CHAPTER IV

RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

The results and discussion pertaining to the study on **"Improving the Efficiency of Selected Natural Dyes on Cotton Fabric"** are discussed under the following heads :

4.1. Findings of the Market Survey
4.2. Findings of the Household Survey
4.3. Evaluation of the Dyed Samples
    4.3.1. Subjective Evaluation
        4.3.1.1. Visual Inspection of Dyed Samples
    4.3.2. Objective Evaluation
        4.3.2.1. Fabric Weight
        4.3.2.2. Fabric Thickness
        4.3.2.3. Tensile Strength of the Fabric (Warp and Weft)
        4.3.2.4. Elongation of the Fabric (Warp and Weft)
4.4. Wettability and Absorbency Tests
    4.4.1. Drop Test
    4.4.2. Sinking Test
    4.4.3. Capillary Rise Test
4.5. Effect of Sunlight, Washing, Wet and Dry Crocking and Pressing and Perspiration on the Dyed Samples
4.6. Colour Strength (K/S Values) of Dyed Samples
4.7. Effect of Physical Contact of Natural Dyed Samples with Human Skin
4.8. Physico-Chemical Characteristics of Natural Dye Effluent with reference to Potential Hydrogen, Total Suspended Solids, Total Dissolved Solids and Chemical Oxygen Demand
4.9. Effect of Natural Dye Effluent on Plant Growth
    4.9.1. Growth Parameter of Plant Samples
    4.9.2. Vigour Index and Germination Percentage

4.9.3. Soil Composition Before and After the Experimental Period with Reference to pH, Electrical Conductivity, Nitrogen, Phosphorus and Potassium

4.1. FINDINGS OF THE MARKET SURVEY

This part of the study includes the following details :

1. Availability of synthetic dyes in the selected shops
2. Availability of natural dyes in the selected shops
3. Availability of natural dyed fabrics in the selected shops

1. Availability of Synthetic Dyes in the Selected Shops

This part of the results give information on the details on availability, sale and purchase of synthetic dyes, type of consumers and the problems faced by the shop owners on the sale of synthetic dyes.

Details on the availability, sale and purchase of synthetic dyes with type of consumers in the selected shops are given in Table VI.

TABLE VI

AVAILABILITY, SALE AND PURCHASE OF SYNTHETIC DYES IN THE SELECTED SHOPS

S.No.	Details	Number of shops in selected cities									
		Coimbatore N-30		Salem N-30		Karur N-30		Madurai N-30		Total N-120	
		N	%	N	%	N	%	N	%	N	%
1.	**Type of Shop**										
	a. Whole Sale	7	23.3	5	16.7	6	20.0	5	16.7	23	19.2
	b. Retail	13	43.4	18	60.0	19	63.3	17	56.7	67	55.8
	c. Petty Shop	10	33.3	7	23.3	5	16.7	8	26.6	30	25.0
	Total	30	100.0	30	100.0	30	100.0	30	100.0	120	100.0
2.	**Demand for Synthetic Dyes**										
	a. Yes	28	93.3	22	73.3	24	80.0	25	83.3	99	82.5
	b. No	2	6.7	8	26.7	6	20.0	5	16.7	21	17.5
	Total	30	100.0	30	100.0	30	100.0	30	100.0	120	100.0
3.	**Type of Synthetic Dyes sold ***										
	a. Reactive	28	93.3	25	83.3	24	80.0	26	86.7	103	85.8
	b. Acid & Basic	14	46.6	5	16.6	9	30.0	7	23.3	35	29.2
	c. Vat	5	16.6	4	13.3	6	20.0	2	6.7	17	14.2
	d. Disperse	7	23.3	3	10.0	4	13.3	2	6.7	17	14.2
	e. Direct	2	6.7	5	16.6	3	10.0	4	13.3	14	11.7
	f. Naphthol	6	20.0	3	10.0	2	6.7	3	10.0	14	11.7
	g. Sulphur	4	13.3	4	13.3	2	6.7	3	10.0	13	10.8
4.	**Mode of Payment**										
	a. Cash	6	20.0	10	33.3	12	40.0	5	16.7	33	27.5
	b. Credit	18	60.0	15	50.0	9	30.0	20	66.7	62	51.7
	c. Cash and Credit	6	20.0	5	16.7	9	30.0	5	16.6	25	20.8
	Total	30	100.0	30	100.0	30	100.0	30	100.0	120	100.0
5.	**Frequency of Purchase ***										
	a. Fort night	5	16.7	11	36.6	3	10.0	14	46.6	33	27.5
	b. Monthly	18	60.0	23	76.6	12	40.0	7	23.3	60	50.0
	c. Whenever required	23	76.6	18	60.0	10	33.3	15	50.0	66	55.0
6.	**Type of Consumers ***										
	a. Small Scale Units	15	50.0	12	40.0	14	46.6	11	36.6	52	43.3
	b. Large Scale Units	6	20.0	9	30.0	8	26.6	4	13.3	27	22.5
	c. Agents	10	33.3	10	33.3	5	16.6	7	23.3	32	26.7
	d. Educational Institution	4	13.3	6	20.0	2	6.6	5	16.6	17	14.2
	e. Researchers	3	10.0	5	16.6	2	6.6	3	10.0	13	10.8

* MULTIPLE RESPONSE

Table VI reveals that among the 30 randomly selected shops for getting details about the synthetic dyes, there were 19.2 per cent whole sale shops, 55.8 per cent of retail shops, and 25 per cent of petty shops (small scale).

Among the 30 shops surveyed 82.5 per cent of the shop owners expressed that there is demand for synthetic dyes while 17.5 expressed that there was not so much demand for the synthetic dyes.

Among the synthetic dyes, reactive dyes were mainly sold, according to 85.8 per cent of the shop owners, next in demand was acid and basic dyes, as expressed by 29.2 per cent which was followed by vat and disperse dyes (14.2 per cent), and the last three in the order were direct and naphthol dyes (11.7 per cent) and sulphur dyes (10.8 per cent).

Only 27.5 per cent of the shop owners could purchase the dyes on cash payment, while 51.7 per cent purchased the dyes always on credit basis and 20.8 per cent paid cash sometimes and availed credit at other times. It was interesting to note that cash was paid for dyes which were in high demand and credit was availed for those dyes which were not in high demand.

The frequency of purchase of the dyes was fortnightly among 27.5 per cent of the shop owners, monthly among 50 per cent and as and when required for 55 per cent of the shop owners. Synthetic dyes were purchased by 43.3 per cent of small scale industries, 26.7 per cent of agents, 22.5 per cent of large scale industries, 14.2 per cent of educational institutions and 10.8 per cent of researchers. The number of consumers varied and the synthetic dyes were purchased by the consumers whenever required. The quantity purchased was not constant and the mode of purchase was only cash basis. The dyes were stored in plastic containers or glass bottles. The quantity purchased depended upon the demand for the synthetic dyes.

As only fresh dyes were effective, the shop owners did not store synthetic dyes for long period.

The major problems faced by the shop owners with reference to selling of synthetic dyes were difficulty in handling 75.5 per cent, due to its corrosive nature, storage of dyes was a problem as expressed by 73 per cent of the shop owners. Some of the dyes have a short shelf life and hence lost their potency (68.0 per cent). Creating respiratory problems, polluting the environment and causing skin allergy were the other problems expressed by 53 per cent, 50 per cent and 47 per cent of the shop owners respectively.

Even though synthetic dyes are in demand in the dyeing industry, the inherent problems faced in handling and storage of the dyes and health hazards faced suggest a suitable alternative.

2. Availability of Natural Dyes in the Selected Shops

This part of the results gives information regarding details on the availability, sale and purchase of natural dyes, type of consumers and the problems faced by the shop owners on the sale of natural dyes.

Details on the availability, sale and purchase of natural dyes with type of consumers in the selected shops is given in Table VII.

TABLE VII

AVAILABILITY, SALE AND PURCHASE OF NATURAL DYES WITH TYPE OF CONSUMERS IN THE SELECTED CITIES

S.No.	Particulars	Number of shops in selected cities									
		Coimbatore N-30		Salem N-30		Karur N-30		Madurai N-30		Total N-120	
		N	%	N	%	N	%	N	%	N	%
1.	**Type of Shop**										
	Whole Sale	4	13.3	6	20.0	3	10.0	6	20.0	19	15.8
	Retail	16	53.3	12	40.0	18	60.0	16	53.3	62	51.7
	Petty Shop	10	33.4	12	40.0	9	30.0	8	26.7	39	32.5
	Total	30	100.0	30	100.0	30	100.0	30	100.0	30	100.0
2.	**Demand for Natural Dyes**										
	Yes	15	50	12	40	14	47	18	60	59	49
	No	15	50	18	60	16	53	12	40	61	51
	Total	30	100.0	30	100.0	30	100.0	30	100.0	30	100.0
3.	**Type of Natural Dyes sold ***										
	Root Dyes	17	56.6	10	33.3	13	43.3	21	70.0	61	50.8
	Bark Dyes	12	40.0	12	40.0	9	30.0	18	60.0	51	42.5
	Seed Dyes	3	10.0	5	16.0	5	16.0	7	23.0	20	16.7
	Leaf Dyes	7	23.0	3	10.0	5	16.0	4	13.3	19	15.8
	Flower Dyes	5	16.0	4	13.0	7	23.0	4	13.0	20	16.7
	Fruit Dyes	4	13.3	3	10.0	6	20.0	3	10.0	16	13.3
4.	**Mode of Payment**										
	Cash	10	33.4	5	16.6	10	33.0	7	23.3	32	26.7
	Credit	11	36.6	15	50.0	14	47.0	20	66.7	60	50.0
	Cash and Credit	9	30.0	10	33.4	6	20.0	3	10.0	28	23.3
	Total	30	100.0	30	100.0	30	100.0	30	100.0	30	100.0
5.	**Frequency of Purchase**										
	Monthly	14	46.6	4	13.3	8	26.6	15	50.0	41	34.2
	Whenever required	16	53.3	26	86.7	22	73.4	15	50.0	79	65.8
	Total	30	100.0	30	100.0	30	100.0	30	100.0	30	100.0
6.	**Type of Consumers ***										
	Small Scale Units	10	33.0	15	50.0	9	30.0	5	16.0	39	32.5
	Large Scale Units	4	13.3	3	10.0	7	23.3	3	10.0	17	14.2
	Agents	12	40.0	6	20.0	7	23.3	9	30.0	34	28.3
	Educational Institution	6	20.0	5	16.0	6	20.0	7	23.3	24	20.0
	Researchers	4	13.0	6	20.0	4	13.3	13	43.3	27	22.5

*** MULTIPLE RESPONSE**

The survey on sale of natural dyes in randomly selected shops revealed that among the 120 shops surveyed there were 51.7 per cent retail shops, 32.5 per cent petty shops (small scale) and 15.8 per cent whole sale shops.

The survey also revealed that 49 per cent of the shop keepers felt that there was a demand for natural dyes, while the rest 51 per cent felt that there was no demand for natural dyes. The demand was felt more in Madurai and Coimbatore than in Karur and Salem.

Though natural dyes are obtained from various parts of plants such as roots, barks, seeds, leaves, fruits and flowers, the dyes obtained from roots (50.8 per cent) and bark (42.5 per cent) were more commonly sold when compared to the dyes obtained from the other parts of plants.

As noticed in any other business, the shop owners were purchasing the natural dyes either through cash payment or credit or using both cash and credit facilities. Irrespective of the cities selected, maximum of the shop owners 50.0 per cent purchased the dyes on credit basis only while 26.7 per cent paid cash and 23.3 per cent paid cash partly and availed credit for the balance while purchasing the dyes.

The frequency of purchase was on monthly basis by 34.2 per cent of the shop owners while the rest 65.8 per cent bought the dyes whenever there was a requirement. Though shelf life did not affect the quality of natural dyes, the shop owners purchased the dyes only on demand and sold out within a short period.

The natural dyes were purchased by 32.5 per cent of small scale industries, 14.2 per cent of large scale industries, 28.3 per cent of agents, 20 per cent of educational institutions and 22.5 per cent of researchers. The consumers purchased the dyes only whenever they required. The large scale units when they bought in large quantity, they purchased on credit basis while the rest purchased only on cash basis. Some of the natural dyes such

as red sandal, annatto and vembadam were procured from the manufacturers directly. The rest were purchased from agents. The shop owners experienced that the demand for the natural dyes were slowly on the increase.

The problems which were faced by the shop owners who sold natural dyes were limited availability, laborious processes involved in processing the dyes, limited colours and lack of colour fastness. These findings confirm that with increased awareness on health care, fabrics dyed with natural dyes are gaining popularity and natural dyes are available to cater the needs of the customers in spite of the problems involved. However problems stated above need to be solved to make the natural dyes more acceptable.

Table VIII gives a comparison of cost of the natural dyes/kg with the cost of synthetic dyes.

TABLE VIII

COST OF NATURAL AND SYNTHETIC DYES

S.No.	Natural dyes	Rs./kg	Synthetic dyes	Rs./kg
1.	Annato	85	Direct	400
2.	Babool	25	Vat	500-3000
3.	Karingali	30	Reactive	450-500
4.	Madder	70	Sulphur	150-200
5.	Red sandal	100	Naphthol	400-500
6.	Vembadam	115	Disperse	400-1000
7.			Acid	400
8.			Basic	350

It is evident from the table that the cost of natural dyes is much less when compared to synthetic dyes. The cost per kg of natural dyes ranged between Rs.25 - Rs.115 while the cost/kg of synthetic dyes ranged from Rs.350-3000. The cost of extraction of the natural dye may increase the cost by another 10-15 per cent and even then the cost will be lower than the synthetic dyes. This is a solid reason for promoting natural dyes.

3. Availability of Natural Dyed Fabrics in Selected Shops

This part of the results give information on type of textile shops, availability and demand for natural dyed fabrics and the special measures adopted to promote the sale of natural dyed materials.

Details regarding type of textile shops selling fabrics that are dyed with natural dyes are given in Table IX.

TABLE IX

DETAILS OF SELECTED TEXTILE SHOPS THAT SELL NATURAL DYED FABRICS

S.No.	Type of shop	Number of shops in selected cities									
		Coimbatore N-30		Salem N-30		Karur N-30		Madurai N-30		Total N-120	
		N	%	N	%	N	%	N	%	N	%
1.	Whole sale	9	30	7	23.3	10	33.3	7	23.3	33	27.5
2.	Retail	15	50	15	50.0	12	40.0	15	50.0	57	47.5
3.	Boutique	6	20	8	26.7	8	26.7	8	26.7	30	25.0

Table IX reveals that 27.5 per cent of the whole sale dealers, 47.5 per cent of retailers and 25 per cent of the boutique shop owners were selling natural dyed fabrics along with synthetic materials. The retail shops were the ones where natural dyed fabrics were available much more frequently than in the other types of shops. The fact that so many shops were selling natural dyed fabrics was very encouraging. However the quantity and variety available in these shops were very limited when compared to synthetic dyed fabrics.

Details regarding the availability and demand for natural dyed fabrics in the selected shops are given in Table X.

TABLE X

AVAILABILITY AND DEMAND FOR NATURAL DYED FABRICS

S.No.	Details of natural dyed fabrics	Number of shops in selected cities									
		Coimbatore N-30		Salem N-30		Karur N-30		Madurai N-30		Total N-120	
		N	%	N	%	N	%	N	%	N	%
1.	**Availablity as fabric**										
	Cotton										
	Available	11	36.7	9	30.0	7	23.3	6	20.0	**33**	**27.5**
	Not available	19	63.3	21	70.0	23	76.7	24	80.0	**87**	**72.5**
	Total	30	100.0	30	100.0	30	100.0	30	100.0	**120**	**100.0**
	Silk										
	Available	8	26.7	7	23.3	6	20.0	4	**13.3**	**25**	**20.8**
	Not available	2	73.3	23	76.7	24	80.0	26	86.7	**95**	**79.2**
	Total	30	100.0	30	100.0	30	100.0	30	100.0	**120**	**100.0**
2.	**Availablity as Dress materials**										
	Cotton										
	Available	8	26.7	4	13.3	-	-	-	-	12	10
	Not available	22	73.3	26	86.7	30	100	30	100	120	90
	Total	30	100.0	30	100.0	30	100	30	100	**120**	**100**
3.	**Furnishing items**										
	Cotton										
	Available	11	36.7	-	-	-	-	-	-	11	9.2
	Not available	19	63.3	30	100	30	100	30	100	109	90.8
	Total	30	100.0	30	100.0	30	100	30	100	**120**	**100.0**
4.	**Demand for the natural dyed fabrics**										
	As fabric										
	Regularly	-	-	-	-	-	-	-	-	-	-
	Frequently	8	26.7	-	-	-	-	-	-	8	6.7
	Rarely	22	73.3	30	100	30	100	30	100	112	93.3
	Total	30	100.0	30	100.0	30	100	30	100	**120**	**100.0**
5.	**As Dress materials**										
	Regularly	5	16.7	3	10.0	-	-	-	-	8	6.7
	Frequently	-	-	-	-	-	-	-	-	-	-
	Rarely	25	83.3	27	90.0	30	100	30	100	112	93.3
	Total	30	100.0	30	100.0	30	100	30	100	**120**	**100.0**
6.	**As Furnishing items**										
	Regularly	-	-	-	-	-	-	-	-	-	-
	Frequently	10	33.3	-	-	-	-	-	-	10	8.3
	Rarely	20	66.7	30	100	30	100	30	100	110	91.7
	Total	30	100.0	30	100.0	30	100	30	100	**120**	**100.0**

* MULTIPLE RESPONSE

The above table shows that the natural dyed fabrics were available in the form of sarees, dress materials and furnishing items. Natural dyed cotton and silk sarees were seen in 27.5 per cent and 20.8 per cent of the shops respectively.

Cotton dress materials were sold in 10.0 per cent of the shops surveyed in Coimbatore and Salem respectively. However it is surprising to note that there was no demand for natural dyed dress materials in Karur and Madurai. Among the selected cities maximum of 9.2 per cent of the shops surveyed in Coimbatore only sold natural dyed furnishing items frequently.

Regarding the demand for the natural dyed dress materials, it was observed that only 6.7 per cent of shops in Coimbatore and Salem experienced demand for the natural dyed dress materials on a regular basis.

When enquired about the cost of the natural dyed fabrics in the selected shops, it was found out that the cost of natural dyed cotton fabric ranged between Rs.43 and Rs.49 per meter and the cost of synthetic fabric ranged between Rs.35 and Rs. 300 per meter. The cost of silk material was noted to be high as the rate ranged between Rs.250 and Rs.600 per meter.

Special measures adopted to promote the sale of materials are given in Table XI.

TABLE XI

SPECIAL MEASURES ADOPTED TO PROMOTE THE SALE OF MATERIALS

S.No.	Methods adopted	Number of shops in selected cities									
		Coimbatore N=30		Salem N=30		Karur N=30		Madurai N=30		Total N=120	
		N	%	N	%	N	%	N	%	N	%
1.	Discount sales	21	70	22	73.3	21	70.0	24	80	88	73.3
2.	Advertising	23	76.7	21	70.0	20	66.7	22	73.3	86	71.7
3.	Banners	20	66.7	20	66.7	18	60.0	17	56.7	75	62.5
4.	Window display	12	40.0	10	33.3	17	56.7	12	40.0	51	42.5
5.	No such sales promotion	7	23.3	8	26.7	9	30	6	20	30	25

* MULTIPLE RESPONSE

All the identified shops were selling wide variety of materials dyed by using synthetic dyes. Sale of natural dyed materials were only a small part of their sales. All the selected shop owners revealed that they realized greater sales during festival season, however in order to promote sales now and then they announced discount sales (73.3 per cent), advertise their new arrivals (71.7 per cent), mounted banners (62.5 per cent) and displayed latest designs (42.5 per cent) in their shops. No special techniques or advertisements were given by 25 per cent of the shops to sell the fabrics. Special efforts were taken to promote the sale of natural dyed fabrics, since all the customers were not interested in natural dyed fabrics. They also expressed that awareness of natural dyed fabrics has to be created especially among youngsters.

The reasons stated by the shop keepers in the selected cities for promoting sale of natural dyed materials is given in Table XII.

TABLE XII

REASONS FOR PROMOTING SALE OF NATURAL DYED MATERIALS

S.No.	Reasons *	Number of shops in selected cities									
		Coimbatore N-30		Salem N-30		Karur N-30		Madurai N-30		Total N-30	
		N	%	N	%	N	%	N	%	N	%
1.	Environmental protection	18	60	17	56.7	18	60	16	53.3	69	57.5
2.	Non Allergic to synthetic dyes	12	40	11	36.7	17	56.7	18	60.0	58	48.3
3.	No skin irritation	10	33	13	43.3	12	40	17	56.7	52	43.3
4.	No respiratory problems	9	30	12	40	11	36.7	13	43.3	45	37.5

* MULTIPLE RESPONSE

About 57.5 per cent of the shops promoted sales by advertising the naturally dyed fabrics to protect the environment while 48.3 per cent, 43.3 per cent and 37.5 per cent promoted sales as the fabric is non-allergic and does not cause skin irritation and no respiratory problems.

4.2. FINDINGS OF THE HOUSE HOLD SURVEY

The results of the house hold survey are presented under the information on general background of selected families, person responsible for purchase of clothing and furnishing items, awareness and purchase of natural dyed fabrics, factors influencing purchase of clothing and furnishing items, frequency of purchase, fabric preferred for regular wear, method adopted for washing and type of water used and attitudes of the homemakers related to natural dyed fabrics.

The details regarding background information of the selected home makers in Coimbatore, Salem, Karur and Madurai are given in Table XIII.

TABLE XIII

INFORMATION ON GENERAL FAMILY BACKGROUND OF SELECTED HOME MAKERS

S.No.	Details	Number of shops in selected cities									
		Coimbatore N-50		Salem N-50		Karur N-50		Madurai N-50		Total N-200	
		N	%	N	%	N	%	N	%	N	%
1.	**Type of family**										
	Joint	18	36	23	46	12	24	20	40	73	36.5
	Nuclear	32	64	27	54	38	76	30	60	127	63.5
2.	**Number of family members**										
	1-3 (small)	36	72	24	48	33	66	18	36	111	55.5
	4-6 (medium)	11	22	16	32	12	24	20	40	59	29.5
	7 and above (large)	3	6	10	20	5	10	12	24	30	15.0
3.	**Educational status**										
	Higher secondary	7	14	18	36	10	20	34	68	69	34.5
	College level	43	86	32	64	40	80	16	32	131	65.5
4	**Employment status of women**										
	Homemaker	21	42	32	64	23	46	35	70	111	55.5
	Full time employed	17	34	7	14	17	34	8	16	49	24.5
	Part time employed	12	24	11	22	10	20	7	14	40	20.0

Contd...

S.No.	Details	Number of shops in selected cities									
		Coimbatore N-50		Salem N-50		Karur N-50		Madurai N-50		Total N-200	
		N	%	N	%	N	%	N	%	N	%
5.	**Monthly income in (rupees) ***										
	4501-7500 (middle income)	20	40	40	80	22	44	40	80	122	61
	7501 and above (High income)	30	60	10	20	28	56	10	20	78	39
6.	**Other sources of income**										
	House rent	12	24	20	40	23	46	10	20	65	32.5
	Land	15	30	22	44	17	34	21	42	75	37.5
	Interest / deposit	11	22	7	14	12	24	8	16	38	19.0

* Housing Urban Development Corporation (HUDCO), 2002)

With regard to the type of family, 63.5 per cent of the households belonged to nuclear family system, while 36.5 per cent belonged to the joint family system.

Due to disintegration of joint family system, the size of the family also tends to shrink because small family norms are widely adopted by majority of the families in Tamilnadu. This is obvious in the present study where 55.5 per cent of the families were small in size, while 29.5 per cent were medium in size and the rest 15 per cent of families only were large in size.

Regarding the educational status of the selected home makers in the specified cities, 65.5 per cent of home makers were educated up to college level and the rest 34.5 per cent had completed their higher secondary level of education. This shows the importance given to education among the selected families.

Regarding employment status of the homemakers, the study unfolded the fact that 24.5 per cent of the homemakers were employed fulltime and 20 per cent had taken up part time jobs. From these figures it is obvious that more and more homemakers today take up jobs outside home to contribute their share towards household income.

Regarding monthly income among the selected families 61 per cent of the families belonged to middle income and the rest belonged to high income category. Other than their regular income in the form of salary or wages, the families were also getting income in the form of house rent (32.5 per cent) from land (37.5 per cent) and interest from deposits (19.0 per cent).

Budgeting was not practised by a majority of 87 per cent of the homemakers.

The details regarding the person responsible for purchase of clothing / furnishing items for the family are given in Table XIV.

TABLE XIV

PERSON RESPONSIBLE FOR THE PURCHASE OF CLOTHING / FURNISHING ITEMS FOR THE FAMILY

S.No.	Person responsible	Number of shops in selected cities									
		Coimbatore N-50		Salem N-50		Karur N-50		Madurai N-50		Total N-200	
		N	%	N	%	N	%	N	%	N	%
1.	**Head of the family**										
	a. Always	20	40	23	46	28	56	22	44	93	46.5
	b. Sometimes	30	60	27	54	22	44	28	56	107	53.5
	c. Rarely	-	-	-	-	-	-	-	-	-	-
2.	**Housewife**										
	a. Always	30	60	31	62	28	56	25	50	114	57.0
	b. Sometimes	20	40	12	24	17	34	10	20	59	29.5
	c. Rarely	-	-	7	14	5	10	15	30	27	13.5
3.	**Daughter**										
	a. Always	20	40	17	34	12	24	15	30	64	32.0
	b. Sometimes	30	60	22	44	23	46	18	36	93	46.5
	c. Rarely	-	-	11	22	15	30	17	34	43	21.5
4.	**Son**										
	a. Always	24	48	18	36	17	34	18	36	77	38.5
	b. Sometimes	26	52	17	34	17	34	16	32	76	38.0
	c. Rarely	-	-	15	30	16	32	16	32	47	23.5

It was interesting to note that, in above 50 per cent of the families surveyed in all the selected cities, home makers took the major responsibility of purchasing clothing and furnishing items for the family always, while 53.5 per cent of head of the family sometimes took care of purchasing clothing in all the of selected cities. It is surprising to observe that in 32 per cent and 38.5 per cent of the families respectively either the daughter or the son purchased their clothing. However purchase of common furnishing items were the sole responsibility of homemakers in the above said families.

Details regarding awareness and purchase towards natural dyed fabrics are given in Table XV.

TABLE XV

DETAILS ON AWARENESS AND PURCHASE OF NATURAL DYED FABRICS

S.No.	Details	Number of shops in selected cities									
		Coimbatore N-50		Salem N-50		Karur N-50		Madurai N-50		Total N-200	
		N	%	N	%	N	%	N	%	N	%
1.	Awareness of natural dyes										
	Aware	38	76	38	76	33	66	30	60	139	69.5
	Not aware	12	24	12	24	17	34	20	40	61	30.5
2.	Purchase of natural dyed fabrics										
	Purchase	30	60	20	40	30	60	12	24	92	46.0
	Do not purchase	20	40	30	60	20	40	38	76	108	54

Though fabrics dyed with natural dyes were in existence from time immemorial they had lost their importance since the emergence of synthetic dyes. In this context it is heartening to note that presently 69.5 per cent of the selected families were aware of natural dyed fabrics.

Though 69.5 per cent were aware of natural dyed fabrics, only 46 per cent of the families had purchased natural dyed fabrics either for apparel or for furnishing purpose. A higher per cent of the families in Coimbatore and Karur expressed that they had purchased the fabrics for clothing purpose,

while in Salem and Madurai those who had purchased the fabrics were much less.

Details regarding the factors influencing the purchase of clothing items and frequency of purchase by the selected families in Coimbatore, Salem, Karur and Madurai are given in Table XVI.

TABLE XVI

FACTORS INFLUENCING THE PURCHASE OF CLOTHING / FURNISHING ITEMS AND FREQUENCY OF PURCHASE

S.No.	Details	Number of shops in selected cities									
		Coimbatore N-50		Salem N-50		Karur N-50		Madurai N-50		Total N-200	
		N	%	N	%	N	%	N	%	N	%
1.	**Factors influencing ***										
a	Cost	35	70	33	66	35	70	42	84	145	72.5
b	Durability	20	40	25	50	32	64	49	98	126	63.0
c	Availability	23	46	34	68	28	56	39	78	124	62.0
d	Washability	31	62	26	52	18	36	35	70	110	55.0
e	Fastness	49	98	18	36	17	34	21	42	105	52.5
f	Texture	18	36	32	64	12	24	6	12	68	34.0
g	Type of fabric	19	38	12	24	11	22	17	34	59	29.5
h	Colour combination	17	34	10	20	13	26	18	36	58	29.0
i	Fashion trend	20	40	11	22	15	30	20	40	66	33.0
2.	**Frequency of purchase ***										
a	Once in 3 months	13	26	8	16	12	24	4	8	37	18.5
b	Once in 6 months	24	48	20	40	28	56	36	72	108	54.0
c	Annually	38	76	33	66	30	60	26	52	127	63.5
d	During festival and celebration	48	96	43	86	45	90	20	40	156	78.0
e	Whenever required	8	16	7	14	12	24	33	66	60	30.0
f	During discount sales	38	76	23	46	38	76	18	36	117	58.5

*** MULTIPLE RESPONSES**

Cost was the major factor which influenced the purchase of material among 72.5 per cent of the families followed by durability by 63 per cent,

availability by 62 per cent, washability by 55 per cent and colour fastness by 52.5 per cent. It was interesting to note that 78 per cent of the homemakers purchased their clothing items during festivals and celebrations. Sixty three and half per cent of homemakers purchased once a year especially when they get money in lump sum as bonus or from lands. Discount sales had motivated 58.5 per cent families for purchase of clothing items.

Fabric preferred for regular wear as expressed by the selected family members in the selected cities in given in Table XVII.

TABLE XVII

PREFERENCE FOR NATURAL DYED AND SYNTHETIC DYED FABRICS BY FAMILY MEMBERS

S.No.	Age group	Number of shops in selected cities															
		Natural dye						Synthetic dye									
		Cotton		Silk		Blend		Cotton		Silk		Wool		Synthetic		Blend	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1.	**Infant wear**																
	Coimbatore	28.0	56.0	-	-	-	-	50.0	100.0	-	-	15.0	30.0	-	-	-	-
	Salem	17.0	34.0	-	-	-	-	45.0	50.0	-	-	23.0	46.0	-	-	-	-
	Karur	10.0	20.0	-	-	-	-	48.0	96.0	-	-	19.0	38.0	-	-	-	-
	Madurai	15.0	30.0	-	-	-	-	44.0	88.0	-	-	14.0	28.0	-	-	-	-
	Mean	17.5	35.0	-	-	-	-	46.8	83.5			17.8	35.5	-	-	-	-
2.	**Toddlers wear**																
	Coimbatore	25.0	50.0	-	-	-	-	42.0	84.0	-	-	15.0	30.0	-	-	-	-
	Salem	24.0	48.0	-	-	-	-	38.0	76.0	-	-	7.0	14.0	-	-	-	-
	Karur	18.0	36.0	-	-	-	-	27.0	54.0	-	-	12.0	24.0	-	-	-	-
	Madurai	19.0	38.0	-	-	-	-	30.0	60.0	-	-	9.0	18.0	-	-	-	-
	Mean	21.5	43.0					34.25	68.5	-	-	10.8	21.5	-	-	-	-
3.	**Girls wear**																
	Coimbatore	26.0	52.0	-	-	28.0	56.0	34.0	68.0	-	-	15.0	30.0	23.0	46.0	-	-
	Salem	7.0	14.0	-	-	25.0	50.0	24.0	48.0	-	-	7.0	14.0	34.0	68.0	-	-
	Karur	6.0	12.0	-	-	21.0	42.0	21.0	42.0	-	-	12.0	24.0	28.0	56.0	-	-
	Madurai	7.0	14.0	-	-	25.0	50.0	20.0	40.0	-	-	9.0	18.0	30.0	60.0	-	-
	Mean	11.5	23.0	-	-	24.8	49.5	24.8	49.5	-	-	10.8	21.5	28.8	57.5	-	-
4.	**Boys wear**																
	Coimbatore	20.0	40.0	-	-	22.0	44.0	30.0	60.0	-	-	9.0	18.0	31.0	62.0	-	-
	Salem	10.0	20.0	-	-	17.0	34.0	24.0	48.0	-	-	7.0	14.0	28.0	56.0.	-	-
	Karur	8.0	16.0	-	-	24.0	48.0	32.0	64.0	-	-	6.0	12.0	19.0	38.0	-	-
	Madurai	7.0	14.0	-	-	20.0	40.0	21.0	42.0	-	-	6.0	12.0	27.0	54.0	-	-
	Mean	11.3	22.5	-	-	20.8	41.5	26.8	53.5	-	-	7.0	14.0	26.3	52.5	-	-

Contd...

S.No.	Age group	Number of shops in selected cities															
		Natural dye						Synthetic dye									
		Cotton		Silk		Blend		Cotton		Silk		Wool		Synthetic		Blend	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
5.	**Ladies wear**																
	Coimbatore	18.0	36.0	23.0	46.0	31.0	62.0	46.0	92.0	35.0	70.0	10.0	20.0	25.0	50.0	34.0	68.0
	Salem	19.0	38.0	18.0	36.0	24.0	48.0	35.0	70.0	28.0	56.0	7.0	14.0	30.0	60.0	28.0	56.0
	Karur	16.0	32.0	21.0	42.0	27.0	54.0	39.0	78.0	20.2	44.0	11.0	22.0	32.0	64.0	23.0	46.0
	Madurai	17.0	34.0	14.0	28.0	20.0	40.0	35.0	70.0	17.0	34.0	3.0	6.0	34.0	68.0	22.0	44.0
	Mean	17.5	35.0	19.0	38.0	25.5	51.0	38.8	77.5	25.5	51.0	7.8	15.5	30.3	60.5	26.8	53.5
6.	**Gents wear**																
	Coimbatore	5.0	10.0	-	-	26.0	52.0	30.0	60.0	-	-	7.0	14.0	35.0	70.0	24.0	48.0
	Salem	2.0	4.0	-	-	25.0	50.0	23.0	46.0	-	-	3.0	6.0	40.0	80.0	30.0	60.0
	Karur	2.0	4.0	-	-	25.0	50.0	31.0	62.0	-	-	2.0	4.0	37.0	74.0	17.0	34.0
	Madurai	3.0	60.0	-	-	24.0	48.0	29.0	58.0	-	-	3.0	6.0	43.0	86.0	12.0	24.0
	Mean	3.0	6.0	-	-	25	50.0	28.6	56.5	-	-	3.8	7.5	38.8	77.5	20.8	41.5

* **MULTIPLE RESPONSE**

It was heartening to note that 35, 43, 23 and 22.5 per cent of the homemakers preferred natural dyed cotton fabrics for infant wear, toddlers wear, girls and boys wear garments. Due to the comfort qualities of cotton and non-allergic quality of natural dyes they preferred natural dyed cotton materials for their apparel purposes. For ladies and gents wear 35 per cent and six per cent respectively preferred cotton dyed with natural dyes. These results emphasized the fact that most of the families were aware of the availability and preferred natural dyed materials.

Due to easy maintenance, durability and wide choice, almost all the families preferred synthetic dyed fabrics for all age groups for their apparel purpose. However only cotton fabrics were preferred for inner wear as synthetic fabric are not suitable for the purpose in the existing climatic conditions.

Though cotton furnishing items were preferred for bed spreads, pillow covers, cushion covers, divan covers, bolster covers, cotton blended fabrics were preferred for curtains, draperies, table cloth, table mat by above 34.65 per cent of the families. Though they preferred to purchase and use natural dyed furnishing materials especially for soft furnishings due to non availability and shortage of wide choice of furnishing materials, 32 per cent of

selected families preferred and used only synthetic dyed cotton blend furnishing fabrics. Besides, easy care, maintenance and colour fastness also restrict their preference.

Regarding the method adopted for washing, among the selected families 71.5 per cent of the families followed hand method of kneading and squeezing using mild soap or detergent powders to wash the natural dyed cotton apparels and furnishing materials to retain its colour fastness property.

Cotton blends and synthetic apparels were washed using washing machine with standard detergent powders such as Surf (56 per cent), Tide (40 per cent), Wheel (20 per cent) and Rin (20 per cent). Expensive furnishing items and silk sarees only were taken care by means of dry cleaning by majority of 86 per cent of the selected families. Irrespective of the city where they lived 58-96 per cent of the homemakers expressed that they used available water in their households for washing their clothes and furnishing items. However 11 per cent of the families surveyed had installed the system of softening hard water. Hence these families use the water obtained from the treatment plant for washing. Minimum of six per cent expressed that they took special care in washing silk sarees at home.

Details regarding attitudes related to natural dyed fabrics as expressed by the selected homemakers in Coimbatore, Salem, Karur and Madurai is given in Table XVIII.

TABLE XVIII

ATTITUDES OF THE HOMEMAKERS TOWARDS NATURAL DYED FABRICS

S.No.	Attitudes	Number of shops in selected cities									
		Coimbatore N-50		Salem N-50		Karur N-50		Madurai N-50		Total N-200	
		N	%	N	%	N	%	N	%	N	%
1.	Eco-friendly	32	64	38	76	29	58	30	60	129	64.5
2.	Non-allergic	28	56	23	46	33	66	26	52	110	55.0
3.	Non availability	36	72	32	64	30	60	14	28	112	52.4
4.	Expensive	38	76	28	56	21	42	20	40	107	51.5
5.	Lack of colour fastness	25	50	20	40	26	52	24	48	95	47.5
6.	Limited colours	20	40	18	36	20	40	17	34	75	37.5

It is interesting to note that 64.5 per cent and 55.0 per cent of the selected families felt that cotton fabrics dyed with natural dyes were eco-friendly and non-allergic, 52.4 per cent expressed that these fabrics were not always available for purchase, while 51.5 per cent felt that these fabrics were expensive, 47.5 per cent felt that colour fastness could not be guaranteed and 37.5 per cent felt that the colours available were limited.

Serious efforts should be taken to explore the colour fastness of the natural dyed fabrics. Once when these two needs are satisfied the demand for natural dyes may be enhanced.

4.3. EVALUATION OF THE DYED SAMPLES

The dyed samples were evaluated subjectively and objectively and the findings are given below :

4.3.1. Subjective Evaluation

Table XIX presents the details relating to the findings on visual inspection of cotton dyed samples.

TABLE XIX

VISUAL INSPECTION OF DYED SAMPLES

S.No.	Sample	Aspects / Percentage of judges evaluating the sample														Mean
		Evenness in dyeing		Brilliancy of colours			Texture			Lustre			General Appearance			
		Even	Uneven	Very bright	Bright	Dull	Smooth	Medium	Rough	High	Medium	Low	Good	Fair	Poor	
Dyed without mordants																
1.	ADS	100	-	10	90	-	100	-	-	-	100	-	100	-	-	98
2.	BDS	100	-	20	80	-	100	-	-	30	70	-	90	10	-	88
3.	KDS	100	-	-	100	-	100	-	-	10	90	-	100	-	-	98
4.	MDS	100	-	-	100	-	100	-	-	-	100	-	80	20	-	96
5.	RDS	100	-	30	70	-	70	30	-	-	100	-	100	-	-	88
6.	VDS	100	-	-	100	-	100	-	-	-	100	-	100	-	-	100
Dyed with metallic mordants																
7.	AMAP	100	-	-	100	-	80	20	-	-	100	-	100	-	-	96
8.	AMFS	90	10	10	90	-	80	20	-	10	90	-	100	-	-	90
9.	AMCPT	100	-	-	100	-	70	30	-	-	100	-	100	-	-	94
10.	BMAP	100	-	-	100	-	90	10	-	20	80	-	100	-	-	94
11.	BMFS	100	-	20	80	-	80	20	-	20	80	-	100	-	-	88
12.	BMCPT	100	-	-	100	-	100	-	-	10	90	-	100	-	-	98
13.	KMAP	100	-	-	100	-	70	30	-	20	80	-	100	-	-	90
14.	KMFS	90	10	10	90	-	80	20	-	20	80	-	80	20	-	84
15.	KMCPT	100	-	20	80	-	80	20	-	10	90	-	90	10	-	88
16.	MMAP	100	-	-	100	-	100	-	-	-	100	-	90	10	-	98
17.	MMFS	80	20	10	90	-	90	10	-	20	80	-	100	-	-	88
18.	MMCPT	100	-	-	100	-	100	-	-	20	80	-	100	-	-	96
19.	RMAP	100	-	20	80	-	80	20	-	-	100	-	100	-	-	92
20.	RMFS	100	-	-	100	-	100	-	-	20	80	-	80	20	-	92
21.	RMCPT	100	-	20	80	-	80	20	-	-	100	-	90	10	-	90
22.	VMAP	100	-	-	100	-	100	-	-	-	100	-	100	-	-	100
23.	VMCPT	100	-	10	90	-	90	10	-	-	100	-	80	20	-	92
24.	VMFS	100	-	20	80	-	80	20	-	-	100	-	100	-	-	92
Dyed with processed mordants																
25.	APAP	100	-	20	80	-	100	-	-	20	80	-	100	-	-	92
26.	APFS	90	10	10	90	-	100	-	-	10	90	-	100	-	-	94
27.	APCPT	100	-	-	100	-	100	-	-	-	100	-	100	-	-	100
28.	BPAP	100	-	10	90	-	100	-	-	50	50	-	100	-	-	88
29.	BPFS	100	-	-	100	-	80	20	-	20	80	-	90	10	-	90
30.	BPCPT	100	-	-	100	-	100	-	-	30	70	-	80	20	-	90
31.	KPAP	100	-	-	100	-	100	-	-	10	90	-	90	10	-	96
32.	KPFS	100	-	-	100	-	100	-	-	-	100	-	90	10	-	98
33.	KPCPT	100	-	-	100	-	100	-	-	-	100	-	100	-	-	100

Contd....

S.No.	Sample	Aspects / Percentage of judges evaluating the sample														Mean
		Evenness in dyeing		Brilliancy of colours			Texture			Lustre			General Appearance			
		Even	Uneven	Very bright	Bright	Dull	Smooth	Medium	Rough	High	Medium	Low	Good	Fair	Poor	
34.	MPAP	90	10	20	80	-	80	20	-	20	80	-	100	-	-	86
35.	MPFS	80	20	20	80	-	80	20	-	-	100	-	100	-	-	88
36.	MPCPT	100	-	20	80	-	80	20	-	-	100	-	100	-	-	92
37.	RPAP	100	-	-	100	-	100	-	-	20	80	-	90	10	-	94
38.	RPFS	90	10	-	100	-	100	-	-	-	100	-	100	-	-	98
39.	RPCPT	100	-	-	100	-	100	-	-	-	100	-	100	-	-	100
40.	VPAP	100	-	-	100	-	100	-	-	10	90	-	100	-	-	98
41.	VPFS	100	-	10	90	-	90	10	-	20	80	-	100	-	-	92
42.	VPCPT	100	-	-	100	-	100	-	-	10	90	-	100	-	-	98
Dyed with biomordants																
43.	APP	95	5	-	100	-	95	5	-	20	80	-	100	-	-	94
44.	APS	100	-	-	100	-	95	5	-	15	85	-	100	-	-	96
45.	APPT	90	10	-	100	-	95	5	-	-	100	-	100	-	-	97
46.	BPP	95	5	10	90	-	95	5	-	-	100	-	100	-	-	96
47.	BPS	95	5	10	90	-	95	5	-	5	95	-	95	5	-	94
48.	BPPT	95	5	10	90	-	95	5	-	-	100	-	100	-	-	96
49.	MPP	100	-	5	95	-	95	5	-	5	95	-	90	10	-	95
50.	MPS	100	-	5	95	-	90	10	-	10	90	-	95	5	-	94
51.	MPPT	100	-	5	95	-	95	5	-	10	90	-	95	5	-	95
52.	AAP	95	5	5	95	-	95	5	-	-	100	-	100	-	-	97
53.	AAS	100	-	5	95	-	95	5	-	5	95	-	100	-	-	97
54.	AAPT	100	-	5	95	-	95	5	-	5	95	-	100	-	-	97
55.	BAP	90	10	5	95	-	95	5	-	5	95	-	100	-	-	95
56.	BAS	90	10	5	95	-	90	10	-	-	100	-	90	10	-	93
57.	BAPT	95	5	5	95	-	90	10	-	-	100	-	100	-	-	96
58.	MAP	100	-	10	90	-	95	5	-	5	95	-	95	5	-	95
59.	MAS	100	-	10	90	-	100	-	-	5	95	-	95	5	-	96
60.	MAPT	100	-	10	90	-	100	-	-	5	95	-	95	5	-	96

With reference to evenness in dyeing, brilliancy of colours, texture, lustre and general appearance of the dyed samples vembadam dyed samples without mordant, vembadam dyed sample using metallic alum following pre mordanting technique, annato dyed sample using processed copper sulphate following post mordanting technique, karingali dyed sample using processed copper sulphate following post mordanting technique and red sandal using processed copper sulphate following post mordanting technique recorded 100 per cent acceptance. All the other samples also had recorded above 85 per

cent values indicating that process and biomordants following different mordanting technique were equally as good or even better than the samples dyed using metallic mordants following different mordanting techniques.

Comparison of the present results obtained is similar to the results using fabrics dyed with reactive dyes as reported by Srivani and Ranganathan (1998) as revealed that the cotton samples dyed without mordants, processed mordants and biomordants has performed better than reactive dyes with reference to evenness in dyeing and texture, while the results were equally good with reference to lustre, brilliancy of colour and general appearance, hence the products obtained using natural dyes, mordants and mordanting techniques are as good as the products obtained using reactive dyes.

4.3.2. Objective Evaluation

The dyed samples were subjected to fabric weight, thickness, tensile strength and elongation. The findings are given below :

4.3.2.1. Fabric Weight

Table XX shows the mean fabric weight of the original undyed cotton samples compared against dyed cotton samples with and without mordants and percentage gain over original undyed samples.

TABLE XX

FABRIC WEIGHT OF ORIGINAL AND DYED SAMPLES

S.No.	Sample	Mean value (gsm)	Gain or loss over original	Percentage gain over original
0	Original undyed	140.66		
Dyed without Mordants				
1	ADS	142.00	1.34	0.95
2	BDS	146.00	5.34	3.80
3	KDS	144.00	3.34	2.37
4	MDS	142.00	1.34	0.95
5	RDS	142.67	2.01	1.43
6	VDS	144.67	4.01	2.85
Dyed with Metallic Mordants				
7	AMAP	142.00	1.34	0.95
8	AMFS	142.00	1.34	0.95
9	AMCPT	143.67	3.01	2.14
10	BMAP	141.33	0.67	0.48
11	BMFS	142.33	1.67	1.19
12	BMCPT	144.00	3.34	2.37
13	KMAP	142.00	1.34	0.95
14	KMFS	142.00	1.34	0.95
15	KMCPT	143.00	2.34	1.66
16	MMAP	142.00	1.34	0.95
17	MMFS	142.67	2.01	1.43
18	MMCPT	143.00	2.34	1.66
19	RMAP	141.00	0.34	0.24
20	RMFS	141.67	1.01	0.72
21	RMCPT	143.33	2.67	1.90
22	VMAP	142.33	1.67	1.19
23	VMFS	142.00	1.34	0.95
24	VMCPT	144.00	3.34	2.37
Dyed with Processed Mordants				
25	APAP	142.67	2.01	1.43
26	APFS	142.00	1.34	0.95
27	APCPT	143.67	3.01	2.14
28	BPAP	143.67	3.01	2.14
29	BPFS	142.67	2.01	1.43
30	BPCPT	144.33	3.67	2.61
31	KPAP	144.00	3.34	2.37
32	KPFS	142.67	2.01	1.43
33	KPCPT	143.67	3.01	2.14

Contd...

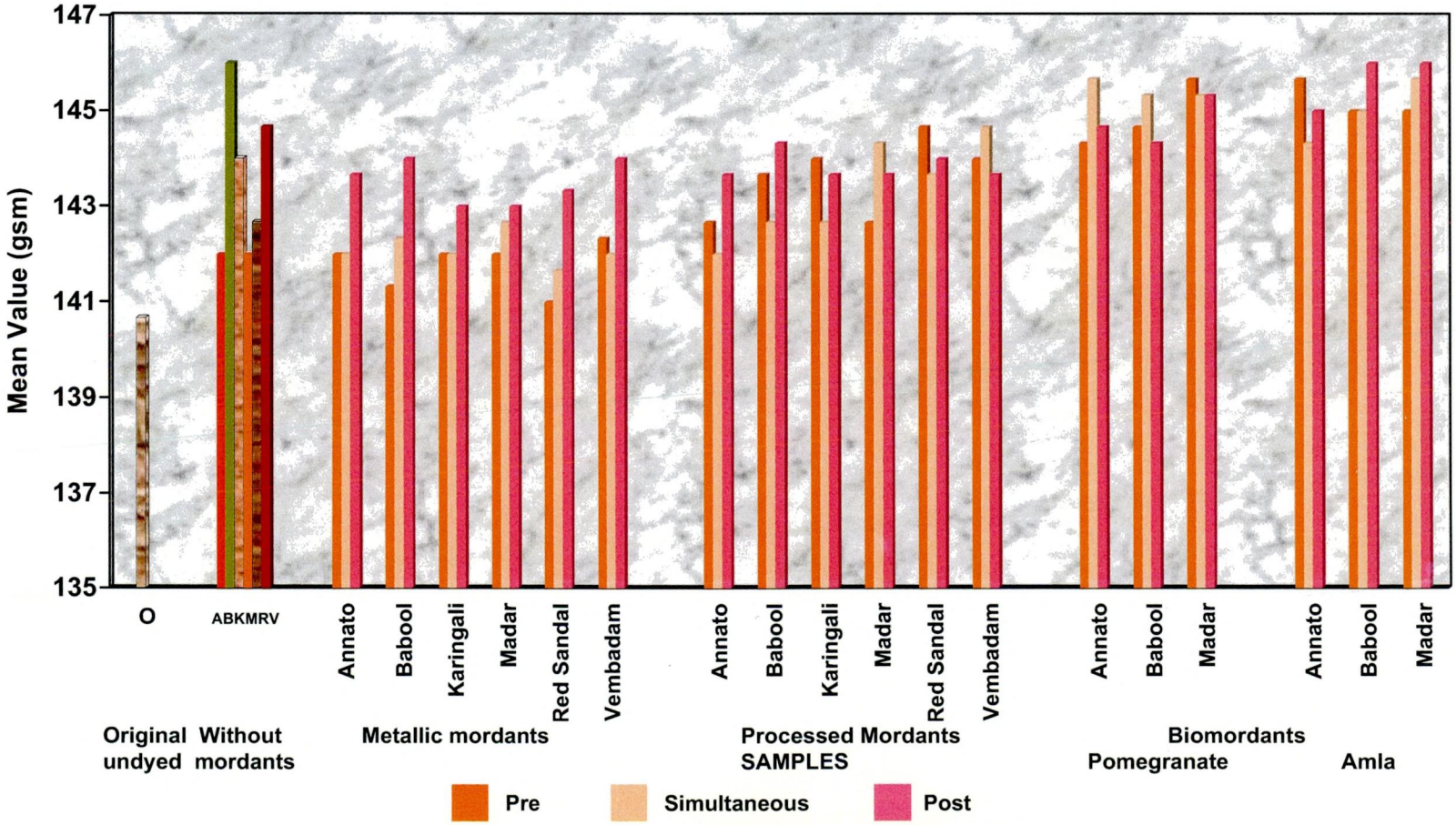
S.No.	Sample	Mean value (gsm)	Gain or loss over original	Percentage gain over original
34	MPAP	142.67	2.01	1.43
35	MPFS	144.33	3.67	2.61
36	MPCPT	143.67	2.34	2.14
37	RPAP	144.67	4.01	2.85
38	RPFS	143.67	3.01	2.14
39	RPCPT	144.00	3.34	2.37
40	VPAP	144.00	3.34	2.37
41	VPFS	144.67	4.01	2.85
42	VPCPT	143.67	3.01	2.14
Dyed with Biomordants				
43	APP	144.33	3.67	2.61
44	APS	145.67	5.01	3.56
45	APPT	144.67	4.01	2.85
46	BPP	144.67	4.01	2.85
47	BPS	145.33	4.67	3.32
48	BPPT	144.33	3.67	2.61
49	MPP	145.67	5.01	3.56
50	MPS	145.33	4.67	3.32
51	MPPT	145.33	4.67	3.32
52	AAP	145.67	5.01	3.56
53	AAS	144.33	3.67	2.61
54	AAPT	145.00	4.34	3.09
55	BAP	145.00	4.34	3.09
56	BAS	145.00	4.34	3.09
57	BAPT	146.00	5.34	3.80
58	MAP	145.00	4.34	3.09
59	MAS	145.67	5.01	3.56
60	MAPT	146.00	5.34	3.80

ANOVA for Fabric Weight-% Loss/Gain (Metallic and Processed Mordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	3.014	5	.603	1.952	NS
	Techniques	17.989	1	17.989	58.242	**
	Mordants	10.848	2	5.424	17.561	**
2-Way Interactions	Dyes * Techniques	4.193	5	.839	2.715	*
	Dyes * Mordants	6.449	10	.645	2.088	*
	Techniques * Mordants	5.232	2	2.616	8.470	**
3-Way Interactions	Dyes * Techniques * Mordants	5.775	10	.577	1.870	NS
Residual		22.239	72	.309		
Total		**75.739**	**107**	**.708**		

FIGURE – I

FABRIC WEIGHT OF ORIGINAL AND DYED SAMPLES



ANOVA for Fabric Weight-% Loss/Gain (biomordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	1.404	2	.702	2.500	NS
	Mordants	.936	1	.936	3.333	NS
	Technique	.505	2	.253	.900	NS
2-Way Interactions	Dyes * Mordants	.917	2	.459	1.633	NS
	Dyes * Technique	.786	4	.197	.700	NS
	Mordants * Technique	3.164	2	1.582	5.633	**
3-Way Interactions	Dyes * Mordants * Technique	4.081	4	1.020	3.633	*
Residual		10.109	36	.281		
Total		**21.902**	**53**	**.413**		

It is evident from Table XX that the fabric weight had increased among all the mercerized natural dyed samples without the use of mordants, samples dyed with metallic mordants, samples dyed with processed mordants as well as samples dyed with biomordants. Among the samples dyed without mordant the maximum increase was recorded by the babool dyed sample (3.80 per cent) followed by vembadam dyed sample (2.85 per cent).

When the mercerized samples were dyed using annato dye with metallic copper sulphate mordant following post mordanting technique resulted in highest fabric weight increase (2.14 per cent). Similarly treating babool, karingali, madder, red sandal and vembadam dyes with metallic copper sulphate following post mordanting technique resulted in maximum increase in fabric weight, the values being 2.37 per cent, 1.66 per cent, 1.66 per cent, 1.90 per cent and 2.37 per cent respectively.

Comparison of mean fabric weight of original undyed cotton sample with natural dyed samples using processed mordants with pre, simultaneous and post mordanting techniques indicated that for the annato and babool dyes using processed copper sulphate following post mordanting technique had recorded the highest increase in fabric weight, the increase being 2.14 per cent and 2.61 per cent respectively.

With reference to karingali and red sandal dyes the processed alum following pre mordanting technique had resulted in maximum increase in fabric weight, the values being 2.37 per cent and 2.85 per cent respectively. As far as the madder and vembadam dyed samples were concerned, the processed ferrous sulphate following simultaneous technique had resulted in appreciable increase in fabric weight, the values being 2.61 per cent and 2.85 per cent.

Using pomegranate as biomordant for dyeing with annato and babool dyes, while all the samples showed increased fabric weight, mercerized samples treated with pomegranate rind following simultaneous mordanting technique recorded a maximum increase by 3.56 per cent and 3.32 per cent respectively. Thus while using biomordants for annato and babool dyes simultaneous mordanting technique seems to be the most desirable. With reference to madder dyes using pomegranate as the biomordant following pre mordanting technique resulted in 3.56 per cent increase in fabric weight.

Using amla as the biomordant for annato dye following pre mordanting technique resulted in maximum increase in fabric weight by 3.56 per cent. When the biomordant amla was used with babool and madder dyes, following post mordanting technique, there was a maximum increase in the fabric weight by 3.8 per cent in both the cases.

These results drive home the fact that dyeing of fabrics with natural dyes results in an increase in fabric weight, depending upon the type of dye used and the type of mordanting technique used. Hence while dyeing with natural dyes one has to keep in mind the most suitable mordant and mordanting technique for each dye.

Statistical analysis of the data relating to fabric weight, comparing the effect of dyes, metallic and processed mordants and mordanting techniques revealed that, there was no statistically significant difference between dyes while between mordants and between techniques, there was a statistical

significance at 1% level. The two way interactions showed significance at 5% level between dyes and mordants, and dyes and mordanting techniques, whereas between mordants and mordanting techniques, the statistical significance was at 1% level. The three way interactions between dyes, mordants and mordanting techniques, there was no statistical significance. These results indicate that the fabric weight had significantly increased when processed mordants were used instead of metallic mordants.

Statistical analysis of the data relating to fabric weight, comparing the effect of dyes, biomordants and mordanting techniques revealed that there was no statistically significant difference between dyes, between techniques and between mordants. The two way interactions showed no significant difference between dyes and mordants, between dyes and techniques whereas between mordants and mordanting techniques the significance was at 1% level. Three way interactions revealed statistically significant results at 5% level between dyes, mordants and mordanting techniques. These results indicate that biomordants and mordanting techniques had increased the fabric weight.

It was heartening to note that, while there was a reduction in the fabric weight after dyeing with reactive dyes as noticed by Srivani and Ranganathan (1998) the fabric weight has actually increased when natural dyes were employed (present study).

Similar results were obtained by Sangeetha and Ranganathan (2001), while using natural dyes according to her, natural dyes performed better than synthetic dyes as regards fabric weight.

Comparison of the different natural dyes using metallic, processed and biomordants following different mordanting techniques revealed that red sandal and vembadam dyed samples using processed mordants following pre and simultaneous mordanting techniques had recorded the highest gain in fabric weight by 4.01 g (2.85 per cent), while babool and vembadam dyes

by 3.34 g (2.37 per cent) came next in the order. Among the biomordants used in dyeing, babool and madder dyed samples using amla as biomordant following post mordanting technique had recorded the highest gain in fabric weight by 5.34 g (3.80 per cent). Thus processing of the metallic mordants and biomordants gave better results for increase in fabric weight.

4.3.2.2. Fabric Thickness

The mean fabric thickness of the original undyed cotton samples compared against dyed with and without mordants using different mordanting techniques and percentage gain or loss over original undyed samples. The Mean fabric thickness values are given in Table XXI.

TABLE XXI

FABRIC THICKNESS OF ORIGINAL AND DYED SAMPLES

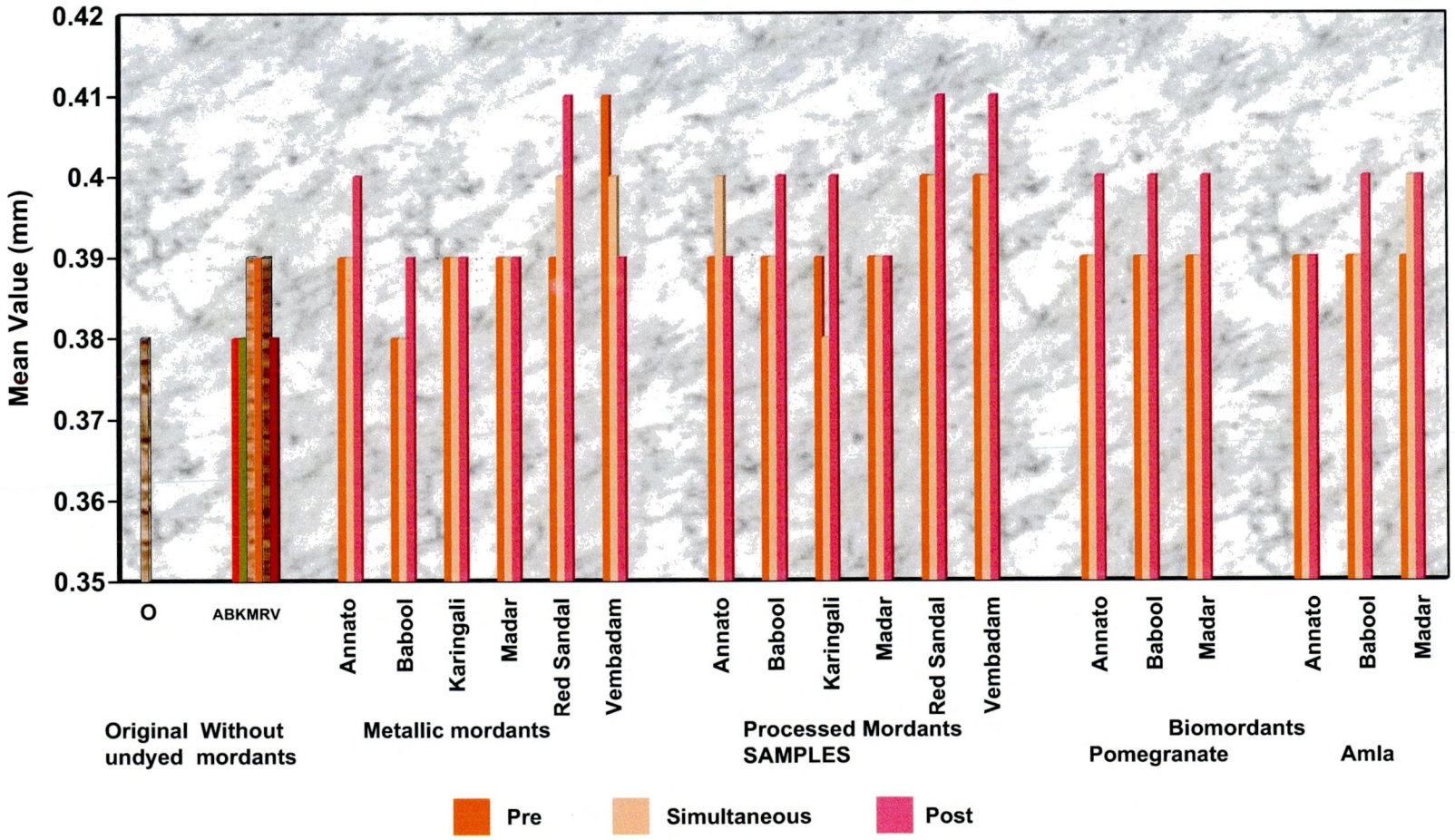
S.No.	Sample	Mean value (mm)	Gain over original	Percentage gain over original
0	Original undyed	0.38		
Dyed without Mordants				
1	ADS	0.38	Nil	Nil
2	BDS	0.38	Nil	Nil
3	KDS	0.39	0.01	2.63
4	MDS	0.39	0.01	2.63
5	RDS	0.39	0.01	2.63
6	VDS	0.38	Nil	Nil
Dyed with Metallic Mordants				
7	AMAP	0.39	0.01	2.63
8	AMFS	0.39	0.01	2.63
9	AMCPT	0.40	0.02	5.26
10	BMAP	0.38	Nil	Nil
11	BMFS	0.38	Nil	Nil
12	BMCPT	0.39	0.01	2.63
13	KMAP	0.39	0.01	2.63
14	KMFS	0.39	0.01	2.63
15	KMCPT	0.39	0.01	2.63
16	MMAP	0.39	0.01	2.63
17	MMFS	0.39	0.01	2.63
18	MMCPT	0.39	0.01	2.63

Contd...

S.No.	Sample	Mean value (mm)	Gain over original	Percentage gain over original
19	**RMAP**	**0.39**	**0.01**	**2.63**
20	**RMFS**	**0.40**	**0.02**	**5.26**
21	**RMCPT**	**0.41**	**0.03**	**7.89**
22	VMAP	0.41	0.03	7.89
23	VMFS	0.40	0.02	5.26
24	VMCPT	0.39	0.01	2.63
Dyed with Processed Mordants				
25	APAP	0.39	0.01	2.63
26	APFS	0.40	0.02	5.26
27	APCPT	0.39	0.01	2.63
28	BPAP	0.39	0.01	2.63
29	BPFS	0.39	0.01	2.63
30	BPCPT	0.40	0.02	5.26
31	KPAP	0.39	0.01	2.63
32	KPFS	0.38	Nil	Nil
33	KPCPT	0.40	0.02	5.26
34	MPAP	0.39	0.01	2.63
35	MPFS	0.39	0.01	2.63
36	MPCPT	0.39	0.01	2.63
37	RPAP	0.40	0.02	5.26
38	RPFS	0.40	0.02	5.26
39	RPCPT	0.41	0.03	7.89
40	VPAP	0.40	0.02	5.26
41	VPFS	0.40	0.02	5.26
42	VPCPT	0.41	0.03	7.89
Dyed with Biomordants				
43	APP	0.39	0.01	2.63
44	APS	0.39	0.01	2.63
45	APPT	0.40	0.02	5.26
46	BPP	0.39	0.01	2.63
47	BPS	0.39	0.01	2.63
48	BPPT	0.40	0.02	5.26
49	MPP	0.39	0.01	2.63
50	MPS	0.39	0.01	2.63
51	MPPT	0.40	0.02	5.26
52	AAP	0.39	0.01	2.63
53	AAS	0.39	0.01	2.63
54	AAPT	0.39	0.01	2.63
55	BAP	0.39	0.01	2.63
56	BAS	0.39	0.01	2.63
57	BAPT	0.40	0.02	5.26
58	MAP	0.39	0.01	2.63
59	MAS	0.40	0.02	5.26
60	MAPT	0.40	0.02	5.26

FIGURE – II

FABRIC THICKNESS OF ORIGINAL AND DYED SAMPLES



ANOVA(a,b) for Fabric Thickness-% Loss/Gain

(Metallic and Processed Mordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	192.110	5	38.422	7.884	**
	Techniques	6.412	1	6.412	1.316	NS
	Mordants	35.524	2	17.762	3.645	*
2-Way Interactions	Dyes * Techniques	32.061	5	6.412	1.316	NS
	Dyes * Mordants	89.899	10	8.990	1.845	NS
	Techniques * Mordants	6.284	2	3.142	.645	NS
3-Way Interactions	Dyes * Techniques * Mordants	123.756	10	12.376	2.539	**
Residual		350.877	72	4.873		
Total		**836.924**	**107**	**7.822**		

ANOVA for Fabric Thickness-% loss/gain (Biomordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	4.873	2	2.437	.463	NS
	Mordants	1.154	1	1.154	.220	NS
	Technique	34.113	2	17.057	3.244	*
2-Way Interactions	Dyes * Mordants	5.386	2	2.693	.512	NS
	Dyes * Technique	8.208	4	2.052	.390	NS
	Mordants * Technique	5.386	2	2.693	.512	Ns
3-Way Interactions	Dyes * Mordants * Technique	3.078	4	.769	.146	Ns
Residual		189.289	36	5.258		
Total		**251.488**	**53**	**4.745**		

It is evident from the data, that the fabric thickness had not increased at all with reference to annato, babool and vembadam dyes when dyed without mordants. The increase in thickness was marginal with reference to karingali, madder and red sandal dyes when dyed without mordants.

The same trend was observed with the samples dyed with babool, karingali and madder dyes irrespective of metallic mordants and mordanting techniques used.

When metallic mordants were used with annato and red sandal dyes the samples treated with metallic copper sulphate using post mordanting technique, resulted a maximum increase in fabric thickness by 5.26 per cent and 7.89 per cent respectively. While for vembadam dyes using metallic alum following pre mordanting technique recorded a maximum increase by 7.89 per cent of fabric thickness.

Examination of the changes in fabric thickness when cotton was dyed with processed mordants revealed that with reference to all the dyes, all the samples revealed increased fabric thickness, except for karingali dyed sample using processed ferrous sulphate following simultaneous mordanting technique.

The maximum increase in fabric thickness by 5.26 per cent was recorded by annato, babool and karingali dyes using processed ferrous sulphate following simultaneous technique and using processed copper sulphate following post mordanting technique respectively.

As far as the madder dye was concerned 2.63 per cent increase in fabric thickness was recorded when processed alum, copper sulphate and ferrous sulphate were used with pre, simultaneous and post mordanting techniques respectively.

Using pomegranate rind biomordant for dyeing with annato, babool and madder dyes, a maximum increase in thickness of 5.26 per cent was recorded using post mordanting technique by all the three dyes.

Irrespective of mordanting techniques used, the annato dyed samples using amla biomordant recorded increased fabric thickness by 2.63 per cent.

As far as the babool dye was concerned, amla biomordant with post mordanting technique recorded a maximum increase in thickness by 5.26 per cent, while madder dye recorded the same per cent with simultaneous and post mordanting technique.

The samples dyed by using processed copper sulphate following post mordanting technique recorded a maximum increase in fabric thickness by 7.89 per cent for both red sandal and vembadam dyes.

Thus for each dye, it is worth while to use mordants and mordanting techniques which will yield best results.

Statistical analysis of the data relating to fabric thickness, comparing the effects of dyes, metallic and processed mordants and mordanting techniques revealed that there was no statistically significant difference between mordanting techniques, while between dyes and between mordants, there was a statistical significance difference at 1% and 5% levels respectively. The two way interactions showed that there was no statistically significant difference between dyes and techniques, dyes and mordants and also between mordanting techniques and mordants. The three way interactions between dyes, mordants and mordanting techniques, there was statistical significant difference at 1% level. These results indicate that the fabric thickness had significantly increased when processed mordants were used instead of metallic mordants.

Statistical analysis of the data relating to fabric thickness, comparing the effect of dyes, biomordants and mordanting techniques revealed that, there was no statically significant difference, while between mordanting techniques at 5% level of significant difference was found. The two way interactions showed that there was no statistically significant difference between dyes and biomordants, dyes and techniques and also biomordants and mordanting techniques. In the three way interactions between dyes, mordants and mordanting techniques, there was no statistical significant difference. These results indicate that biomordants and mordanting techniques had increased the fabric thickness.

Comparison of the different natural dyes using metallic, processed and biomordants following different mordanting techniques revealed that red

sandal and vembadam dyed samples using both processed metallic mordants following post and pre mordanting techniques had recorded the maximum gain in fabric thickness by 0.03mm (7.89 per cent). Babool and madder dyed samples using both pomegranate rind and amla as biomordant following post mordanting technique and annato dyed sample using pomegranate rind as biomordant following post mordanting technique had recorded the highest gain in fabric thickness by 0.02 mm (5.26 per cent).

4.3.2.3. Tensile Strength of the fabric (Warp)

Table XXII shows the mean tensile strength (warp side) of the original undyed mercerized cotton samples compared against samples dyed with and without mordants using different mordanting techniques and percentage gain over original undyed samples.

TABLE XXII

TENSILE STRENGTH OF ORIGINAL AND DYED SAMPLES (WARP)

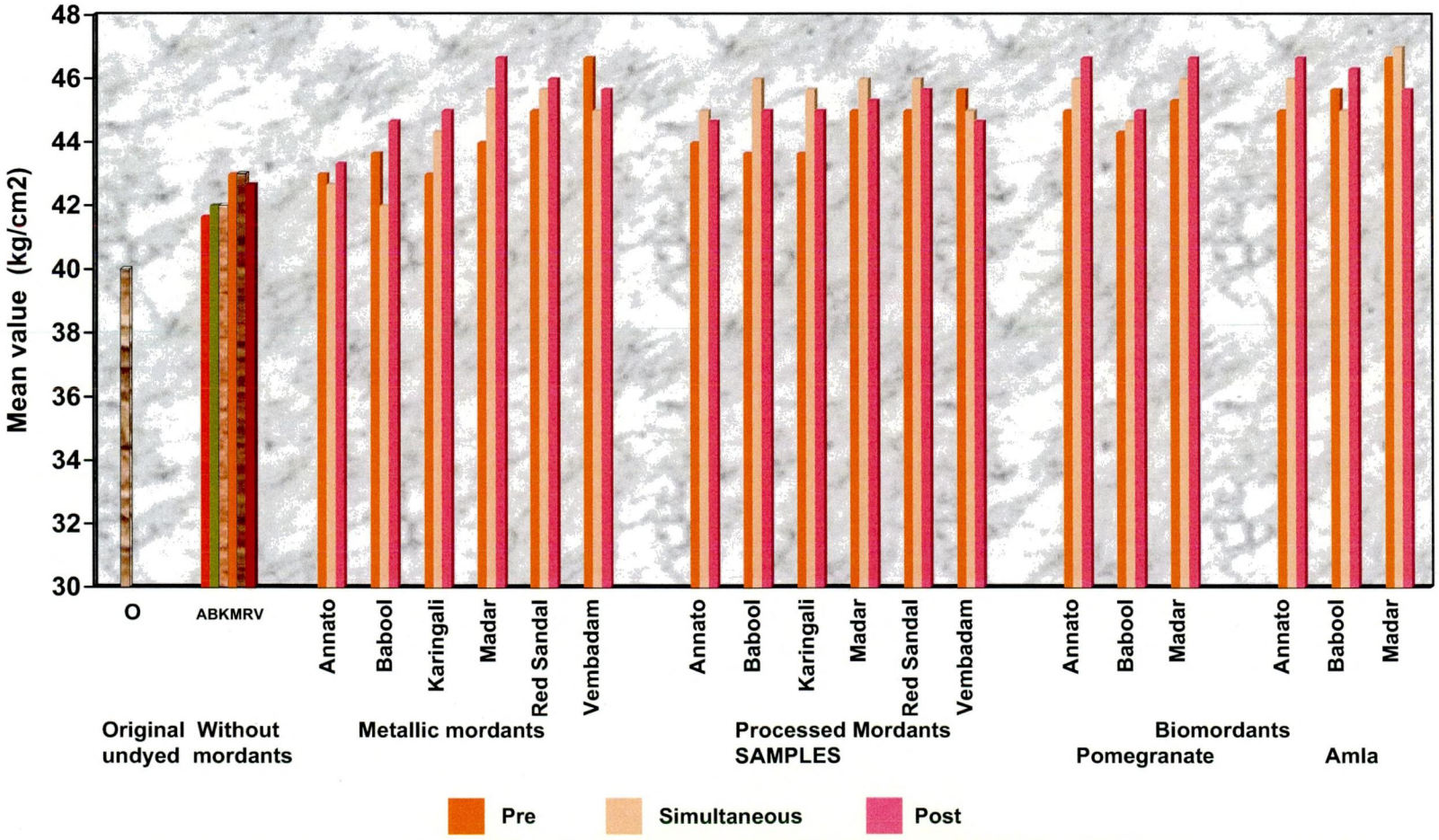
S.No.	Sample	Mean value (kg/cm^2)	Gain or loss over original	Percentage gain over original
0	Original undyed	40.0		
Dyed without Mordants				
1	ADS	41.67	1.67	4.18
2	BDS	42.00	2.00	5.00
3	KDS	42.00	2.00	5.00
4	MDS	43.00	3.00	7.50
5	RDS	43.00	3.00	7.50
6	VDS	42.67	2.67	6.68
Dyed with Metallic Mordants				
7	AMAP	43.00	3.00	7.50
8	AMFS	42.67	2.67	6.68
9	AMCPT	43.33	3.33	8.33
10	BMAP	43.67	3.67	9.18
11	BMFS	42.00	2.00	5.00
12	BMCPT	44.67	4.67	11.68
13	KMAP	43.00	3.00	7.50
14	KMFS	44.33	4.33	10.83
15	KMCPT	45.00	5.00	12.50
16	MMAP	44.00	4.00	10.00
17	MMFS	45.67	5.67	14.18
18	MMCPT	46.67	6.67	16.68

Contd....

S.No.	Sample	Mean value (kg/cm2)	Gain or loss over original	Percentage gain over original
19	RMAP	45.00	5.00	12.50
20	RMFS	45.67	5.67	14.18
21	RMCPT	46.00	6.00	15.00
22	VMAP	46.67	6.67	16.68
23	VMFS	45.00	5.00	12.50
24	VMCPT	45.67	5.67	14.18
Dyed with Processed Mordants				
25	APA P	44.00	4.00	10.00
26	APFS	45.00	5.00	12.50
27	APCPT	44.67	4.67	11.68
28	BPAP	43.67	3.67	9.18
29	BPFS	46.00	6.00	15.00
30	BPCPT	45.00	5.00	12.50
31	KPAP	43.67	3.67	9.18
32	KPFS	45.67	5.67	14.18
33	KPCPT	45.00	5.00	12.50
34	MPAP	45.00	5.00	12.50
35	MPFS	46.00	6.00	15.00
36	MPCPT	45.33	5.33	13.33
37	RPAP	45.00	5.00	12.50
38	RPFS	46.00	6.00	15.00
39	RPCPT	45.67	5.67	14.18
40	VPAP	45.67	5.67	14.18
41	VPFS	45.00	5.00	12.50
42	VPCPT	44.67	4.67	11.68
Dyed with Biomordants				
43	APP	45.00	5.00	12.50
44	APS	46.00	6.00	15.00
45	APPT	46.67	6.67	16.68
46	BPP	44.33	4.33	10.83
47	BPS	44.67	4.67	11.68
48	BPPT	45.00	5.00	12.50
49	MPP	45.33	5.33	13.33
50	MPS	46.00	6.00	15.00
51	MPPT	46.67	6.67	16.68
52	AAP	45.00	5.00	12.50
53	AAS	46.00	6.00	15.00
54	AAPT	46.67	6.67	16.68
55	BAP	45.67	5.67	14.18
56	BAS	45.00	5.00	12.50
57	BAPT	46.33	6.33	15.83
58	MAP	46.67	6.67	16.68
59	MAS	47.00	7.00	17.50
60	MAPT	45.67	5.67	14.18

FIGURE – III

TENSILE STRENGTH OF ORIGINAL AND DYED SAMPLES (WARP)



ANOVA for Breaking Strength-Warp-% Loss/Gain (Metallic and Processed Mordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	319.734	5	63.947	14.932	**
	Techniques	48.669	1	48.669	11.365	**
	Mordants	69.907	2	34.954	8.162	**
2-Way Interactions	Dyes * Techniques	104.456	5	20.891	4.878	**
	Dyes * Mordants	122.454	10	12.245	2.859	**
	Techniques * Mordants	83.796	2	41.898	9.784	**
3-Way Interactions	Dyes * Techniques * Mordants	68.287	10	6.829	1.595	NS
Residual		308.333	72	4.282		
Total		**1125.637**	**107**	**10.520**		

ANOVA for Breaking Strength-Warp-% Loss/Gain (Biomordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	62.731	2	31.366	7.971	**
	Mordants	29.630	1	29.630	7.529	**
	Technique	25.926	2	12.963	3.294	*
2-Way Interactions	Dyes * Mordants	7.176	2	3.588	.912	NS
	Dyes * Technique	23.380	4	5.845	1.485	NS
	Mordants * Technique	3.704	2	1.852	.471	NS
3-Way Interactions	Dyes * Mordants * Technique	38.657	4	9.664	2.456	NS
Residual		141.667	36	3.935		
Total		332.870	53	6.281		

It is evident from the data that the tensile strength had increased in the warp side among all the natural dyed mercerized cotton samples, which were dyed without the use of mordants, samples dyed with metallic mordants, samples dyed with processed mordants, and samples dyed with biomordants. The increase in tensile strength when dyed without mordants ranged from 4.18 per cent to 7.50 per cent, the maximum increase being recorded by the madder and red sandal dyed samples, followed by vambadam dyed samples.

With reference to annato, babool and karingali dyes, the samples dyed using metallic copper sulphate as the mordant following post mordanting technique resulted in highest tensile strength on the warp side by 8.33 per cent, 11.68 per cent and 12.50 per cent respectively.

The same trend was noticed with reference to madder and red sandal dyes, while using metallic copper sulphate following post mordanting technique the increase in tensile strength on the warp side being 16.68 per cent and 15.00 per cent respectively. However for the vambadam dye, metallic alum using pre mordanting technique gave best results with 16.68 per cent increase in tensile strength on the warp side.

Comparison of mean tensile strength of original undyed cotton samples warp with those dyed using processed mordants following pre, simultaneous and post mordanting techniques revealed that for annato and babool dyes using processed ferrous sulphate following simultaneous technique had recorded the highest increase in tensile strength, the increase being 12.50 per cent and 15.00 per cent respectively.

With reference to karingali dye, the samples treated with processed ferrous sulphate using simultaneous mordanting technique resulted in maximum increase in tensile strength on the warp side the value being 14.18 per cent. As far as the madder and red sandal dyed samples were concerned the processed ferrous sulphate following simultaneous mordanting technique had resulted in an appreciable increase in warp tensile strength, the value being for both 15.00 per cent.

Maximum increase in tensile strength upto 14.18 per cent was noticed in the sample treated with processed alum following pre mordanting technique while dyeing with vembadam dye. Thus when processed mordants were used for dyeing, the processed ferrous sulphate mordant using simultaneous technique resulted in maximum increase in warp tensile strength with respect to all the dyes except vembadam dye.

Using pomegranate rind as the biomordant for dyeing with annato, babool and madder dyes, while all the samples showed increased tensile strength on the warp side, the samples treated with pomegranate rind using post mordanting technique recorded a maximum increase in tensile strength by 16.68 per cent, 12.50 per cent and 16.68 per cent respectively.

The same trend was noticed with reference to increase in tensile strength when annato, babool and madder dyes were used for dyeing, using amla as biomordant following post mordanting technique, the values being 16.68 per cent, 15.83 per cent and 17.50 per cent respectively.

Thus while using biomordants for annato, babool and madder dyes post mordanting technique seems to be most desirable.

Statistical analysis of the data relating to breaking strength (warp side), comparing the effects of dyes, metallic and processed mordants and mordanting techniques revealed that significant difference at 1% level was found between dyes and also between mordants, whereas between mordanting techniques the statistical significance was at 5% level. The two way interactions showed that there was no stastically significant difference between dyes and mordants, dyes and mordanting techniques, mordants and mordanting techniques. The three way interactions between dyes, mordants and mordanting techniques also proved that there was no statistically significant difference. These results indicate that the breaking strength (warp side) had increased significantly when processed mordants were used instead of metallic mordants.

Statistical analysis of the data relating to breaking strength (warp side), comparing the effects of dyes, biomordants and mordanting techniques revealed that there was significant difference between dyes, between mordanting techniques and between mordants. The two way interactions showed statistical significance at 1% level between dyes and mordanting techniques, between dyes and mordants and also between mordanting

techniques and mordants. Three way interactions revealed that between dyes, mordanting techniques and mordants, there was no statistical significant difference. These results indicate that biomordants and mordanting techniques had increased breaking strength (warp side) significantly.

Comparison of the different natural dyes using metallic, processed and biomordants following different mordanting techniques revealed that madder dyed samples using amla as biomordant following simultaneous mordanting technique had recorded the highest gain in Tensile strength on warp side by 7 kg/cm^2 (17.50 per cent).

Table XXIII shows the mean tensile strength of the original undyed cotton samples weft side compared against dyed with and without mordants and percentage gain or loss over original undyed samples.

TABLE XXIII

TENSILE STRENGTH OF ORIGINAL AND DYED SAMPLES (WEFT)

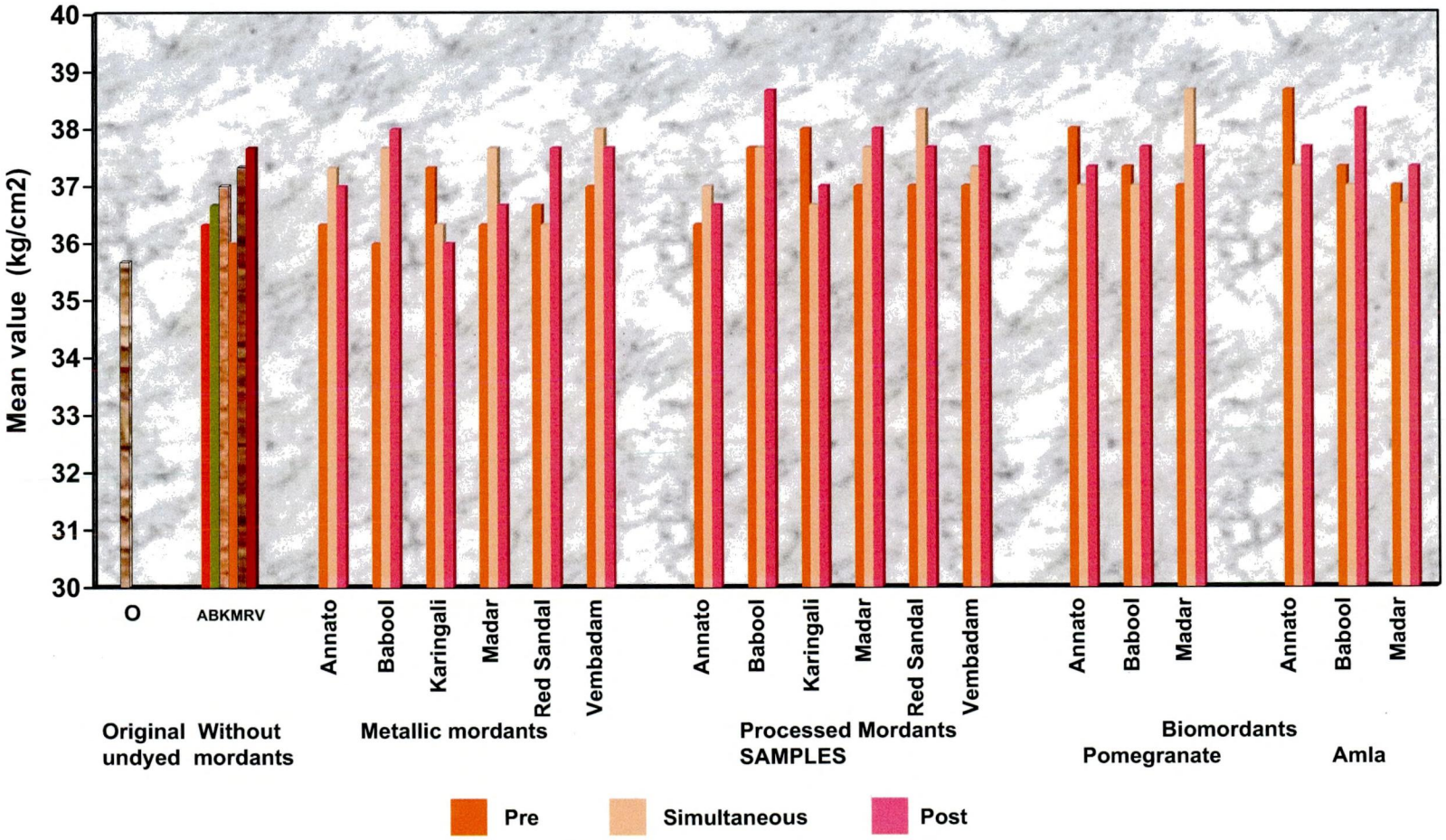
S.No.	Sample	Mean value (kg/cm2)	Gain or loss over original	Percentage gain over original
0	Original undyed	35.67		
Dyed Without Mordants				
1	ADS	36.33	0.66	1.85
2	BDS	36.67	1.00	2.80
3	KDS	37.00	1.33	3.73
4	MDS	36.00	0.33	0.93
5	RDS	37.33	1.66	4.65
6	VDS	37.67	2.00	5.61
Dyed with Metallic Mordants				
7	AMAP	36.33	0.66	1.85
8	AMFS	37.33	1.66	4.65
9	AMCPT	37.00	1.33	3.73
10	BMAP	36.00	0.33	0.93
11	BMFS	37.67	2.00	5.61
12	BMCPT	38.00	2.33	6.53
13	KMAP	37.33	1.66	4.65
14	KMFS	36.33	0.66	1.85
15	KMCPT	36.00	0.33	0.93
16	MMAP	36.33	0.66	1.85
17	MMFS	37.67	2.00	5.61
18	MMCPT	36.67	1.00	2.80

Contd...

S.No.	Sample	Mean value (kg/cm2)	Gain or loss over original	Percentage gain over original
19	RMAP	36.67	1.00	2.80
20	RMFS	36.33	0.66	1.85
21	RMCPT	37.67	2.00	5.61
22	VMAP	37.00	1.33	3.73
23	VMFS	38.00	2.33	6.53
24	VMCPT	37.67	2.00	5.61
Dyed with Processed Mordants				
25	APAP	36.33	0.66	1.85
26	APFS	37.00	1.33	3.73
27	APCPT	36.67	1.00	2.80
28	BPAP	37.67	2.00	5.61
29	BPFS	37.67	2.00	5.61
30	BPCPT	38.67	3.00	8.41
31	KPAP	38.00	2.33	6.53
32	KPFS	36.67	1.00	2.80
33	KPCPT	37.00	1.33	3.73
34	MPAP	37.00	1.33	3.73
35	MPFS	37.67	2.00	5.61
36	MPCPT	38.00	2.33	6.53
37	RPAP	37.00	1.33	3.73
38	RPFS	38.33	2.66	7.46
39	RPCPT	37.67	2.00	5.61
40	VPAP	37.00	1.33	3.73
41	VPFS	37.33	1.66	4.65
42	VPCPT	37.67	2.00	5.61
Dyed with Biomordants				
43	APP	38.00	2.33	6.53
44	APS	37.00	1.33	3.73
45	APPT	37.33	1.66	4.65
46	BPP	37.33	1.66	4.65
47	BPS	37.00	1.33	3.73
48	BPPT	37.67	2.00	5.61
49	MPP	37.00	1.33	3.73
50	MPS	38.67	3.00	8.41
51	MPPT	37.67	2.00	5.61
52	AAP	38.67	2.33	8.41
53	AAS	37.33	1.66	4.65
54	AAPT	37.67	2.00	5.61
55	BAP	37.33	1.66	4.65
56	BAS	37.00	1.33	3.73
57	BAPT	38.33	2.66	7.46
58	MAP	37.00	1.33	3.73
59	MAS	36.67	1.00	2.80
60	MAPT	37.33	1.66	4.65

FIGURE – IV

TENSILE STRENGTH OF ORIGINAL AND DYED SAMPLES (WEFT)



ANOVA for Breaking Strength-Weft-% Loss/Gain (Metallic and Processed Mordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	94.023	5	18.805	4.168	**
	Techniques	57.054	1	57.054	12.645	**
	Mordants	35.513	2	17.757	3.935	*
2-Way Interactions	Dyes * Techniques	41.626	5	8.325	1.845	NS
	Dyes * Mordants	126.916	10	12.692	2.813	**
	Techniques * Mordants	.582	2	.291	.065	NS
3-Way Interactions	Dyes * Techniques * Mordants	102.464	10	10.246	2.271	*
Residual		324.858	72	4.512		
Total		**783.037**	**107**	**7.318**		

ANOVA for Breaking Strength-Weft-% Loss/Gain (Biomordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	6.113	2	3.056	.700	NS
	Mordants	.146	1	.146	.033	NS
	Technique	11.353	2	5.676	1.300	NS
2-Way Interactions	Dyes * Mordants	29.982	2	14.991	3.433	*
	Dyes * Technique	58.509	4	14.627	3.350	*
	Mordants * Technique	14.263	2	7.132	1.633	NS
3-Way Interactions	Dyes * Mordants * Technique	17.174	4	4.294	.983	NS
Residual		157.190	36	4.366		
Total		**294.730**	**53**	**5.561**		

It is evident from the data that the tensile strength had increased among the natural dyed mercerized cotton samples (weft side) even without the use of mordants, samples dyed with metallic mordants, samples dyed with processed mordants, and samples dyed with biomordants. The increase in tensile strength when dyed without mordants ranged from 0.93 per cent to 5.61 per cent, the maximum increase being recorded by the vembadam dyed sample.

With regard to annato, madder and vembadam dyes, maximum increase in tensile strength in weft side by 4.65 per cent, 5.61 per cent and 6.53 per cent were recorded by the samples treated using metallic ferrous sulphate following simultaneous mordanting technique. For babool and red sandal dyes, using metallic copper sulphate with post mordanting technique resulted in maximum increase by 6.53 per cent and 5.61 per cent in the tensile strength on weft side.

With reference to karingali, maximum increase in tensile strength by 4.65 per cent was recorded by the samples treated with metallic alum following pre mordanting technique.

Examination of the changes in tensile strength on weft side, when cotton samples were dyed with processed mordants revealed that with reference to annato, babool, karingali and red sandal dyes, all the samples revealed increased tensile strength irrespective of mordants and mordanting techniques used. The Maximum increase in tensile strength by 3.73 per cent, 8.41 per cent, 6.53 per cent were identified with processed ferrous sulphate using simultaneous mordanting technique, processed copper sulphate using post mordanting technique and processed alum using pre mordanting technique respectively.

With reference to madder and vembadam dyes, the samples treated with processed copper sulphate using post mordanting technique recorded a maximum increase in tensile strength by 6.53 per cent and 5.61 per cent respectively. For red sandal dye, using processed ferrous sulphate following simultaneous mordanting technique resulted in maximum increase by 7.46 per cent in the tensile strength.

Using pomegranate rind and amla biomordants for dyeing with annato dye following pre mordanting technique, maximum increase in tensile strength on weft side by 6.53 per cent and 8.41 per cent were recorded respectively.

With reference to babool and madder dyes, when pomegranate rind biomordant was used, maximum increase in tensile strength by weft side, 5.61 per cent, and 8.41 per cent were observed when post mordanting and simultaneous mordanting techniques were applied.

When the biomordant amla was used with babool and madder dyes, the samples using post mordanting technique recorded a maximum increase in tensile strength by 7.46 per cent and 4.65 per cent respectively. Thus while using biomordants for babool and madder dyes post mordanting technique seems to be desirable.

Statistical analysis of the data relating to tensile strength (weft side), comparing the effects of dyes, metallic and processed mordants and mordanting techniques revealed that, there was significant difference at 1% level between dyes, and between mordanting techniques, while between mordants there was a statistical significance at 5% level. The two way interactions showed that there was no statistical significance between dyes and mordanting techniques, and techniques and mordants, whereas between dyes and mordants the statistical significance was at 1% level. The three way interactions between dyes, mordanting techniques and mordants, there was a statistical significant difference at 5% level. These results indicate that the tensile strength had significantly increased when processed mordants were used instead of metallic mordants.

Statistical analysis of the data relating to tensile strength (weft side), comparing the effects of dyes, biomordants and mordanting techniques revealed that there was no statistically significant difference between dyes, and between mordants and also between techniques. The two way interactions showed statistically significant difference at 5% level between dyes and mordants, and dyes and mordanting techniques, where as between mordants and techniques there was no statistically significant difference.

Three way interactions between dyes, mordants and mordanting techniques, there was no statistically significant difference. These results indicate that biomordants and mordanting techniques had increased the tensile strength significantly.

In the breaking strength test, using reactive dyes, there was increase in strength in certain cases, and decrease in strength in certain other cases for the warp side of the fabric, while a uniform increase in strength in the weft direction as observed by Srivani and Ranganathan (1998). In the present study the breaking strength had increased uniformly in both warp and weft direction, while employing natural dyes.

Similar findings were reported by Anita and Jacob (2003) who found that cotton fabrics dyed by using natural dyes using henna leaves along with eco-friendly mordants alum, copper sulphate and ferrous sulphate have improved in tear strength besides gaining weight and thickness over control.

Comparison of the different natural dyes using metallic, processed and biomordants following different mordanting techniques revealed that babool dyed samples using processed mordants following post mordanting technique had recorded the highest gain in tensile strength on weft side by 3 kg/cm^2 (8.41 per cent). Annato and madder dyed samples using amla and pomegranate rind as biomordants following pre and simultaneous techniques respectively recorded 2.33 kg/cm^2 (8.41 per cent)in tensile strength on weft side.

4.3.2.4. Elongation of the Fabric (Warp)

Table XXIV shows the mean elongation (warp side) of the original undyed mercerized cotton samples compared against samples dyed with and without mordants following different mordanting techniques and percentage gain or loss over original undyed samples.

TABLE XXIV

ELONGATION OF ORIGINAL AND DYED SAMPLES (WARP)

S.No.	Sample	Mean value (cm)	Gain or loss over original	Percentage gain over original
0	Original undyed	3.5		
Dyed without Mordants				
1	ADS	3.83	0.33	9.43
2	BDS	3.75	0.25	7.14
3	KDS	3.58	0.08	2.29
4	MDS	3.68	018	5.14
5	RDS	3.68	0.18	5.14
6	VDS	3.58	0.08	2.29
Dyed with Metallic Mordants				
7	AMAP	3.83	0.33	9.43
8	AMFS	3.68	0.18	5.14
9	AMCPT	3.75	0.25	7.14
10	BMAP	3.68	0.18	5.14
11	BMFS	3.75	0.25	7.14
12	BMCPT	3.83	0.33	9.43
13	KMAP	3.58	0.08	2.29
14	KMFS	3.68	0.18	5.14
15	KMCPT	3.75	0.25	7.14
16	MMAP	3.68	0.18	5.14
17	MMFS	3.75	0.25	7.14
18	MMCPT	3.68	0.18	5.14
19	RMAP	3.68	0.18	5.14
20	RMFS	3.58	0.08	2.29
21	RMCPT	3.58	0.08	2.29
22	VMAP	3.75	0.25	7.14
23	VMFS	3.83	0.33	9.43
24	VMCPT	3.68	0.18	5.14
Dyed with Processed Mordants				
25	APAP	3.75	0.25	7.14
26	APFS	3.83	0.33	9.43
27	APCPT	3.75	0.25	7.14
28	BPAP	3.68	0.18	5.14
29	BPFS	3.58	0.08	2.29
30	BPCPT	3.58	0.08	2.29
31	KPAP	3.58	0.08	2.29
32	KPFS	3.68	0.18	5.14
33	KPCPT	2.75	0.25	7.14
34	MPAP	3.75	0.25	7.14
35	MPFS	3.75	0.25	7.14
36	MPCPT	3.83	0.33	9.43

Contd....

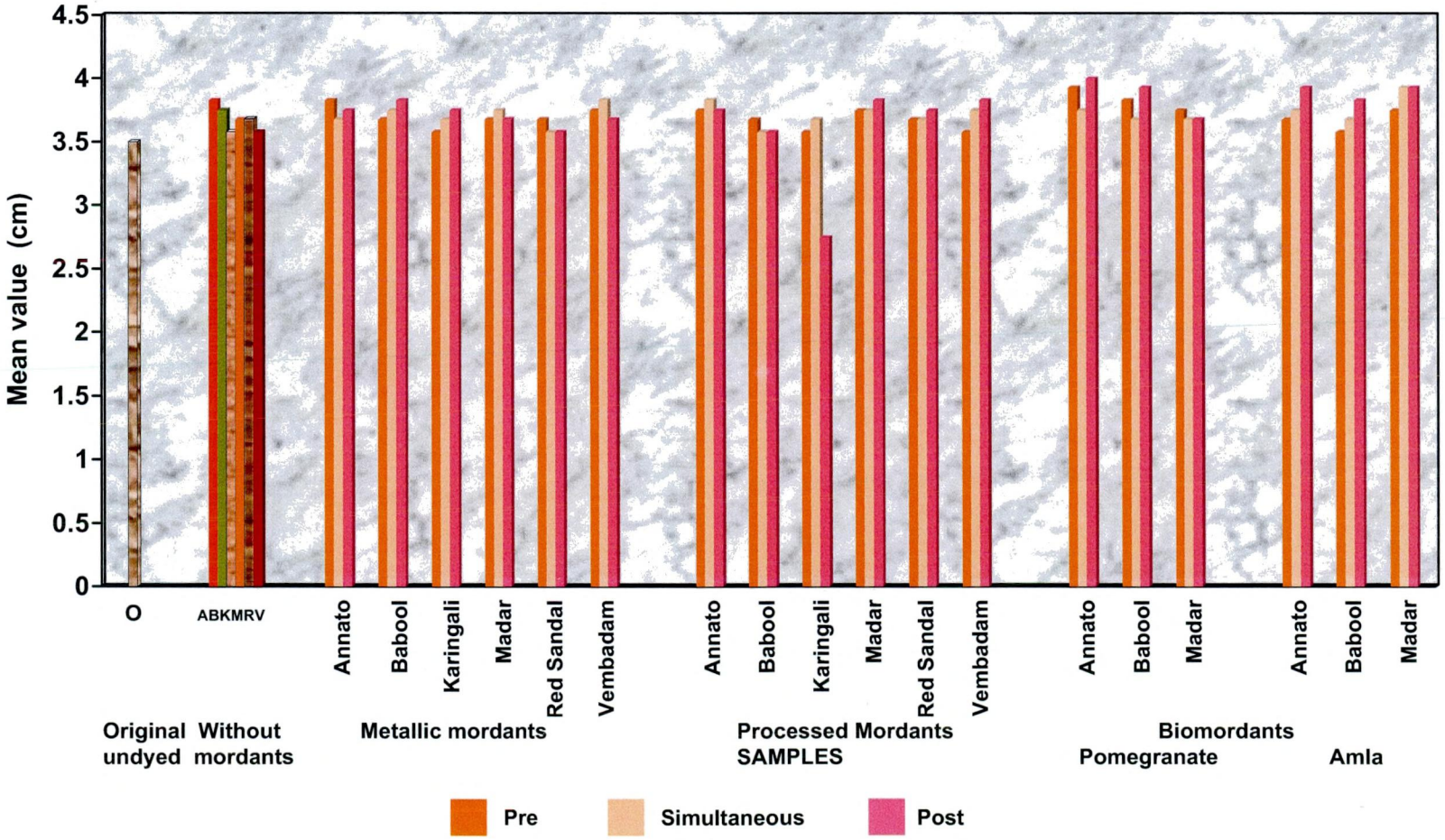
S.No.	Sample	Mean value (cm)	Gain or loss over original	Percentage gain over original
37	RPAP	3.68	0.18	5.14
38	RPFS	3.68	0.18	5.14
39	RPCPT	3.75	0.25	7.14
40	VPAP	3.58	0.08	2.29
41	VPFS	3.75	0.25	7.14
42	VPCPT	3.83	0.33	9.43
Dyed with Biomordants				
43	APP	3.93	0.43	12.29
44	APS	3.75	0.25	7.14
45	APPT	4.00	0.50	14.28
46	BPP	3.83	0.33	9.29
47	BPS	3.68	0.18	5.14
48	BPPT	3.93	0.43	12.29
49	MPP	3.75	0.25	7.14
50	MPS	3.68	0.18	5.14
51	MPPT	3.68	0.18	5.14
52	AAP	3.68	0.18	5.14
53	AAS	3.75	0.25	7.14
54	AAPT	3.93	0.43	12.29
55	BAP	3.58	0.08	2.29
56	BAS	3.68	0.18	5.14
57	BAPT	3.83	0.33	9.29
58	MAP	3.75	0.25	7.14
59	MAS	3.93	0.43	12.29
60	MAPT	3.93	0.43	12.29

ANOVA for Elongation-Warp-% Loss/Gain (Metallic and Processed Mordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	191.327	5	38.265	1.306	NS
	Techniques	.472	1	.472	.016	NS
	Mordants	36.848	2	18.424	.629	NS
2-Way Interactions	Dyes * Techniques	138.416	5	27.683	.945	NS
	Dyes * Mordants	116.213	10	11.621	.397	NS
	Techniques * Mordants	23.621	2	11.810	.403	NS
3-Way Interactions	Dyes * Techniques * Mordants	186.130	10	18.613	.635	NS
Residual		2108.844	72	29.289		
Total		**2801.871**	**107**	**26.186**		

FIGURE – V

ELONGATION OF ORIGINAL AND DYED SAMPLES (WARP)



ANOVA for Elongation-Warp-% Loss/Gain (Biomordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	52.910	2	26.455	1.000	NS
	Mordants	3.779	1	3.779	.143	NS
	Technique	171.958	2	85.979	3.250	*
2-Way Interactions	Dyes * Mordants	188.964	2	94.482	3.571	*
	Dyes * Technique	71.807	4	17.952	.679	NS
	Mordants * Technique	126.606	2	63.303	2.393	NS
3-Way Interactions	Dyes * Mordants * Technique	3.779	4	.945	.036	NS
Residual		952.381	36	26.455		
Total		**1572.184**	**53**	**29.664**		

Table XXIV shows that the fabric elongation had increased among all the natural dyed mercerized warp side samples, dyed without the use of mordants, samples dyed with metallic mordants, samples dyed with processed mordants, and samples dyed with biomordants.

Among the samples dyed without the mordants, the maximum increase of 9.43 per cent and 7.14 per cent was recorded by the annato and babool dyed samples respectively.

Among the samples dyed using metallic mordants, maximum increase in elongation by 9.43 per cent and 5.14 per cent respectively were noticed with annato and red sandal dyes, using metallic alum as mordant and adopting pre mordanting technique.

With reference to babool and karingali dyes, metallic copper sulphate using post mordanting technique recorded a maximum increase in elongation on the warp side 9.43 per cent and 7.14 per cent respectively, while the madder and vembadam dyed samples using metallic ferrous sulphate following simultaneous technique recorded a maximum increase by 7.14 and 9.43 per cent respectively in elongation of the fabric on the warp side.

Among the samples dyed with processed mordants, maximum increase in elongation by 9.43 per cent, 5.14 per cent and 7.14 per cent respectively were noticed for annato, babool and karingali dyes treated with processed ferrous sulphate following simultaneous mordanting technique, processed alum using pre mordanting technique and processed copper sulphate using post mordanting technique respectively. As far as the madder, red sandal and vembadam dyed samples were concerned, the processed copper sulphate using post mordanting technique had resulted an appreciable increase in fabric elongation on the warp side, the values being 9.43 per cent, 7.14 per cent and 9.43 per cent respectively.

Among the samples dyed with biomordants, maximum increase in elongation by 14.28 per cent and 12.29 per cent respectively were recorded by annato and babool dyes, when the samples treated with pomegranate rind biomordant following post mordanting technique.

Maximum increase in elongation by 7.14 per cent was recorded for madder dye when the pomegranate rind biomordant was used with pre mordanting technique.

When the biomordant amla was used with annato and babool dyes, a maximum increase in elongation by 12.29 per cent and 9.29 per cent respectively were recorded by the samples with amla as biomordant using post mordanting technique. As far as the madder dye was concerned, a maximum increase in elongation by 12.29 per cent was recorded by the samples using amla as biomordant with simultaneous as well as post mordanting techniques.

Statistical analysis of the data relating to fabric elongation (warp side), comparing the effect of dyes, metallic and processed mordants and mordanting techniques revealed that there was no statistically significant difference between dyes, between mordaning techniques and also between mordants. The two way interactions showed no significant difference between

dyes and mordanting techniques, between dyes and mordants and also between mordanting techniques and mordants. In the three way interactions between dyes, mordanting techniques and mordants, there was no significant difference. These results indicate that the fabric elongation had significantly increased when processed mordants were used.

Statistical analysis of the data relating to fabric elongation (warp side), comparing the effect of dyes, biomordants and mordanting techniques revealed that, there was no statistical significant difference between dyes, and between mordants while between mordanting techniques, there was a statistical significance at 5% level. The two way interaction showed significant difference at 5% level between dyes and mordants, whereas between dyes and mordanting techniques and between mordants and mordanting techniques there was no statistical significance. The three way interactions between dyes, biomordants and mordanting techniques there was no statistically significanct difference. These results indicate that biomordants and mordanting techniques had increased the fabric elongation.

Comparison of the different natural dyes using metallic, processed and biomordants following different mordanting techniques revealed that elongation on annato and vembadam dyed samples using both metallic and processed mordants following pre simultaneous and post mordanting techniques and baool and madder dyed samples using metallic and processed mordants following post mordanting techniques respectively had recorded the highest elongation by 0.33cm (9.43 per cent). Annato dyed samples using pomegranate rind as biomordant following post mordanting technique had recorded the highest gain in elongation on warp by 0.55 cm (14.28 per cent).

Elongation of the Fabric (Weft)

Table XXV shows the mean elongation (weft side) of the original undyed mercerized cotton samples compared against samples dyed with and

without mordants following different mordanting techniques and percentage gain or loss over original undyed samples.

TABLE XXV

ELONGATION OF ORIGINAL AND DYED SAMPLES (WEFT)

S.No.	Sample	Mean value (cm)	Gain or loss over original	Percentage gain over original
0	Original undyed	4.25		
Dyed without Mordants				
1	ADS	4.33	0.08	1.88
2	BDS	4.75	0.50	11.76
3	KDS	4.33	0.08	1.88
4	MDS	4.50	0.25	5.88
5	RDS	4.33	0.08	1.88
6	VDS	4.58	0.33	7.64
Dyed with Metallic Mordants				
7	AMAP	4.50	0.25	5.88
8	AMFS	4.68	0.43	9.80
9	AMCPT	4.33	0.08	1.88
10	BMAP	4.75	0.50	11.76
11	BMFS	5.25	1.00	23.52
12	BMCPT	5.50	1.25	29.41
13	KMAP	4.33	0.08	1.88
14	KMFS	4.50	0.25	5.88
15	KMCPT	4.75	0.50	-11.76
16	MMAP	4.50	0.25	5.88
17	MMFS	4.58	0.33	7.64
18	MMCPT	4.50	0.25	5.88
19	RMAP	4.43	0.18	4.12
20	RMFS	4.58	0.33	7.64
21	RMCPT	4.68	0.43	10.11
22	VMAP	5.00	0.75	17.65
23	VMFS	5.25	1.00	23.53
24	VMCPT	4.75	0.50	11.76
Dyed with Processed Mordants				
25	APAP	4.50	0.25	5.88
26	APFS	4.33	0.08	1.88
27	APCPT	4.75	0.50	11.76
28	BPAP	5.25	1.00	23.53
29	BPFS	5.25	1.00	23.53
30	BPCPT	5.5	1.25	29.41
31	KPAP	4.50	0.25	5.88
32	KPFS	4.50	0.25	5.88
33	KPCPT	4.58	0.33	7.64

Contd...

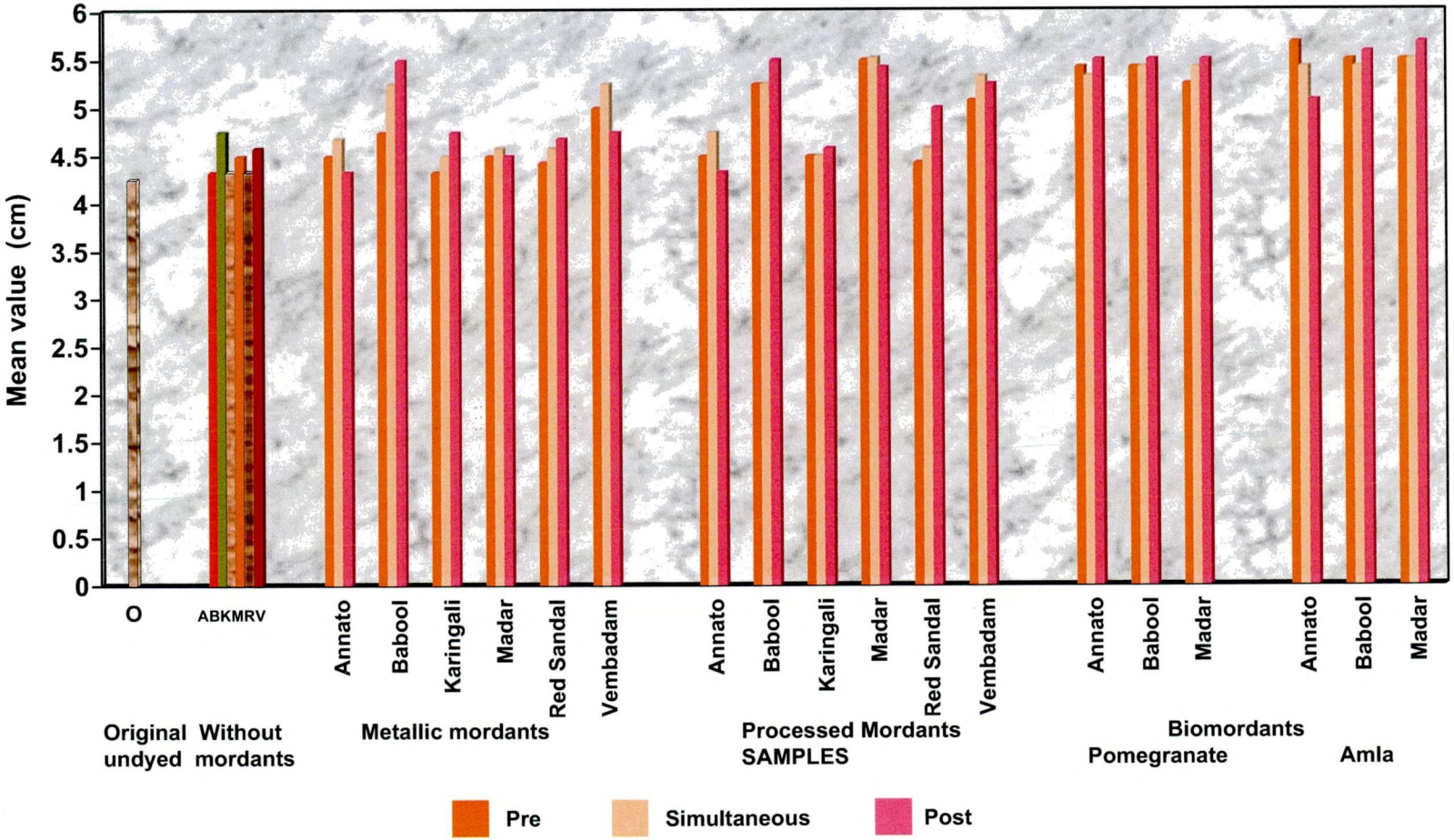
S.No.	Sample	Mean value (cm)	Gain or loss over original	Percentage gain over original
34	MPAP	5.50	1.25	29.41
35	MPFS	5.25	1.00	23.53
36	MPCPT	5.43	1.18	27.65
37	RPAP	4.43	0.18	4.11
38	RPFS	4.58	0.33	7.64
39	RPCPT	5.00	0.75	17.65
40	VPAP	5.08	0.83	19.53
41	VPFS	5.33	1.88	25.41
42	VPCPT	5.25	1.00	23.53
Dyed with Biomordants				
43	APP	5.43	1.18	27.65
44	APS	5.33	1.18	25.41
45	APPT	5.50	1.00	29.41
46	BPP	5.43	1.18	27.65
47	BPS	5.43	1.18	27.65
48	BPPT	5.50	1.25	29.41
49	MPP	5.25	1.00	23.53
50	MPS	5.43	1.18	27.65
51	MPPT	5.50	1.25	29.41
52	AAP	5.68	1.43	33.53
53	AAS	5.43	1.18	27.65
54	AAPT	5.08	1.83	19.53
55	BAP	5.50	1.25	29.41
56	BAS	5.43	1.18	27.65
57	BAPT	5.58	1.33	31.18
58	MAP	5.50	1.25	29.41
59	MAS	5.50	1.25	29.41
60	MAPT	5.68	1.43	33.53

ANOVA for Elongation-Weft-% Loss/Gain (Metallic and Processed Mordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	5092.913	5	1018.583	39.740	**
	Techniques	800.974	1	800.974	31.250	**
	Mordants	296.681	2	148.340	5.787	**
2-Way Interactions	Dyes * Techniques	1271.306	5	254.261	9.920	**
	Dyes * Mordants	929.771	10	92.977	3.627	**
	Techniques * Mordants	66.000	2	33.000	1.287	NS
3-Way Interactions	Dyes * Techniques * Mordants	330.001	10	33.000	1.287	NS
Residual		1845.444	72	25.631		
Total		**10633.090**	**107**	**99.375**		

FIGURE – VI

ELONGATION OF ORIGINAL AND DYED SAMPLES (WEFT)



ANOVA for Elongation-Weft-% Loss/Gain (Biomordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	32.039	2	16.019	.781	NS
	Mordants	31.398	1	31.398	1.531	NS
	Technique	16.660	2	8.330	.406	NS
2-Way Interactions	Dyes * Mordants	47.418	2	23.709	1.156	NS
	Dyes * Technique	190.952	4	47.738	2.328	NS
	Mordants * Technique	78.175	2	39.088	1.906	NS
3-Way Interactions	Dyes * Mordants * Technique	137.127	4	34.282	1.672	NS
Residual		738.178	36	20.505		
Total		**1271.947**	**53**	**23.999**		

The Table XXV shows that the fabric elongation had increased among all the natural dyed mercerized weft side samples, dyed without the use of mordants, samples dyed with metallic mordants, samples dyed with processed mordants, and samples dyed with biomordants.

Among the samples dyed without use of the mordants, a maximum increase of 11.76 per cent and 7.64 per cent was recorded by the babool dyed sample followed by vembadam dyed samples respectively.

Among the samples dyed using metallic mordants, maximum increase in elongation on the weft side by 9.80 per cent, 7.64 per cent and 23.53 per cent was recorded when metallic ferrous sulphate was used with simultaneous mordanting technique for annato, madder and vembadam dyes.

When the mercerized cotton samples were dyed with babool dye, using metallic copper sulphate as the mordant with post mordanting technique, highest fabric elongation of 29.41 per cent was noticed. Similarly dyeing with karingali and red sandal dyes with metallic copper sulphate as mordant following post mordanting technique resulted in highest increase in elongation on the weft side the values being 11.76 per cent and 10.11 per cent respectively.

Comparison of mean fabric elongation of original undyed cotton samples with those dyed using processed mordants with pre, simultaneous and post mordanting techniques indicated that for annato using processed ferrous sulphate following simultaneous mordanting technique recorded a maximum increase in elongation by 11.76 per cent, whereas babool and karingali dyes using processed copper sulphate following post mordanting technique had recorded the highest increase in fabric elongation. The increase was 11.76 per cent, 29.41 per cent and 7.64 per cent respectively.

With reference to madder, red sandal and vembadam dyes, processed alum using pre mordanting technique, processed copper sulphate using post mordanting technique and processed ferrous sulphate using simultaneous mordanting technique resulted in maximum increase in elongation by 29.41 per cent, 17.65 per cent and 25.41 per cent respectively.

Using pomegranate biomordant for dyeing with annato and madder dyes, while all the samples showed increased elongation by the weft side the samples treated with pomegranate rind using post mordanting technique recorded a maximum increase by 29.41 per cent for both the dyes.

With reference to babool and annato dyes using the pomegranate rind and amla biomordants following post and pre mordanting techniques recorded a maximum increase by 29.41 per cent and 33.53 per cent respectively.

With reference to babool and madder dyes using amla as biomordant recorded a maximum increase by 31.18 per cent and 33.53 per cent respectively following post mordanting technique.

Statistical analysis of the data relating to fabric elongation (weft), comparing the effect of dyes, metallic and processed mordants and mordanting techniques revealed that there was no statistical significant difference between dyes, between mordanting techniques and also between mordants. The two way interactions showed no significant difference between dyes and mordanting techniques, between dyes and mordants, and between

mordants and mordanting techniques. In the three way interactions between dyes, mordanting techniques and mordants there was no significant statistical difference. These results indicate that the fabric elongation had significantly increased when processed mordants were used.

Statistical analysis of the data relating to fabric elongation (weft side), comparing the effects of dyes, biomordants and mordanting techniques revealed that there was no statistically significant difference between dyes, between mordants and also between mordanting techniques. The two way interactions showed no significant difference between dyes and mordants, between dyes and mordanting technique and also between mordants and mordanting techniques. In the three way interactions between dyes, mordants and mordanting techniques, there was no significant statistical difference. These results indicate that biomordants and mordanting techniques had increased the fabric elongation.

Elongation on the warp and weft side had uniformly increased while employing natural dyed in the present study, whereas elongation on the warp side had decreased, and elongation on the weft direction had increased when reactive dyes were used according to Srivani and Ranganathan (1998).

Comparison of the different natural dyes using metallic, processed and biomordants following different mordanting techniques revealed that madder dyed samples using amla as biomordant following post mordanting technique had recorded the highest gain in elongation on weft side by 1.43 cm (33.53 per cent), while babool dyed samples using both metallic and processed mordants following post mordanting technique and madder dyed samples using processed mordants following pre mordanting technique had recorded 1.25 cm (29.41 per cent).

4.4. Wettability and Absorbency Tests

The wettability and absorbency test includes drop test, sinking test and capillary rise test. The findings are as follows :

4.4.1. Drop Test

Table XXVI shows the mean drop test values of the undyed original mercerized cotton samples compared against dyed with and without mordants and percentage gain or loss over original undyed samples.

TABLE XXVI

DROP TEST VALUES FOR ORIGINAL AND DYED SAMPLES

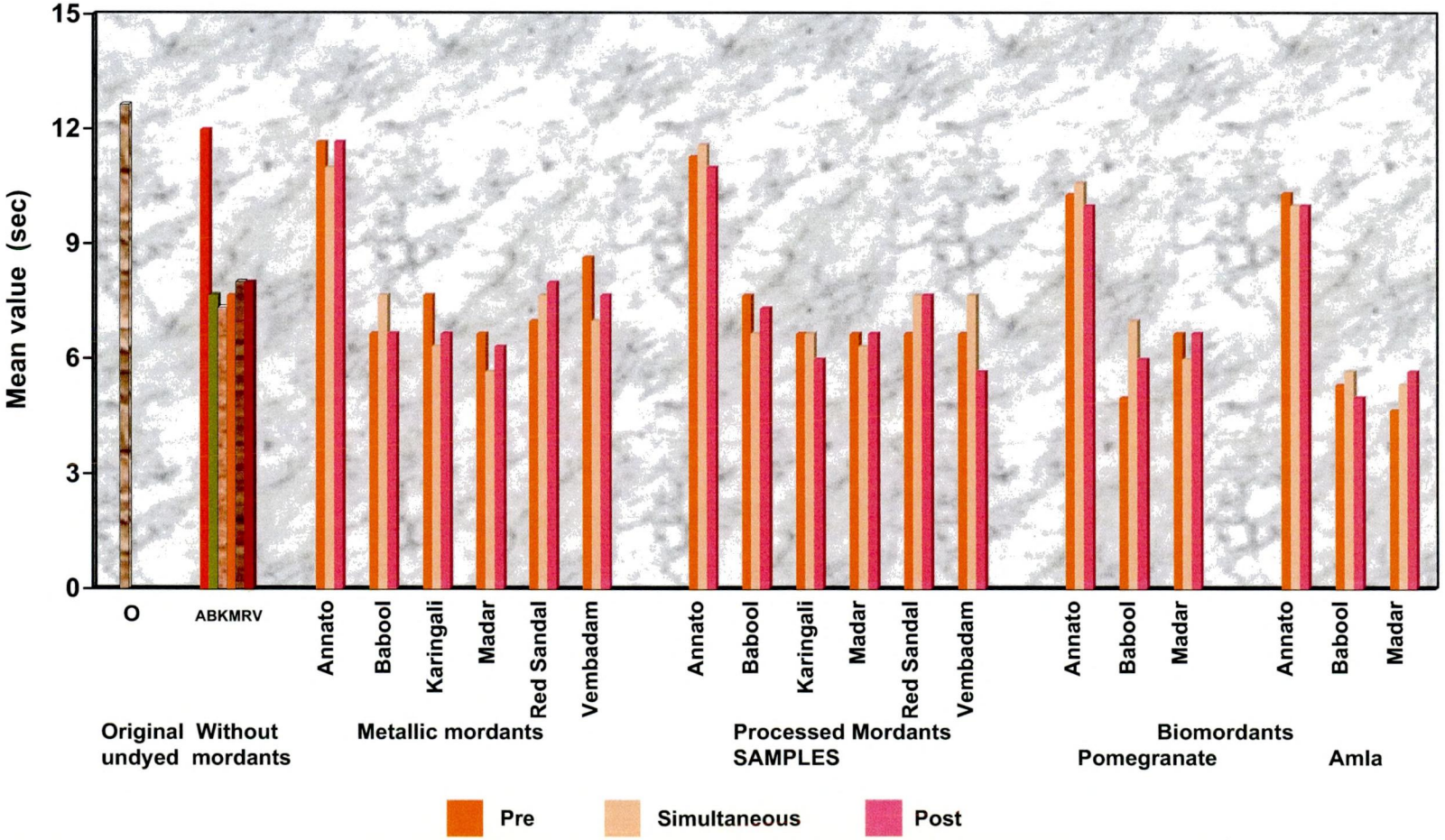
S.No.	Sample	Mean value (sec)	Gain or loss over original	Percentage gain over original
0	Original undyed	12.63		
Dyed without Mordants				
1	ADS	12.00	-0.63	-4.99
2	BDS	7.67	-4.96	-39.27
3	KDS	7.33	-5.3	-41.96
4	MDS	7.67	-4.96	-39.27
5	RDS	8.00	-4.63	-36.66
6	VDS	8.00	-4.63	-36.66
Dyed with Metallic Mordants				
7	AMAP	11.67	0.96	-7.60
8	AMFS	11.00	-1.63	-12.91
9	AMCPT	11.67	-0.96	-7.60
10	BMAP	6.67	-5.96	-47.19
11	BMFS	7.67	-4.96	-39.27
12	BMCPT	6.67	-5.96	-47.19
13	KMAP	7.67	-4.96	-39.27
14	KMFS	6.33	-6.03	-49.88
15	KMCPT	6.67	-5.96	-47.19
16	MMAP	6.67	-5.96	-47.19
17	MMFS	5.67	-6.96	-55.11
18	MMCPT	6.33	-6.3	-49.88
19	RMAP	7.00	-5.63	-44.58
20	RMFS	7.67	-4.96	-39.27
21	RMCPT	8.00	-4.63	-36.66
22	VMAP	8.67	-3.96	-31.35
23	VMFS	7.00	-5.63	-44.58
24	VMCPT	7.67	-4.96	-39.27

Contd....

S.No.	Sample	Mean value (sec)	Gain or loss over original	Percentage gain over original
Dyed with Processed Mordants				
25	APAP	11.3	-1.33	-10.53
26	APFS	11.6	-1.03	-8.16
27	APCPT	11.0	-1.63	-12.91
28	BPAP	7.67	-4.96	-39.27
29	BPFS	6.67	-5.96	-47.19
30	BPCPT	7.33	-5.30	-41.96
31	KPAP	6.67	-5.96	-47.19
32	KPFS	6.67	-5.96	-47.19
33	KPCPT	6.00	-6.63	-52.49
34	MPAP	6.67	-5.96	-47.19
35	MPFS	6.33	-6.30	-49.88
36	MPCPT	6.67	-5.96	-47.19
37	RPAP	6.67	-5.96	-47.19
38	RPFS	7.67	-4.96	-39.27
39	RPCPT	7.67	-4.96	-39.27
40	VPAP	6.67	-5.96	-47.19
41	VPFS	7.67	-4.96	-39.27
42	VPCPT	5.67	-6.96	-55.11
Dyed with Biomordants				
43	APP	10.3	-2.33	-18.45
44	APS	10.6	-2.03	-16.07
45	APPT	10.0	-2.63	-20.82
46	BPP	5.00	-7.63	-60.41
47	BPS	7.00	-5.63	-44.58
48	BPPT	6.00	-6.63	-52.49
49	MPP	6.67	-5.96	-47.19
50	MPS	6.00	-6.63	-52.49
51	MPPT	6.67	-5.96	-47.19
52	AAP	10.33	-2.3	-18.21
53	AAS	10.0	-2.63	-20.82
54	AAPT	10.0	-2.63	-20.82
55	BAP	5.33	-7.3	-57.80
56	BAS	5.67	-6.96	-55.11
57	BAPT	5.00	-7.63	-60.41
58	MAP	4.67	-7.96	-63.02
59	MAS	5.33	-7.3	-57.80
60	MAPT	5.67	-6.96	-55.11

FIGURE – VII

DROP TEST OF ORIGINAL AND DYED SAMPLES



ANOVA for Drop Test-% Loss/Gain (Metallic and Processed Mordants)

		Unique Method				
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Main Effects	Dyes	19003.211	5	3800.642	133.927	**
	Techniques	101.139	1	101.139	3.564	NS
	Mordants	57.396	2	28.698	1.011	NS
2-Way Interactions	Dyes * Techniques	398.425	5	79.685	2.808	*
	Dyes * Mordants	592.065	10	59.207	2.086	*
	Techniques * Mordants	135.409	2	67.704	2.386	NS
3-Way Interactions	Dyes * Techniques * Mordants	684.010	10	68.401	2.410	*
Residual		2043.253	72	28.379		
Total		**23014.907**	**107**	**215.093**		

ANOVA for Drop Test-% Loss/Gain (Biomordants)

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Main Effects	Dyes	14987.011	2	7493.505	188.243	**
	Mordants	410.313	1	410.313	10.307	**
	Technique	80.892	2	40.446	1.016	NS
2-Way Interactions	Dyes * Mordants	147.761	2	73.880	1.856	NS
	Dyes * Technique	278.805	4	69.701	1.751	NS
	Mordants * Technique	14.024	2	7.012	.176	NS
3-Way Interactions	Dyes * Mordants * Technique	245.370	4	61.343	1.541	NS
Residual		1433.077	36	39.808		
Total		**17597.253**	**53**	**332.024**		

It is evident from the data that among the natural dyed mercerized samples, dyed without the use of mordants, samples dyed with metallic mordants, samples dyed with processed mordants, and samples dyed with biomordants, the time taken for absorbency by drop test had decreased. The lower the mean value, the quicker is the absorbency of the sample.

Among the samples dyed without mordants the decrease in the per cent of time taken for drop test ranged from 4.99 to 41.96 per cent, the

maximum decrease being recorded by the karingali dyed sample followed by babool and madder dyed samples.

Among the samples dyed with metallic mordants, the annato dyed sample with metallic ferrous sulphate mordant following simultaneous mordanting technique resulted in highest reduction in time for drop test by (12.91 per cent).

With reference to babool and karingali dyes, the samples treated with the metallic alum and copper sulphate mordants following pre and post mordanting techniques and metallic ferrous sulphate using simultaneous technique recorded a maximum decrease in time taken for drop test by 47.19 per cent and 49.88 per cent respectively.

With reference to madder, vembadam and red sandal dyes, the samples treated with metallic ferrous sulphate following simultaneous technique and metallic alum using pre mordanting technique recorded maximum decrease in time taken for drop test by 55.11 per cent for madder and 44.58 per cent for both vembadam and red sandal dyes.

Thus while using metallic ferrous sulphate mordant for annato, karingali, madder and vembadam dyes simultaneous technique seems to be more effective.

Among the samples dyed with processed mordants, comparison of mean time taken for drop test by original undyed cotton samples with those dyed using processed mordants with pre, simultaneous and post mordanting techniques indicated that for the annato and babool dyes using processed copper sulphate following post mordanting technique and processed ferrous sulphate following simultaneous mordanting technique had recorded the highest decrease in time taken for drop test. The decrease being 12.91 per cent and 47.19 per cent respectively.

With reference to karingali and vembadam dyes, the processed copper sulphate following post mordanting technique had resulted in maximum decrease in time taken for drop test, the values being 52.49 per cent and 55.11 per cent respectively. As far as the madder dyed samples were concerned the processed ferrous sulphate following simultaneous techniques had resulted in appreciable decrease in time taken for drop test, the value being 49.88 per cent. In red sandal dye, processed alum using pre mordanting technique recorded a decrease of 47.19 per cent in time taken for drop test.

With regard to using pomegranate rind biomordant for dyeing with annato and babool dyes, while all the samples showed decrease in time taken for drop test, mercerized samples treated with pomegranate rind using post mordanting with annato dye and pre mordanting technique for babool recorded a maximum decrease by 20.82 per cent and 60.41 per cent respectively.

With reference to madder dye using pomegranate rind mordant, the samples treated with pre and post mordanting techniques recorded maximum decrease in drop test by 47.19 per cent. When the biomordant amla was used with annato dye following simultaneous and post mordanting techniques resulted 20.82 per cent decrease in time taken for drop test.

With reference to babool and madder dyes, using amla biomordant following post and pre mordanting techniques respectively resulted in 60.41 per cent and 63.02 percent decrease in drop test.

Statistical analysis of the data relating to fabric drop test, comparing the effects of dyes, metallic and processed mordants and mordanting techniques revealed that there was no statistical significant difference between mordanting techniques and between mordants, while between dyes there was a statistical significant difference at 1% level. Two way interactions showed statistical significant difference at 5% level between dyes and

TABLE XXVII

SINKING TEST VALUES FOR ORIGINAL AND DYED SAMPLES

S.No.	Sample	Mean value (sec)	Gain or loss over original	Percentage gain or loss over original
0	Original undyed	15.00		
Dyed without mordants				
1	ADS	11.00	-4.00	-26.67
2	BDS	7.03	-7.97	-53.13
3	KDS	8.47	-6.53	-43.53
4	MDS	7.20	-7.80	-52.00
5	RDS	9.03	-5.97	-39.80
6	VDS	9.67	-5.33	-35.53
Dyed with Metallic mordants				
7	AMAP	10.67	-4.33	-28.86
8	AMFS	10.33	-4.67	-31.13
9	AMCPT	10.00	-5.00	-33.33
10	BMAP	6.67	-8.33	-55.53
11	BMFS	7.67	-7.33	-48.86
12	BMCPT	7.00	-8.00	-53.33
13	KMAP	7.33	-7.67	-51.13
14	KMFS	7.00	-8.00	-53.33
15	KMCPT	7.07	-7.93	-52.87
16	MMAP	6.67	-8.33	-55.53
17	MMFS	6.00	-9.00	-60.00
18	MMCPT	5.67	-9.33	-62.20
19	RMAP	8.67	-6.33	-42.20
20	RMFS	8.00	-7.00	-46.67
21	RMCPT	9.33	-5.67	-37.80
22	VMAP	8.00	-7.00	-46.66
23	VMFS	8.00	-7.00	-46.67
24	VMCPT	8.33	-6.67	-44.46
Dyed with Processed mordants				
25	APAP	9.03	-5.97	-39.80
26	APFS	9.67	-5.33	-35.53
27	APCPT	9.00	-6.00	-40.00
28	BPAP	6.33	-8.67	-57.80
29	BPFS	6.67	-8.33	-55.53
30	BPCPT	6.00	-9.00	-60.00
31	KPAP	6.67	-8.33	-55.53
32	KPFS	7.00	-8.00	-53.33
33	KPCPT	7.07	-7.93	-52.86
34	MPAP	6.00	-9.00	-60.00
35	MPFS	7.00	-8.00	-53.33
36	MPCPT	7.33	-7.67	-51.13

Contd...

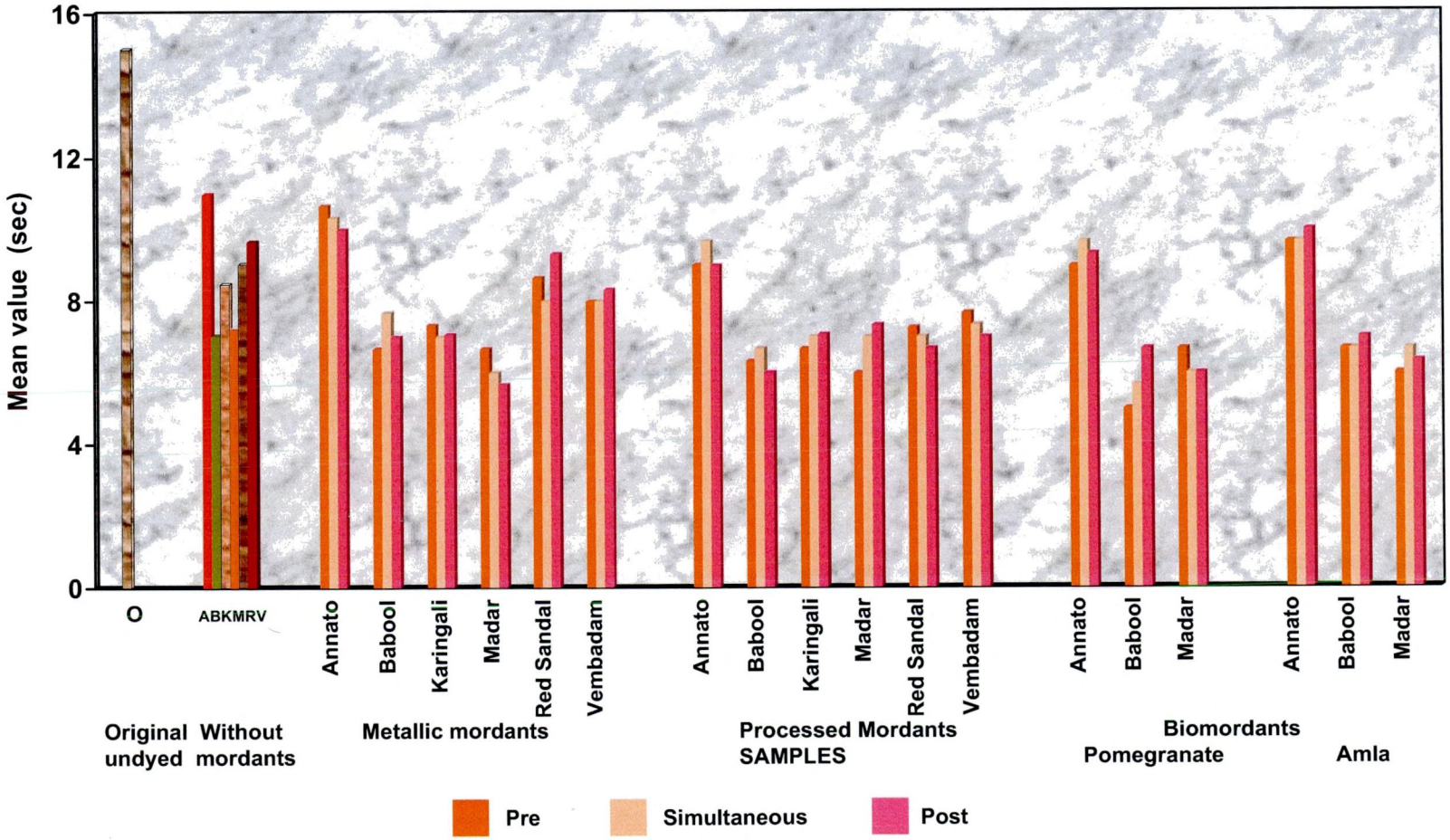
S.No.	Sample	Mean value (sec)	Gain or loss over original	Percentage gain or loss over original
37	RPAP	7.27	-7.73	-51.53
38	RPFS	7.00	-8.00	-53.33
39	RPCPT	6.67	-8.33	-55.53
40	VPAP	7.67	-7.33	-48.86
41	VPFS	7.33	-7.67	-51.13
42	VPCPT	7.00	-8.00	-53.33
Dyed with Biomordants				
43	APP	9.00	-6.00	-40.00
44	APS	9.67	-5.33	-35.53
45	APPT	9.33	-5.67	-37.80
46	BPP	5.00	-10.00	-66.66
47	BPS	5.67	-9.33	-62.20
48	BPPT	6.67	-8.33	-55.53
49	MPP	6.67	-8.33	-55.53
50	MPS	6.00	-9.00	-60.00
51	MPPT	6.00	-9.00	-60.00
52	AAP	9.67	-5.33	-35.53
53	AAS	9.67	-5.33	-35.53
54	AAPT	10.00	-5.00	-33.33
55	BAP	6.67	-8.33	-55.53
56	BAS	6.67	-8.33	-55.53
57	BAPT	7.00	-8.00	-53.33
58	MAP	6.00	-9.00	-60.00
59	MAS	6.67	-8.33	-55.53
60	MAPT	6.33	-8.67	-57.80

ANOVA for Sinking Test-% Loss/Gain (Metallic and Processed Mordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	5828.872	5	1165.774	46.235	**
	Techniques	569.481	1	569.481	22.586	**
	Mordants	10.107	2	5.053	.200	NS
2-Way Interactions	Dyes * Techniques	667.654	5	133.531	5.296	**
	Dyes * Mordants	195.325	10	19.533	.775	NS
	Techniques * Mordants	64.889	2	32.444	1.287	NS
3-Way Interactions	Dyes * Techniques * Mordants	317.531	10	31.753	1.259	NS
Residual		1815.407	72	25.214		
Total		**9469.267**	**107**	**88.498**		

FIGURE – VII

SINKING TEST OF ORIGINAL AND DYED SAMPLES



ANOVA Sinking Test-% Loss/Gain (Biomordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	5730.041	2	2865.021	108.781	**
	Mordants	161.317	1	161.317	6.125	*
	Technique	60.905	2	30.453	1.156	NS
2-Way Interactions	Dyes * Mordants	80.658	2	40.329	1.531	NS
	Dyes * Technique	102.058	4	25.514	.969	NS
	Mordants * Technique	1.646	2	.823	.031	NS
3-Way Interactions	Dyes * Mordants * Technique	141.564	4	35.391	1.344	NS
Model		6278.189	17	369.305	14.022	**
Residual		948.148	36	26.337		
Total		**7226.337**	**53**	**136.346**		

It is evident from the data that the time taken for sinking (absorbency) had increased among the natural dyed mercerized samples dyed without the use of mordants, samples dyed with metallic mordants, samples dyed with processed mordants, and samples dyed with biomordants. Among the samples dyed without mordants, decrease in sinking time was recorded when dyed without mordants ranged from 26.67 to 53.13 per cent. The maximum decrease was recorded by the babool dyed samples.

Among the samples dyed using metallic mordants, the mercerized cotton samples treated with metallic copper sulphate using post mordanting technique, metallic alum using pre mordanting technique and metallic ferrous sulphate using simultaneous mordanting technique had resulted in maximum decrease in sinking time, with reference to annato, babool and karingali dyes, the values being 33.33 per cent, 55.53 per cent and 53.33 per cent respectively.

As far as the madder, red sandal and vembadam dyed samples were concerned, the metallic copper sulphate following post mordanting technique had resulted in an appreciable decrease in sinking time, the values being 62.20 per cent for madder and for both red sandal and vembadam dyes it was

46.67 per cent using metallic ferrous sulphate following simultaneous mordanting technique.

Examination of the changes in sinking when cotton samples were dyed with processed mordants revealed that with reference to annato and babool dyes, processed copper sulphate using post mordanting technique resulted in highest decrease in sinking time by 40.00 per cent and 60.00 per cent respectively.

With reference to karingali and madder dyes, the samples treated with processed alum using pre mordanting technique resulted in maximum decrease in sinking time, the reduction being 55.53 per cent and 60 per cent respectively.

As far as the red sandal and vembadam dyed samples were concerned, the processed copper sulphate using post mordanting technique had resulted in appreciable decrease in sinking time , the values being 55.53 per cent and 53.33 per cent respectively.

Among the samples dyed with biomordants using pomegranate rind biomordant for dyeing with annato and babool dyes, while all the samples showed decreased sinking time, the samples treated with pomegranate rind mordant following pre mordanting technique recorded a maximum decrease by 40.0 per cent and 66.66 per cent respectively.

With reference to madder dye, the samples treated with pomegranate rind biomordant using simultaneous and post mordanting technique resulted in maximum decrease in sinking time by 60.00 per cent.

With reference to annato and babool dyes using, amla biomordant following pre, simultaneous and post mordanting techniques had resulted in appreciable decrease in sinking time, the values being 35.53 per cent and 55.53 per cent respectively.

With reference to madder dye, using amla biomordant following pre mordanting technique recorded a maximum decrease in sinking time by 60 per cent.

Statistical analysis of the data relating to fabric sinking performance, comparing the effects of dyes, metallic and processed mordants and mordanting techniques revealed that, there was significant difference at 1% level between dyes and between mordanting techniques, whereas there was no significant difference between mordants. The two way interactions showed significance at 1% level between dyes and mordanting techniques whereas no significant difference between dyes and mordants and between mordanting techniques and mordants. In the three way interactions between dyes, mordants and mordants techniques there was no statistical significance. These results indicate that the absorbency performance by sinking had significantly decreased when processed mordants were used.

Statistical analysis of the data relating to fabric sinking performance, comparing the effects of dyes, biomordants and mordanting techniques revealed that there was no statistical significant difference between mordanting techniques, while between mordants the significant difference was at 1% level and between dyes the significant difference was at 5% level. The two way interactions showed that there was no statistical significant difference between dyes and mordants, dyes and mordanting techniques and also mordants and mordanting techniques. Three way interactions revealed statistically significant results at 1% level between dyes, mordants and mordanting techniques. These results indicate that biomordants and mordanting techniques had decreased the absorbency performance of the fabric significantly.

Comparison of the different natural dyes using metallic, processed and biomordants following different mordanting techniques revealed that metallic, processed and biomordants the babool dyed samples using pomegranate rind biomordant following pre mordanting technique had recorded a highest

decrease in sinking time by 10 sec (66.66 per cent), while babool and madder dyed samples using processed mordants following post and pre mordanting techniques respectively had recorded 9 sec (60 per cent).

4.4.3. Capillary Rise Test

Table XXVIII shows the mean capillary rise of the original undyed cotton samples compared against samples dyed with and without mordants and percentage gain or loss over original undyed samples.

TABLE XXVIII

CAPILLARY RISE TEST VALUES FOR ORIGINAL AND DYED SAMPLES

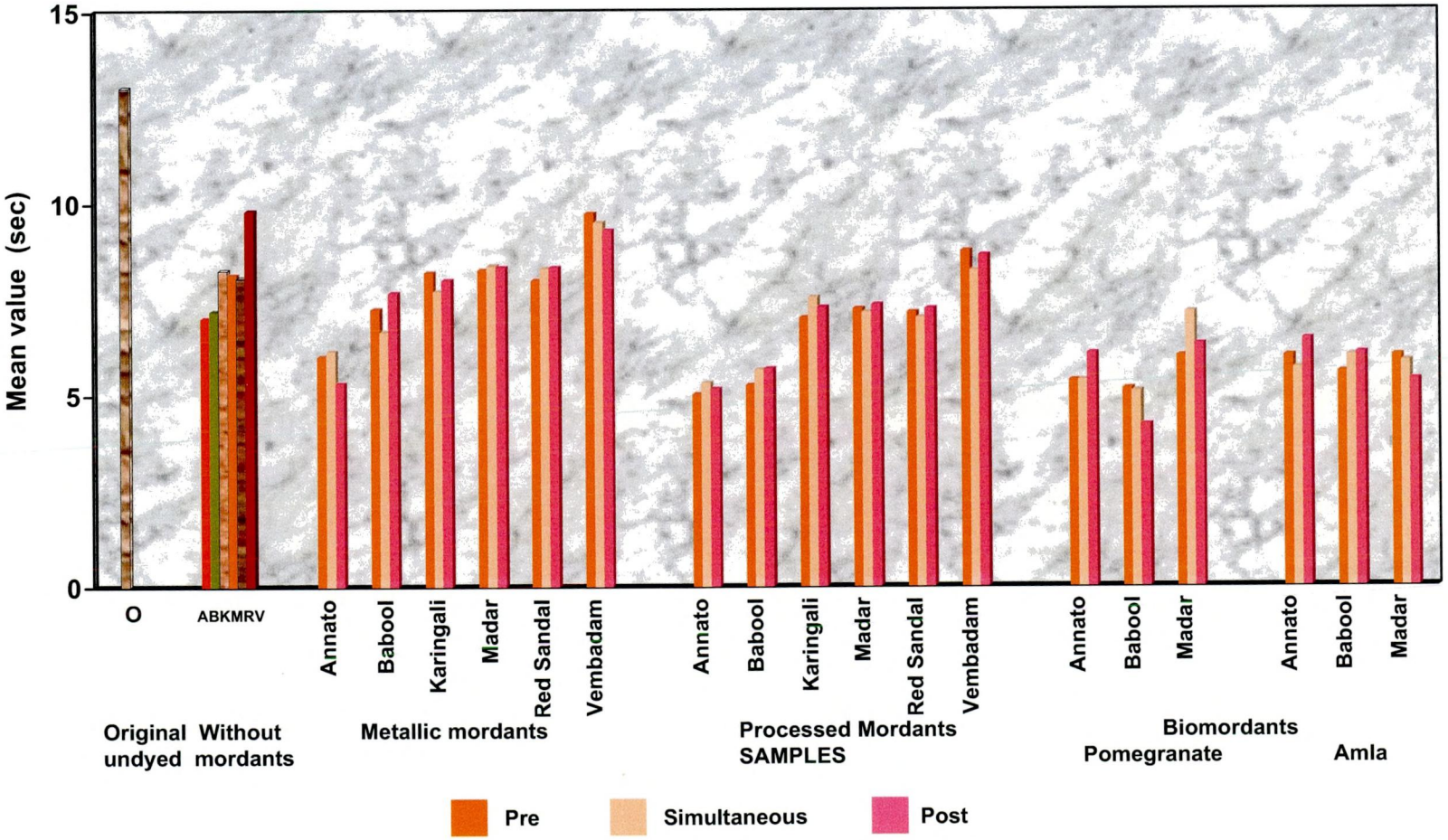
S.No.	Sample	Mean value (sec)	Gain or loss over original	Percentage gain or loss over original
0	Original undyed	13.03		
Dyed without Mordants				
1	ADS	7.03	-6.0	-46.05
2	BDS	7.20	-5.83	-44.74
3	KDS	8.27	-4.76	-36.53
4	MDS	8.17	-4.86	-37.30
5	RDS	8.07	-4.96	-38.07
6	VDS	9.83	-3.20	-24.56
Dyed with Metallic Mordants				
7	AMAP	6.03	-7.0	-53.72
8	AMFS	6.17	6.86	-52.65
9	AMCPT	5.33	-7.7	-59.09
10	BMAP	7.27	-5.76	-44.21
11	BMFS	6.67	-6.36	-48.81
12	BMCPT	7.70	-5.33	-40.91
13	KMAP	8.23	-4.8	-36.84
14	KMFS	7.73	-5.3	-40.68
15	KMCPT	8.03	-5.0	-38.37
16	MMAP	8.30	-4.73	-36.30
17	MMFS	8.40	-4.63	-35.53
18	MMCPT	8.37	-4.66	-35.76
19	RMAP	8.03	-5.0	-38.37
20	RMFS	8.33	-4.7	-36.07
21	RMCPT	8.37	-4.66	-35.76
22	VMAP	9.77	-3.26	-25.02
23	VMFS	9.53	-3.5	-26.86
24	VMCPT	9.33	-3.7	-28.40

Contd...

S.No.	Sample	Mean value (sec)	Gain or loss over original	Percentage gain or loss over original
Dyed with Processed Mordants				
25	APAP	5.03	-8.0	-61.40
26	APCPT	5.33	-7.7	-59.09
27	APFS	5.17	-7.86	-60.32
28	BPAP	5.27	-7.76	-59.55
29	BPFS	5.67	-7.36	-56.49
30	BPCPT	5.70	-7.33	-56.25
31	KPAP	7.03	-6.00	-46.05
32	KPFS	7.57	-5.46	-41.90
33	KPCPT	7.30	-5.73	-43.98
34	MPAP	7.27	-5.76	-44.21
35	MPFS	7.17	-5.86	-44.97
36	MPCPT	7.37	-5.66	-43.44
37	RPAP	7.17	-5.86	-44.97
38	RPCPT	7.03	-6.00	-46.05
39	RPFS	7.27	-5.76	-44.21
40	VPAP	8.77	-4.26	-32.69
42	VPFS	8.27	-4.76	-36.53
41	VPCPT	8.67	-4.36	-33.46
Dyed with Biomordants				
43	APP	5.40	-7.63	-58.56
44	APS	5.40	-7.63	-58.56
45	APPT	6.10	-6.93	-53.18
46	BPP	5.17	-7.86	-60.32
47	BPS	5.10	-7.93	-60.86
48	BPPT	4.23	-8.8	-67.54
49	MPP	6.03	-7.0	-53.72
50	MPS	7.17	-5.86	-44.97
51	MPPT	6.33	-6.7	-51.42
52	AAP	6.03	-7.0	-53.72
53	AAS	5.70	-7.33	-56.25
54	AAPT	6.47	-6.56	-50.35
55	BAP	5.60	-7.43	-57.02
56	BAS	6.03	-7.01	-53.72
57	BAPT	6.10	-6.93	-53.18
58	MAP	6.03	-7.0	-53.72
59	MAS	5.87	-7.16	-54.95
60	MAPT	5.40	-7.63	-58.56

FIGURE – IX

CAPILLARY RISE OF ORIGINAL AND DYED SAMPLES



ANOVA for Capillary Rise-% Loss/Gain (Metallic and Processed Mordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	8121.867	5	1624.373	166.211	**
	Techniques	1691.990	1	1691.990	173.130	**
	Mordants	2.694	2	1.347	.138	NS
2-Way Interactions	Dyes * Techniques	173.846	5	34.769	3.558	**
	Dyes * Mordants	108.299	10	10.830	1.108	NS
	Techniques * Mordants	18.335	2	9.168	.938	NS
3-Way Interactions	Dyes * Techniques * Mordants	175.248	10	17.525	1.793	NS
Residual		703.652	72	9.773		
Total		**10995.931**	**107**	**102.766**		

ANOVA for Capillary Rise-% Loss/Gain (Biomordants)

		Sum of Squares	df	Mean Square	F	Sig.
Main Effects	Dyes	317.882	2	158.941	17.204	**
	Mordants	51.930	1	51.930	5.621	*
	Technique	15.074	2	7.537	.816	NS
2-Way Interactions	Dyes * Mordants	452.609	2	226.305	24.496	**
	Dyes * Technique	198.273	4	49.568	5.365	**
	Mordants * Technique	31.478	2	15.739	1.704	NS
3-Way Interactions	Dyes * Mordants * Technique	146.921	4	36.730	3.976	**
Residual		332.586	36	9.238		
Total		**1546.754**	**53**	**29.184**		

It is evident from the data that time taken for the capillary rise had decreased among the natural dyed mercerized samples dyed without the use of mordants, samples dyed with metallic mordants, samples dyed with processed mordants, and samples dyed with biomordants.

Among samples dyed without mordants maximum decrease in time taken for capillary rise was 46.05 per cent for the annato dyed sample followed by babool and red sandal dyed samples which took 44.74 and 38.07 per cent respectively.

Among samples dyed with metallic mordants, while all the samples revealed a decrease in time taken for capillary rise, irrespective of mordants and mordanting techniques used, the annato and vembadam dyed samples using metallic copper sulphate following post mordanting technique recorded a maximum decrease in time by 59.09 per cent and 28.40 per cent respectively.

The babool and karingali dyed samples using metallic ferrous sulphate as the mordant and following simultaneous mordanting technique recorded a maximum decrease in time for capillary rise test by 48.81 per cent and 40.68 per cent respectively. With reference to madder and red sandal dyes, maximum decrease in time for capillary rise by 36.30 per cent and 38.37 per cent was recorded by the samples treated with metallic alum mordant using pre mordanting technique respectively.

Examination of the changes in time required for capillary rise test when cotton was dyed with processed mordants revealed that with reference to annato, babool and karingali dyes, all the samples revealed decreased time for capillary rise irrespective of mordants and mordanting techniques used. The samples treated with processed alum using pre mordanting technique recorded maximum decrease in time for capillary rise by 61.40 percent, 59.55 per cent and 46.05 per cent respectively.

With reference to madder and vembadam dyes, the samples treated with processed ferrous sulphate using simultaneous mordanting technique resulted maximum decrease in time taken for capillary rise by 44.97 per cent and 36.53 per cent respectively, while processed copper sulphate mordanted sample using post mordanting technique resulted a maximum decrease in time taken for capillary rise by 46.05 per cent when used with red sandal dye.

Among the samples dyes with biomordants using pomegranate rind biomordant for dyeing with annato dye, both pre and simultaneous mordanting

techniques resulted maximum decrease in time taken for capillary rise by 58.56 per cent respectively.

With reference to babool and madder dyes, pomegranate rind biomordant using post mordanting technique and pre mordanting technique resulted maximum decrease by 67.54 per cent and 53.72 per cent respectively.

With reference to annato, babool and madder dyes, the samples treated with amla biomordant using simultaneous, pre mordanting and post mordanting techniques resulted in highest decrease in time taken for capillary rise by 56.25 per cent, 57.02 per cent and 58.56 per cent respectively.

Statistical analysis of the data relating to fabric capillary rise, comparing the effects of dyes, metallic and processed mordants and mordanting techniques revealed that there was significant difference at 1% level between dyes and between mordanting techniques, whereas there was no significant difference between mordants. The two way interactions showed significant difference at 1% level between dyes and mordanting techniques, whereas there was no significant difference between dyes and mordants and between mordanting techniques and mordants. In the three way interactions between dyes, mordanting techniques and mordants there was no statistical significant difference. These results indicate that the absorbency performance by capillary rise had significantly decreased when processed mordants were used.

Statistical analysis of the data relating to fabric capillary rise, comparing the effects of dyes, biomordants and mordanting techniques revealed that there was no statistical significant difference between mordanting techniques, while between mordants the significant difference was at 1% level and between dyes the significant difference was 5% level. The two way interactions showed that there was no statistical significant difference between dyes and mordants, between dyes and mordanting techniques

whereas between mordants and techniques, the significant difference was at 1% level. Three way interactions revealed statistically significant results at 1% level between dyes, mordants and mordanting techniques. These results indicate that biomordants and mordanting techniques had decreased the absorbency performance of the fabric significantly.

Comparison of the different natural dyes using metallic, processed and biomordants following different mordanting techniques revealed that babool dyed samples using pomegranate rind biomordant following post mordanting technique had resulted maximum decrease in time taken for capillary rise by 8.8 sec (67.54 per cent), while annato and babool dyed samples, using processed mordants following pre mordanting technique had taken 8 sec(61.40 per cent)and 7.76 sec (59.55 per cent) respectively.

The findings regarding the absorbency performance in the present study is justified by the observation made by Pardeshi et al (2002) who points out that mercerization improves the lustre, enhances dyeability, improves the strength and also the soft feel.

4.5. EFFECT OF SUNLIGHT, WASHING, WET AND DRY CROCKING AND PRESSING AND PERSPIRATION ON THE DYED SAMPLES

The results pertaining to sunlight, washing, crocking, pressing and perspiration for the dyed samples are given below.

The results of the color fastness test on exposure to sunlight, washing, crocking, pressing and perspiration for the mercerized cotton samples dyed by using metallic, processed and biomordants following pre, simultaneous and post mordanting techniques are shown in Table XXIX.

TABLE XXIX

COLOUR FASTNESS OF ORIGINAL AND DYED SAMPLES

S.No.	Samples	Sun light	Colour fastness to										Percentage
			Washing		Crocking		Pressing		Perspiration				
									Acid		Alkali		
		cc	cc	cs	ds	ws	ds	ws	cc	cs	cc	cs	
Dyed without mordants													
1	ADS	5	5	4	5	4	5	5	4	4	4	4	89.0
2	BDS	5	5	4	5	4	5	5	4	4	4	4	89.0
3	KDS	5	5	4	5	4	5	5	4	4	4	4	89.0
4	MDS	5	5	4	5	4	5	5	4	4	4	4	89.0
5	RDS	4	5	4	5	4	5	5	4	4	4	4	89.0
6	VDS	5	5	4	5	4	5	5	4	4	4	4	89.0
Dyed with metallic mordants													
7	AMAP	4	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	89.0
8	AMFS	4	5	5	5	4	5	5	4	3	4	3	85.4
9	AMCPT	5	5	5	5	4/5	5	5	4	4	4	4	90.9
10	BMAP	4	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	89.0
11	BMFS	5	5	5	5	4	5	5	4	3	4	3	87.2
12	BMCPT	5	5	5	5	4/5	5	5	4	4	4	4	90.9
13	KMAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
14	KMFS	4	5	5	5	4	5	5	4	3	4	3	85.4
15	KMCPT	4	5	5	5	4/5	5	5	4	4	4	4	89.0
16	MMAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
17	MMFS	5	5	5	5	5	5	5	4	3	4	3	89.0
18	MMCPT	5	5	5	5	4/5	5	5	4	4	4	4	90.9
19	RMAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
20	RMFS	5	5	5	5	5	5	5	4	3	4	3	89.0
21	RMCPT	5	5	5	5	4/5	5	5	4	4	4	4	90.9
22	VMAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
23	VMFS	5	5	5	5	4/5	5	5	4	3	4	3	87.2
24	VMCPT	5	5	5	5	4	5	5	4	4	4	4	90.9
Dyed with processed mordants													
25	APAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
26	APFS	5	5	5	5	4/5	5	5	4	3	4	3	87.2
27	APCPT	5	5	5	5	4/5	5	5	4	4	4	4	90.9
28	BPAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
29	BPFS	5	5	5	5	4/5	5	5	4	3	4	3	87.2
30	BPCPT	5	5	5	5	4/5	5	5	4	4	4	4	90.9
31	KPAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
32	KPFS	5	5	5	5	4	5	5	4	3	4	3	87.2
33	KPCPT	5	5	5	5	4/5	5	5	4	4	4	4	90.9
34	MPAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
35	MPFS	5	4	5	5	4	5	5	4	3	4	3	85.4
36	MPCPT	5	4	5	5	4/5	5	5	4	4	4	4	89.0
37	RPAP	5	5	5	5	4/5	5	5	4/5	4/5	4/5	4/5	90.9
38	RPFS	5	4	5	5	4	5	5	4	4	4	4	89.0
39	RPCPT	5	4	5	5	4/5	5	5	5	5	5	5	96.3
40	VPAP	5	5	5	5	5	5	5	4/5	4/5	4/5	4/5	92.7
41	VPFS	5	4	5	5	4	5	5	4	4	4	4	89.0
42	VPCPT	5	4	5	5	5	5	5	5	5	5	5	98.1

Contd...

S.No.	Samples	Sun light	Colour fastness to										Percentage
			Washing		Crocking		Pressing		Perspiration				
									Acid		Alkali		
		cc	cc	cs	ds	ws	ds	ws	cc	cs	cc	cs	
Dyed with biomordants													
43	APP	4	4	5	5	5	5	5	5	5	5	5	98.1
44	APS	4	4	5	5	5	5	5	4	4	4	4	87.2
45	APPT	4	4	5	5	5	5	5	5	5	5	5	98.1
46	BPP	4	4	5	5	5	5	5	5	5	5	5	98.1
47	BPS	4	4	5	5	5	5	5	4	4	4	4	87.2
48	BPPT	4	4	5	5	5	5	5	5	5	5	5	98.1
49	MPP	4	4	5	5	5	5	5	5	5	5	5	98.1
50	MPS	4	4	5	5	5	5	5	4	4	4	4	89.0
51	MPPT	4	4	5	5	5	5	5	5	5	5	5	98.1
52	AAP	4	4	5	5	5	5	5	5	5	5	5	98.1
53	AAS	4	4	5	5	5	5	5	4	4	4	4	87.2
54	AAPT	4	4	5	5	5	5	5	5	5	5	5	96.3
55	BAP	4	4	5	5	5	5	5	5	5	5	5	98.1
56	BAS	4	4	5	5	5	5	5	4	4	4	4	87.2
57	BAPT	4	4	5	5	5	5	5	5	5	5	5	98.1
58	MAP	4	4	5	5	5	5	5	5	5	5	5	98.1
59	MAS	4	4	5	5	5	5	5	4	4	4	4	89.0
60	MAPT	4	4	5	5	5	4	5	5	5	5	5	96.3

- cc – colour change
- cs – colour staining

* ds – dry staining
* ws – wet staining

All the samples dyed with the different dyes, without mordanting recorded 89 per cent with respect to colour fastness to various tests. Among the metallic mordants used for dyeing, the colour fastness values ranged between 85.4 per cent to 90.9 per cent irrespective of mordants and mordanting techniques used. With regard to processed mordants used in vembadam and red sandal dyeing, processed copper sulphate using post mordanting technique, recorded a maximum value by 98.1 per cent and 96.3 per cent respectively. The rest of the samples recorded values ranging between 85.4 per cent to 98.0 per cent. As far as the biomordants were concerned, except amla mordanted annato and madder dyed samples using post mordanting, rest of the pre and post mordanted samples scored a maximum of 98.1 per cent with respect to colour fastness to various tests.

Thus colour fastness of the natural dyed samples showed an excellent rating during washing, sun drying and pressing in general for all the samples irrespective of the dyes, mordants and mordanting techniques.

Comparison of the present results obtained using natural dyes with reference to color fastness to sunlight, wash fastness, dry and wet pressing, dry and wet crocking, with results obtained using reactive dyes revealed that in all the cases the results obtained using natural dyes were on par with the results obtained using reactive dyes.

4.6 COLOUR STRENGTH (K/S VALUES) OF DYED SAMPLES

The colour strength K/S values of the natural dyed samples are given in Table XXX.

TABLE XXX

COLOUR STRENGTH (K/S) OF DYED SAMPLES

S.No.	Samples	Colour Difference			
		?L	?a	?b	Error ?E
Dyed Without Mordants					
1	ADS	Reference Blanks			
2	BDS				
3	KDS				
4	MDS				
5	RDS				
6	VDS				
Dyed with Metallic Mordants					
7	AMAP	-0.91	-8.85	-4.81	
8	AMFS				41.01
9	AMCPT	-6.76	1.68	5.20	
10	BMAP	3.73	3.24	-0.92	
11	BMFS				22.55
12	BMCPT	+0.05	+3.00	-2.94	
13	KMAP				13.01
14	KMFS				24.21
15	KMCPT	-4.76	-5.58	-3.52	
16	MMAP	-3.42	+3.44	-8.07	
17	MMFS				41.75
18	MMCPT				13.27
19	RMAP				17.15
20	RMFS				24.53
21	RMCPT				15.25

Contd...

S.No.	Samples	Colour Difference			
		?L	?a	?b	Error ?E
22	VMAP				15.27
23	VMFS				18.55
24	VMCPT	-0.71	+0.28	+5.96	
Dyed with Processed Mordants					
25	APAP	+2.89	-1.53	-8.37	
26	APFS				43.91
27	APCPT				14.37
28	BPAP				12.71
29	BPFS				19.07
30	BPCPT	-2.29	+2.58	-0.77	
31	KPAP				12.19
32	KPFS				19.65
33	KPCPT	-2.47	-5.64	-2.47	
34	MPAP	+4.17	-8.41	+3.36	
35	MPFS				13.45
36	MPCPT				20.31
37	RPAP	+5.49	+1.87	+5.52	
38	RPFS				26.13
39	RPCPT	-9.41	-1.34	2.73	
40	VPAP				13.75
41	VPFS				19.09
42	VPCPT	-3.72	-0.78	+0.47	
Dyed with Biomordants					
43	APP	+3.52	+4.65	-7.21	
44	APS	+3.75	+2.46	-3.97	
45	APPT	+4.07	-2.35	-3.75	
46	BPP	+8.26	-1.57	+0.43	
47	BPS	+4.44	+0.26	+1.27	
48	BPPT				4.61
49	MPP	+4.62	-0.65	-1.16	
50	MPS				18.41
51	MPPT				18.47
52	AAP				10.35
53	AAS	9.99	-3.47	-8.31	
54	AAPT	7.39	-0.42	-7.49	
55	BAP				17.81
56	BAS				12.31
57	BAPT				18.15
58	MAP				14.19
59	MAS				20.23
60	MAPT				18.55

Comparison of the colour strength of the dyed cotton samples with reference blanks (colours obtained without mordants) revealed, that out of the 54 samples using different mordants, different dyes and different mordanting techniques 32 samples (60 Per cent) had recorded Error ?E indicating the intensity of colour developed was deep while rest of the samples had developed relatively lighter shades. Samples using metallic ferrous sulphate following simultaneous technique (41.01 and 41.75) as well as processed ferrous sulphate following simultaneous technique 43.91 had recorded highest values for ?E. Thus when the colour strength required is more the specific dyes, mordants and mordanting techniques numerically indicated in the table as 8, 11, 13, 14, 17, 18, 19, 20, 21, 22, 23 26, 27, 28, 29, 31, 32, 35, 36, 38, 40, 41, 48, 50, 51, 52, 55, 56, 57, 58, 59 and 60 may be employed. (Those items which have given values for ?E). When colour strength required is less, the rest of the techniques may be employed. Table XXIX also further confirms that it is possible to get deep shades from natural dyes by effectively combining with them suitable mordants and employing suitable mordanting techniques.

4.7. EFFECT OF PHYSICAL CONTACT OF NATURAL DYED SAMPLES WITH HUMAN SKIN

Evaluation of the effect of physical contact of natural dyed samples on human experienced by the selected members using coding sheet is given in Table XXXI.

TABLE XXXI

EFFECT OF PHYSICAL CONTACT OF NATURAL DYED SAMPLES WITH HUMAN SKIN

Effects	Coding details									
	Nothing		Sunlight		Moderate		Severe		Total	
	N	%	N	%	N	%	N	%	N	%
Red marks on the skin	54	100	-	-	-	-	-	-	54	100
Swelling on the skin	54	100	-	-	-	-	-	-	54	100
Rashes on the skin	54	100	-	-	-	-	-	-	54	100
Itching on the skin	54	100	-	-	-	-	-	-	54	100
Irritation on the skin	54	100	-	-	-	-	-	-	54	100

Effect of physical contact for any allergic reactions revealed that there were no unwanted effects on the skin when the naturally dyed fabrics come in to direct physical contact with the skin. The findings were very encouraging.

4.8. PHYSICO-CHEMICAL CHARACTERISTICS OF NATURAL DYE EFFLUENT WITH REFERENCE TO POTENTIAL HYDROGEN, TOTAL SUSPENDED SOLIDS, TOTAL DISSOLVED SOLIDS AND CHEMICAL OXYGEN DEMAND

Results pertaining to the physico-chemical characteristics of the natural dye effluent using metallic, processed, biomordants and reactive dye effluent are discussed. Characteristics of Natural Dye Effluent, reactive dye effluent and BIS tolerance limit are given in Table XXXII.

TABLE XXXII

PHYSICO-CHEMICAL PARAMETRS OF NATURAL AND REACTIVE DYE EFFLUENT

S.No.	Particulars	BIS (Limits) 3307 (1997)	Natural dye effluent			Reactive dye effluent
			Metallic Mordant	Processed Mordant	Bio-mordant	
1	pH at 30°C	8.5-9	4.50	4.70	6.25	10.18
2	Total supended solids (TSS)(mg/l)	100	5574	441	285.2	62
3	Chemical oxygen demand (COD)(mg/d)	250	6048	1692	3510	3660
4	Total dissolved solids (TDS) (mg/l)	2100	5430	3230	2910	54220

The pH values for the natural dye effluents were 4.50 for metallic mordants, 4.70 for processed mordants and 6.25 for biomordants. Though the pH values of the natural dye effluents varied, they were all still within the prescribed levels of Bureau of Indian Standards. However the pH of the reactive dye effluent was above the prescribed limits.

The natural dye effluents obtained from metallic mordanted, processed mordanted, and biomordanted samples contained 5574 mg/l, 441 mg/l and 285.2 mg/l of suspended solids. While all the values were higher than the levels suggested by Bureau of Indian Standards, the suspended solids were very high (5574) in the effluent released after using metallic mordants which may be due to large quantity of dye particles.

The dissolved solids content was also much higher in all the dye effluents when compared with BIS, however they were much lower for the processed and biomordanted effluents (3230 and 2910), when compared with the values obtained for metallic mordanted and reactive dye effluents (5430 and 54220) respectively.

Effluents from various textile processing units contain various classes of dyes and chemicals such as acids / alkalis, surfactants and salts. These

need special treatment before they are let in the drain. In order to reduce the problem of effluent treatments the effluents can be suitably treated and reused Shenai (2003).

In the present study the effluents were taken for analysis and for pot culture study soon after dyeing. However if they had been stored for a week or two and supernatant solution taken for analyses, as well as for pot culture study, there are possibilities that the physico-chemical values might have come down further and the spernantent effluent would have promoted still better plant growth. The natural dye effluent may be filtered and the solid residue can be used as biomanure for crop cultivation as suggested by Kumar et al. (2003).

4.9. EFFECT OF NATURAL DYE EFFLUENT ON PLANT GROWTH

4.9.1. Growth Parameters of Plant Samples

Results pertaining to the physico- chemical characteristics of the natural dye effluent, biometrical and biochemical response of cow pea, horse gram and green gram seedlings to natural dye effluents under pot culture experiment physio-chemical analysis of the irrigated soil samples with natural dye effluent are presented in the following pages. The results of the investigations are also discussed.

Root Length

The effect of natural dye effluent on root length of Cow pea, Horse gram and Green gram seedlings at different stages of growth are shown in Table XXXIII.

TABLE XXXIII

ROOT LENGTH OF COW PEA, HORSE GRAM AND GREEN GRAM SEEDLINGS AT DIFFERENT STAGES OF GROWTH

Item	Days	Treatment	N	Mean (cm) and Standard deviation	Comparison between	't' Value	Significant
Root length of Cow pea	30 days	A. Control[@]	3	17.2 ± 0.264	A Vs B	0.691	NS
		B. 50 : 50	3	16.9 ± 0.238	B Vs C	5.014	**
		C. Effluent	3	13.5 ± 0.500	A Vs C	5.354	**
	60 days	A. Control[@]	3	18.5 ± 0.450	A Vs B	1.9	NS
		B. 50 : 50	3	19.8 ± 0.321	B Vs C	7.5	**
		C. Effluent	3	15.6 ± 0.321	A Vs C	1.9	NS
	90 days	A. Control[@]	3	24.8 ± 0.321	A Vs B	0.7	NS
		B. 50 : 50	3	25.5 ± 0.500	B Vs C	6.7	**
		C. Effluent	3	19.4 ± 0.550	A Vs C	6.7	**
Root length of Horse gram	30 days	A. Control[@]	3	12.7 ± 0.949	A Vs B	0.06	NS
		B. 50 : 50	3	12.8 ± 0.778	B Vs C	0.511	NS
		C. Effluent	3	11.7 ± 1.506	A Vs C	0.440	NS
	60 days	A. Control[@]	3	18.6 ± 0.321	A Vs B	4.2	*
		B. 50 : 50	3	20.7 ± 0.264	B Vs C	8.9	**
		C. Effluent	3	14.6 ± 0.493	A Vs C	8.0	**
	90 days	A. Control[@]	3	26.0 ± 0.500	A Vs B	3.1	*
		B. 50 : 50	3	28.5 ± 0. 450	B Vs C	2.3	NS
		C. Effluent	3	22.3 ± 2.080	A Vs C	1.4	NS
Root length of Green gram	30 days	A. Control[@]	3	7.6 ± 0.550	A Vs B	1.340	NS
		B. 50 : 50	3	8.2 ± 0.264	B Vs C	5.596	**
		C. Effluent	3	5.9 ± 0.208	A Vs C	2.364	NS
	60 days	A. Control[@]	3	8.2 ± 0.264	A Vs B	4.4	*
		B. 50 : 50	3	10.2 ± 0.264	B Vs C	7.5	**
		C. Effluent	3	6.8 ± 0.264	A Vs C	3.1	*
	90 days	A. Control[@]	3	8.8 ± 0.321	A Vs B	1.3	NS
		B. 50 : 50	3	12.2 ± 0.208	B Vs C	14.6	**
		C. Effluent	3	7.8 ± 0.251	A Vs C	2.5	*

[@] Control – Tap water
* Significant at 5% level
** Significant at 1% level
NS – Not Significant

It was interesting to note that the root length of all the three leguminous plants was maximum for seedlings which were fed with 50:50 water and effluent when compared with ordinary water fed and 100% effluent

fed seedlings. The root length of seedlings fed with ordinary water recorded values slightly lower than the 50:50 combination and still lower values recorded for the 100% effluent treated seedlings.

However statistical analysis of the data revealed that the differences in root length between tap water fed and 50:50 combination fed seedlings were not statistically significant for all the three seedlings at the end of 90 days. Significant differences were observed between 50:50 combination and 100% effluent as well as ordinary water fed seedlings.

These results indicate that when the effluent is mixed with tap water it does not affect the growth of the seedlings and irrigating with100% effluent should be avoided as it affects the root and growth.

Shoot Length

The shoot length of the seedlings as influenced by various dilutions of the effluent are tabulated in Table XXXIV.

TABLE XXXIV

SHOOT LENGTH OF COW PEA, HORSE GRAM AND GREEN GRAM SEEDLINGS AT DIFFERENT STAGES OF GROWTH

Item	Days	Treatment	N	Mean (cm) and Standard deviation	Comparison between	't' value	Significant
Shoot length of Cow pea	30 days	A. Control@	3	132.6± 2.516	A Vs B	7.7	**
		B. 50 : 50	3	102.3 ± 2.081	B Vs C	1.78	NS
		C. Effluent	3	92.6 ± 1 527	A Vs C	10.0	**
	60 days	A. Control@	3	142 ± 2.0	A Vs B	2.75	*
		B. 50 : 50	3	153 ± 2.6	B Vs C	3.2	**
		C. Effluent	3	98 ± 1.0	A Vs C	16.2	*
	90 days	A. Control@	3	196.3 ± 2.08	A Vs B	2.9	*
		B. 50 : 50	3	185.7 ± 2.08	B Vs C	20.4	**
		C. Effluent	3	102 ± 2 64	A Vs C	23	**

Contd....

Shoot length of Horsegram	30 days	A. Control[@]	3	70.6 ± 1.527	A Vs B	0.55	NS
		B. 50 : 50	3	72.6 ± 2.516	B Vs C	4.02	*
		C. Effluent	3	55.3 ± 2.516	A Vs C	0.55	NS
	60 days	A. Control[@]	3	132.6 ± 2.516	A Vs B	3.0	**
		B. 50 : 50	3	122 ± 2.0	B Vs C	14.0	**
		C. Effluent	3	84 ± 1.0	A Vs C	15.1	**
	90 days	A. Control[@]	3	173.7 ± 0.763	A Vs B	5.0	**
		B. 50 : 50	3	187.3 ± 0.493	B Vs C	19.1	**
		C. Effluent	3	147.4 ± 1.571	A Vs C	9.0	**
Shoot length of Green gram	30 days	A. Control[@]	3	34.2 ± 0.862	A Vs B	5.16	**
		B. 50 : 50	3	40.4 ± 0.404	B Vs C	6.7	**
		C. Effluent	3	30.9 ± 1.058	A Vs C	1.9	NS
	60 days	A. Control[@]	3	92.8 ± 2.04	A Vs B	2.75	*
		B. 50 : 50	3	85.3 ± 0.378	B Vs C	17.1	**
		C. Effluent	3	61.3 ± 1.135	A Vs C	11.25	**
	90 days	A. Control[@]	3	122.1± 2.1	A Vs B	3.2	**
		B. 50 : 50	3	112.8 ± 1.2	B Vs C	8.2	**
		C. Effluent	3	94.6 ± 1.42	A Vs C	9.1	**

[@] Control – Tap water
* Significant at 5% level
** Significant at 1% level
NS – Not Significant

The mean shoot lengths recorded for all the three leguminous seedlings at the end of 90 days indicated that the seedlings which were fed with ordinary water had recorded higher values when compared with seedlings fed with 50:50 combination, as well as 100% effluent. However 50:50 combination fed seedlings had recorded values which were much higher than those recorded by the 100% effluent fed seedlings. Thus the effluent should always be mixed with tap water before being released for irrigation.

Statistical analysis of the data revealed significant difference at 1% level between shoot lengths recorded by the plants fed with tap water and 50:50 combination fed plants as well as between control and 100 % effluent fed plants and control groups in majority of the cases.

These findings drive home the fact that the shoot lengths of effluent treated plants are affected significantly and hence the effluent needs to be treated before being released for irrigation.

4.9.2. Vigour Index and Germination Percentage

Results pertaining to the effect of natural dye effluent on germination percentage and vigour index of cowpea, horse gram and green gram are discussed below.

The Table XXXV shows the results of the germination percentage and vigour index of Cow pea, Horse gram and Green gram in 30 days, 60 days and 90 days.

TABLE XXXV

EFFECT OF NATURAL DYE EFFLUENT ON GERMINATION (%) AND VIGOUR INDEX FOR COWPEA, HORSEGRAM AND GREEN GRAM

S.No.	Item	Treatment details	Germination	Number of days								
				30			60			90		
				Root length (cm)	Shoot length (cm)	Vigour index	Root length (cm)	Shoot length (cm)	Vigour index	Root length (cm)	Shoot length (cm)	Vigour index
1	Cowpea	T_1 – Tap water	100	17.2	132.6	14980	18.5	142.0	16050	24.8	196.3	22110
		T_2 – Water 50 :Effluent 50	90	16.9	102.3	10728	19.8	153.0	15552	25.5	185.9	19026
		T_3 – 100% effluent	60	13.2	92.6	6348	15.6	93.0	6516	19.4	102.0	7284
2	Horse gram	T_1 – Tap water	100	12.7	70.6	8330	18.6	132.6	15120	26.0	173.7	19970
		T_2 – Water 50 :Effluent 50	80	12.8	72.6	6832	20.7	122.0	11416	28.5	187.3	17264
		T_3 – 100% effluent	70	11.7	55.3	4690	14.6	84.0	6902	22.3	147.4	11879
3	Green gram	T_1 – Tap water	100	7.6	34.2	4180	8.2	92.8	10100	8.8	122.1	13090
		T_2 – Water 50 :Effluent 50	90	8.2	40.4	4374	10.2	85.3	8595	12.2	112.8	11250
		T_3 – 100% effluent	90	5.9	30.9	3312	6.8	61.3	6219	7.88	94.6	9223

Vigour Index = Germination (%) x (Root length + Shoot Length)

For all the three leguminous seeds which were fed with tap water the germination percentage was 100. However the same was 90 per cent when the tap water was mixed with effluent in the ratio of 50:50 for cow pea and green gram, while for horse gram there was only 80 per cent germination with the feeding of 50:50 proportion of tap water and effluent. These results indicate that when equal quantities of tap water is mixed with effluent the germination percentage is reduced only slightly. However when the effluent alone is fed, the germination percentage reduced to 60 and 70 per cent respectively for cow pea and horse gram. The green gram appears to have tolerated the effluent and germination remained at 90 per cent level.

Calculation of the vigour index revealed that the vigour index was maximum all the way for all the three seedlings, which were fed with tap water and the vigour index was maximum on the 90^{th} day. The vigour index was proportionately less for all the three seedlings which were fed with 50:50 proportion as well as total effluent feeding, the earlier one showing better results.

The vigour index recorded by the seedlings fed with 50:50 proportion had recorded values which were only slightly lower than the values recorded by the seedlings fed with ordinary water. Thus for achieving maximum germination percentage and vigour index it may be advisable to mix the effluent with ordinary water and feed the same to the plants.

4.9.3. Soil Composition Before and After the Experimental Period with Reference to pH, Electrical Conductivity, Nitrogen, Phosphorous and Potassium

The initial and post harvest soil samples were tested for pH, electrical conductivity, nitrogen, phosphorous and potassium. The details of the analysis are given below :

The effect of natural dye effluent on soil before and after the experimental period is given in Table XXXVI.

TABLE – XXXVI

SOIL COMPOSITION BEFORE AND AFTER THE EXPERIMENTAL PERIOD

Particulars	Initial	50:50	100% effluent
pH	7.72	6.66	6.83
Electrical Conductivity (dSm-1)	0.06	0.70	0.50
Nitrogen (kg / ha)	120	148	106
Phosphorous (kg / ha)	9.3	33.4	34.0
Potassium (kg / ha)	44	376	317

The pH of the soil samples varied between 6.66 (T_2) to 6.83 (T_3). The pH values of the soil was less in both the treatments when compared to the initial values. This may be due to the fact that the phenolic compounds which may be present in the effluent interact with microorganisms present in the effluent / soil and reduce the pH of the soil which will actually promote the growth of the plant.

Aziz et al. (1994) reported electrical conductivity (EC) as a measure of total salt content in the soil. The EC values significantly increased when compared to the initial group. The highest value of 0.70 EC was observed in (50:50) dilution (T_2) least value of 0.50 were observed in the 100% effluent group.

The nitrogen in soil required for the satisfactory growth of crop plants. The available nitrogen content was highest (148 kg / ha) in 50 : 50 effluent treated soil compared to the initial and 100 per cent effluent treated soil and the least value of 106 kg / ha was observed in 100 per cent effluent group.

The available phosphours content of soil by 33.4 kg / ha in 50 : 50 T_2 dilution and 34.0 kg / ha in 100 per cent effluent (T_3) dilution.

The available potassium content of the soil was increased to a maximum of 376 kg / ha in 50 : 50 (T_2) dilution and 317 kg / ha in 100 per cent effluent (T_3) dilution. The available nitrogen and potassium to the usage of effluent water were due to the natural dye particles to the soil contaminants through the effluent water.

It may be concluded that 50 : 50 (T_2) dilution was very effective in promoting the growth of the experimental plants.