) while minimum tuber yield was noted in C_1 accession (7.19 g/plant). Similar trend of results was observed during second year of investigation and pooled analysis. Among land use systems, significantly maximum root tuber yield (9.68 g/plant) was observed in sole crop in pooled analysis whereas it was non-significant in both years of investigation.

Analogous result of non-significant effect of intercropping (with coconut) in the yield attributes of *Indigoferatinctoria* accession were noticed by Sarada and Reghunath (2008) [9]. It could be due to availability of light which led to high rate of photosynthesis which had exposed maximum photosynthetic area (leaf area) to harness the available light energy and efficiently use it to synthesize adequate amount of photosynthates for biomass production. This leads to higher nutrient uptake resulting in their better translocation efficiency brought out by the combined application of various sources paving the way for better tuber development.

Table-3 *Tuber yield (g/plant) of safed musli as influenced by moringa based AF system*

Treatments	Tuber yield (g/plant)		
	2014	2015	Pooled
Accessions (C)			
C_1	7.19	7.67	7.43
C_2	11.93	9.92	10.92
C_3	7.83	8.37	8.09
C_4	7.29	8.06	7.67
C_5	12.36	11.35	11.85
C_6	11.58	10.91	11.24
C_7	11.93	10.64	11.28
C_8	10.79	9.70	10.25
C_9	8.38	7.97	8.17
C_{10}	8.14	8.37	8.25
S. Em±	0.241	0.317	0.462
C.D. @ 5%	0.69	0.91	1.48
Landuse Systems (A)			
A_0	9.89	9.48	9.68
A_1	9.59	9.11	9.35
S. Em±	0.108	0.142	0.088
C.D. @ 5%	NS	NS	0.25
Interaction (A X C)			
S. Em±	0.340	0.448	0.280
C.D. @ 5%	NS	NS	NS
CV %	6.05	8.34	7.24

Kumari *et al.* (2008 a& b) [10,11] revealed that the green forage yields (t/ha) for hybrid napier and guinea grass were higher in sole crop and reduction was noticed in horti-pasture system under of drumstick (*Moringa oleifera* Lam) cv. PKM-1. Maheshwari *et al.* (1985) [12] found similar results that sole crop of *Rauvolfia serpentina* produced higher number of roots when grown as sole crop. Similar results in the other species were reported by different workers *viz.,* Shinde (2001) [13] in forage crops with tree species, Parekh *et al.* (2005)[14] in pulse crop with forest tree species, Venugopal *et al.* (2008) [15] in patchouli (*Pogostemon patchouli* Benth.) in open and shade condition, Rathod *et al.* (2010) [16] in senna (*Cassia angustifolia*) with Rabi crops and Zhang *et al.* (2015) [17] in a young walnut and wheat alley cropping system.

Table-4 *Economics of safedmusli grown under moringa based AF system.*

Treatments	Yield (kg/ha)	Cost of cultivation (Rs.)	Income from *safedmusli* (Rs.)	Income from moringa * (Rs.)	Gross income (Rs.)	Net income (Rs.)	B:C Ratio
A0C1	1612.41	135969.87	322481.25	-	322481.25	186511.38	1.37
A0C2	2370.62	135969.87	474124.22	-	474124.22	338154.35	2.49
A0C3	1754.24	135969.87	350847.66	-	350847.66	214877.79	1.58
A0C4	1633.02	135969.87	326604.69	-	326604.69	190634.82	1.40
A0C5	2509.61	135969.87	501921.88	-	501921.88	365952.01	2.69
A0C6	2481.88	135969.87	496376.56	-	496376.56	360406.69	2.65
A0C7	2479.39	135969.87	495878.91	-	495878.91	359909.04	2.65
A0C8	2216.35	135969.87	443269.53	-	443269.53	307299.66	2.26
A0C9	1764.55	135969.87	352909.38	-	352909.38	216939.51	1.60
A0C10	1832.44	135969.87	366488.28	-	366488.28	230518.41	1.70
A1C1	1453.16	137469.87	290631.25	41662.5	332293.75	194823.88	1.42
A1C2	2134.95	137469.87	426989.06	41662.5	468651.56	331181.69	2.41
A1C3	1585.86	137469.87	317172.92	41662.5	358835.42	221365.55	1.61
A1C4	1531.12	137469.87	306224.48	41662.5	347886.98	210417.11	1.53
A1C5	2377.14	137469.87	475427.60	41662.5	517090.10	379620.23	2.76
A1C6	2159.16	137469.87	431832.92	41662.5	473495.42	336025.55	2.44
A1C7	2177.08	137469.87	435416.04	41662.5	477078.54	339608.67	2.47
A1C8	2010.86	137469.87	402172.60	41662.5	443835.10	306365.23	2.23
A1C9	1605.77	137469.87	321154.17	41662.5	362816.67	225346.80	1.64
A1C10	1575.91	137469.87	315182.29	41662.5	356844.79	219374.92	1.60

*The yield and income from moringa was considered from the second year.

Yield of intercrop also decreased with the age of the tree crop (Gill *et al.,* 2004) [18]. Benefit Cost Ratio (BCR) was found higher in the *safed musli* accession C_5 in both land use systems of sole cropping (2.69) and intercropping with Moringa (2.76). Accession C_1 showed minimum BCR in both land use systems and it was noted lowest in the safed musli grown as sole crop (1.37).

In most of cases, effect of land use systems on yield parameter of *safed musli* was found non-significant and higher in sole crop. It might be due to the fact that Moringa was in establishment stage. The crown in moringa tree is also sparse and allows a good amount of light to pass through.

Conclusion

It is concluded that there was a great variation among 10 accessions for various growth properties of safed musli. Based on superiority of yield and economics, accession such as C_5 (Sahyadri, Maharashtra), C_6 (Bhuvadi, Dang, Gujarat), C_7 (Rambhas chikar, Dang, Gujarat) and C_2 (Melghat, Maharashtra), are suited for growing under South Gujarat condition. There is non-significance difference in yield parameter of safedmusli grown as sole crop as well as intercrop under moringa having the age of two year. Besides this, most of accessions grown as intercrop under moringa were more beneficial as compared to safed musli grown as sole crop. This indicates that safed musli can be successfully grown under the tree canopy of moringa in the initial year of tree planting till canopy closure with maximum economic benefit.

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