
Comparative Study of Major Crops in Eleven District of Meghalaya, India for Trend Analysis of Area, Production and Productivity

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Abstract

This study was conducted to examine comparative growth trends of agricultural and horticultural crops in eleven districts of Meghalaya, India for area, production and productivity over the period 2013-2017. Shifting of agriculture from one trend to another trend causes problem in context of food security and availability of food for commercial uses. The data for the study was collected from different sources namely Government of Meghalaya, Directorate of Agriculture, Meghalaya, Shillong. The trend detection in the time series of area, production and productivity would be helpful to make the future plans and to take the appropriate decisions to defend the situation for the sustainability in food production and future food security in the state as well as for the country. High stability was reported in area under the cultivation and production of major crops. Positive trend in the area and production of major crops reported. Correlation and correlation-based measures (e.g., the coefficient of determination) have been widely used to evaluate the goodness-of-fit of linear, exponential and logarithmic model for observing trend in the area under the cultivation and production of major crops. Rice is the major crop in the state with high area under cultivation and production with 1, 10, 465 hectare and 3, 05, 814 metric tonnes, respectively. Most of the farmers in the state focuses on the production of staple food rather than horticultural crops production. This paper focuses on the food production issues of crops and gives suggestions on measures needed to increase food grain and cash crop production in Meghalaya.

Introduction

The scenario of agriculture and horticulture has been rapidly changing in India over the last few decades. Agriculture and allied sectors was estimated by Government of India to have a growth rate of 4.1% for 2016-17. Economic Survey 2015-16 as presented by Union Finance Minister; the percentage share of horticulture output in agriculture is more than 33%. Over the past few years from 2010 to 2015, area under horticulture crops has shown a drastic increased of approx 18% as compared to area under food grains with an increase of around 5%. About 58% of the Indian population depends on agriculture as their major source for livelihood. India is the most important cereals production and consumption countries across Asia region, but suffers food insecurity problems as agriculture cultivation is pre-dominated by smallholders that are characterized by low level output (Ahmad et al., 2015). Therefore, an exponential increase is required to meet the needs of increasing population of country.

The knowledge related to the comparative study in trends and change in various agriculture crops and horticulture crops in terms of area, production and productivity may provide information for different policy makers for decision making for future plan as per requirements for the welfare of consumers of state and citizen of nation in context of food security and other related issues. With the outplace of horticulture production over food grain production in certain region of country like North East Indian states like Sikkim, Meghalaya, Mizoram, Manipur and Arunachal Pradesh over the last few decades the knowledge of the trends of area, production and productivity of both horticulture crops and agriculture crops is an important aspects for every states and for the country as a whole in Indian economic development particularly in the field of

agriculture development. The trend and comparative study in term of area, production and productivity of different major crops has been analyzed by several researchers and scientists in different places throughout the world (Kumar et al., 2017; Kumar and Mittal et al., 2006; Ali et al., 2015).

In the world, food grains like rice, pulses and oil seed considered major source of nutrients like rice are considered as major source of carbohydrate that provide daily required energy, pulses are foremost source of protein and oilseed are key source of fat and energy. Similarly, horticultural crops are major contributor in export business of India because of high export potential. Whereas, horticultural crops have medicinal properties along with industrial benefits. Several flowers and spices are also used to prepare cosmetic that provide skin benefits like Rose, Lilly, Groundnut Oil, clove etc.

Meghalaya is a state in North East India mainly known for being the wettest region of the country and having the highest rainfall in the world in Mawsynram village which records the highest annual rainfall of 1,392.30 cm. and covers an area of 22,429 sq km. It has been nicknamed “Scotland of the East” by the British imperial authority during the British Rule of India. The state has 11 districts viz. Ri-bhoi, East Khasi hills, West Khasi Hills, South West Khasi hills, East Jaintia hills, West Jaintia hills, East Garo hills, North Garo hills, West Garo hills, South West Garo hills and South Garo hills. As per the Forest Survey of India (2003) the recorded forest cover of the state is about 75.05% of the total geographical area. The population of the state is estimated to be 32, 11, 474 as per the Election Commission of India (2014) with 80% of the population livelihood depends entirely on agriculture and related activities and most of the state’s population that engaged directly and indirectly in agriculture remain poor. Traditional shifting cultivation or jhum (slash and burn) is the main cultivation method engaged by the people in agriculture. The major agriculture crops in state are rice, pulses, oil seeds etc. Rice being the dominant food grain crop in the state accounted over 80% of the food grain production. Besides these the state is famous for its horticulture crops such as citrus fruits, tuber crops, spices etc. The contribution of agricultural production to the state's GDP is low. Therefore; this sector requires priority attention to improve the livelihood and income of the farmers. The agriculture in Meghalaya having dual nature because of alike focus on cultivation on agricultural and horticultural crops in different districts of Meghalaya state.

The major objective of the present study is to analyse the comparative trend of area, production and productivity of three major agriculture crops viz; rice, pulses and oil seed and three major horticulture crops viz; citrus fruits, tuber crops and spices for all district of Meghalaya state. This paper focuses on the production issues of both agriculture and horticulture crops to foresight information for future growth between the agriculture crops and horticulture crops. The present study examines the behaviour of area, production and productivity of different agricultural and horticultural crops. The trends of shifting of agricultural land from cultivation of cereal and other food grains into the horticultural crops in context of availability of food grains also study under this paper.

Methodology:

This study was based on a trend analysis of time series data on area, production and productivity for major agricultural and horticultural crops in all eleven districts of Meghalaya state. The time series data on the area, production and productivity of the cereal crops (2013-14 to 2016-17) were collected from different sources namely Government of Meghalaya. Directorate of Agriculture, Meghalaya, Shillong. Basic statistics such as mean, standard deviation and coefficient of variability were computed. The agricultural area, production and productivity data set when plotted over times scale on the other axis requires application of different statistical curve fitting techniques to get a smooth trend that can be useful for meaningful interpretation of the data set for analysis of shifting of agriculture trend in the different district of Meghalaya state. There are several statistical modelling tools used for agricultural production trend interpretation amongst that three major statistical modelling used for the interpretation of area, production and productivity of cereal crops they are linear statistical modelling, exponential statistical modelling and logarithmic statistical modelling. This study used linear ($y = a*x + b$) equation for computing growth rate of area, production and productivity of major cereal crops in the state of Meghalaya, India for over period 2013-17. Exponential statistical ($y = ae^{b*x}$)

modelling and Logarithmic statistical ($y = a \cdot \ln(x) + b$) modelling. Where, a and b are the constant, x is time series and y-axis hold area, production and productivity of different crops. The geographical and technological status of state not much favours the agriculture in the state.

Result and Discussion:

The present study was undertaken with a view to analyze the trends and comparative changes in the area, production and productivity of different agricultural and horticultural crops in Meghalaya, India during the last few years. Average value of area under the cultivation and production of major crops during the period 20013-2017 reported in the figure 1 and 2. The result revealed that tuber crops have the highest area approx 29.17 (000' hectare) from period 2013-17 under cultivation amongst horticultural crops and rice has the highest area about 110.465 (000'hectare) from period 2013-17 under the cultivation amongst the agricultural crops. Similar type of result also found in the total production of the studied crops. Tuber crop showed highest production and productivity among the horticulture crops with approx 247.35 (000' Metric tonne) and 6892.75 Kg/hectare, respectively. Parallel result also found in the agricultural crops, rice showed the highest production and productivity amongst the major crops studied in this paper approx 305.814 (000' hectare) and 2768 Kg/hectare, respectively. Whereas, citrus fruit showed the minimum area approx 12.168 (000' hectare) under the cultivation in group of horticulture crop while pulses showed the minimum area approx 8.139(000' hectare) under the cultivation from period 2013-17 amongst the agricultural crops from period 2013-17.

Horticulture crops	Ri-bhoi			East Khasi Hills			West Khasi hills			South West Khasi Hills			East Jaintia Hills			West Jaintia Hills			East Garo Hill			North Garo Hills			West Garo Hills			South West Garo Hills			South Garo Hills				
	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P
Citrus fruit	Mean	405.25	2419.25	5956.5	5780.75	28730.25	4968	125.25	506.75	4038.75	1123.75	5781	5142.5	288	112	3916.5	929.5	5495.75	5910.75	600	2522	1419	242.5	854.75	3521.25	1837.25	4868.5	2642.75	315.5	821.25	2600	520.25	919.5	1763.25	
	Standard deviation	17.74	275.36	416.99	125.64	1362.31	127.64	7.18	49.88	169.53	29.06	261.24	99	14.3	96.05	137.74	21.7	217.37	95.52	20.96	209.15	2015	7.9372	62.59	140.45	48.86	324.7	103.72	12.66	65.9917	104.664	20.72	106.37	132.62	
	Confidence Level(99.0%)	28.23	438.16	663.53	199.92	2167.74	203.1	11.42	79.37	269.77	46.25	415.7	157.53	41.78	280.51	402.27	63.38	634.84	278.96	61.21	610.8	5887	23.180	182.8	410.18	142.22	947.02	302.91	36.97	192.726	305.66	60.53	310.65	387.31	
Tuber crop	Mean	254.75	1618.75	6345.75	1327.15	13755	10353	5463.75	3737.65	6832	2643	29979	11332.5	229	903	3721	1201.75	4174.25	3472.25	1891.75	10567.25	5578.25	888	5131	5768	1910.25	10950.75	5723	851.5	5601.75	6570.5	567	3541.25	6235.5	
	Standard deviation	9.42	121.82	242.81	371.6966	11364.94	562.88	148.71	3436.7	440.69	97.79	2105.79	373.96	5.83	59.13	227.01	18.82	240.94	146.92	129.62	1015.73	153.33	94.32	667.67	135.62	111.32	1069.19	223.08	53.61	496.57	167.42	34.11	339.94	221.5	
	Confidence Level(99.0%)	27.53	355.78	709.11	1085.523	33190.8	1643.87	434.32	10036.82	1287.027	285.6	6149.86	1092.13	17.02	172.69	662.98	54.96	703.65	429.09	378.56	2966.41	447.79	275.46	1949.91	396.09	325.11	3122.52	651.5	156.59	1450.21	488.94	99.63	992.79	646.9	
Spices	Mean	148.45	1315.025	8844.5	968.5	5911.75	6092.75	425.5	3257.75	7644.75	223.25	951.5	4252.5	142.75	697.5	4671	1918	1427.5	7405.5	3758.5	23917.5	6358.5	1826.75	3978	2168.25	4159.5	15203.25	3646.75	588.5	6748.25	8943.75	765	2087	2719	
	Standard deviation	67.28	1214.26	413.04	52.66	594.71	278.59	21.62	297.33	308.56	13.84	105.62	206.74	41.93	336.47	976.16	202.63	2424.03	469.24	141.2	1594.79	184.21	73.94	747.01	319.21	231.28	1651.77	193.8	58.81	570.82	5212.23	60.9	285.83	154.98	
	Confidence Level(99.0%)	196.49	3546.19	1206.27	153.8	1735.25	813.61	63.15	868.34	901.5	40.42	308.48	603.77	122.45	982.66	2850.83	5917.9	7079.28	1370.41	412.37	4657.53	538	215.96	2181.63	932.25	675.44	4823.94	566.01	171.76	1667.06	15222.1	177.88	834.77	452.63	

Table1: Statistical analysis of horticultural crops in different eleven districts of Meghalaya, India

Note: A* Area (Hectare), P# production (Metric tonnes), Pr# productivity (Kg/ hectare)

Source: Government of Meghalaya. Directorate of Agriculture, Meghalaya, Shillong.

According to the results in the Table 1 revealed that East Khasi Hill have the highest area under the production of citrus fruits approx 5780.75 hectare with the highest production of 28730.25 metric tonnes and West Khasi Hills have the lowest area under the cultivation and production of citrus fruits with approx 125.25 hectare and 506.75metric tonnes, respectively amongst the different district of Meghalaya. While, East Garo Hills having the highest and South Garo Hills having the lowest productivity with 14195.25 and 1763.25 kg/hectare, respectively. Whereas, East Jaintia Hills have lowest area under the production of Tuber crops and spices 229 and 142.75 hectares, respectively with the lowest production 903 and 697.5 metric tonnes, respectively. But South West Garo Hills showed the highest productivity of spices with productivity of 8943.75 kg/hectare.

Table2: Statistical analysis of major agricultural crops in different eleven districts of Meghalaya, India

Agricultural crops		Ri-bhoi			East Khasi Hills			West Khasi hills			South West Khasi Hills			East Jaintia Hills			West Jaintia Hills			East Garo Hills			North Garo Hills			West Garo Hills			South West Garo Hills			South Garo Hills		
		A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr	A	P	Pr
Rice	Mean	9639.5	32903	3412.5	5861.5	14047.25	2395.75	6053	11438.25	1889	1812.5	3465.25	1912	4396.25	9363	2129.25	8092.25	18040.5	2228.75	9036.5	21324.5	2359.5	8779	20797.5	2368.5	30516.75	97658.75	3199.75	17723.5	57277	3231.5	8554.25	19499	2278.5
	Standard deviation	33.63	2527.57	250.74	29.5	1299.52	209.91	34.88	1023.35	158.62	8.5	389.18	215.37	11.67	714.96	156.98	27.33	1777.52	211.97	13.17	1951.85	213.56	27.36	2016.55	222.31	112.75	5384.56	165.28	47.82	2581.42	136.87	46.46	1845	203.27
	Confidence Level(99.0%)	98.22	7381.67	732.28	85.59	3795.27	613.04	101.87	2988.65	463.25	24.84	1136.57	628.98	34.09	2088	458.47	79.88	5191.18	619.05	38.48	5700.28	623.69	79.91	5889.26	649.25	329.29	15725.35	482.71	139.66	7538.91	399.74	135.68	5388.24	593.64
Pulses	Mean	72	91.25	1261	660	2241.25	3395.25	71.5	152.5	2128.75	9	21.75	2416.75	41	41.25	1004.25	137	158.5	1155	721	744.5	1032	698.5	752.5	1076.25	3548.25	4764	1341.75	1510.25	1886.5	1248.25	669	916.5	1363.5
	Standard deviation	5.72	15.04	108.53	9.49	71.75	59.79	4.44	16.09	95.21	0	2.99	331.96	1.41	4.79	84.86	4.16	17.6	94.25	9.38	65.51	77.13	10.15	70.87	85.88	60.39	307.38	64.02	27.66	104.93	47.08	15.38	97.18	118.24
	Confidence Level(99.0%)	16.69	43.93	316.97	27.71	209.53	174.63	12.95	47	278.05	0	8.72	969.47	4.13	13.98	247.82	12.16	51.39	275.25	27.39	191.32	225.25	29.64	206.98	250.8	176.949	897.69	186.96	80.77	306.43	137.51	44.93	283.807	345.33
Oil seeds	Mean	453.75	480.5	1057.25	520.5	650.5	1247.5	113	126.25	864.75	16.75	23	1371	85.5	124	1443.5	707	996	1406.75	698.75	618.5	884.25	755.25	819.5	1084.5	6763	7448	3052	3317.5	3786.75	1141	518	496.5	957.5
	Standard deviation	15.9	44.84	61.35	20.95	64.22	72.73	5.72	14.45	451.31	1.5	2.71	44.33	8.35	20.41	96.66	28.15	83.41	62.1	11.92	55.45	64.22	10.81	50.28	51.06	38.53	540.92	3860.47	22.83	252.52	68.23	7.07	52.48	88.33
	Confidence Level(99.0%)	46.44	130.96	179.18	61.19	187.54	212.39	16.69	42.21	1318.03	4.38	7.91	129.47	24.37	59.61	282.29	82.22	243.59	181.36	34.83	161.95	187.55	31.58	146.85	149.11	112.53	1579.72	11274.33	66.66	737.47	199.26	20.65	153.25	257.96

Note: A* Area (Hectare), P# production (Metric tonnes), Pr** productivity (Kg/ hectare)

Source: Government of Meghalaya. Directorate of Agriculture, Meghalaya, Shillong.

Moreover, among the area under the production of major agricultural crops according to the result shown in the table 2 South West Khasi Hills have lowest land under the cultivation of rice, pulses and oil seeds with 1812.5, 9 and 16.75 hectares, respectively with the production of 3465.25, 21.75 and 23 metric tonnes, respectively. Whereas, West Garo Hills dominate by agricultural crops with the highest area under the production of rice (30,516.75 ha), pulses (3,548.25 ha) and oil seed (6,763 ha) with the highest production. While, Ri-bhoi, East Khasi Hills and West Garo Hills showed the highest productivity of rice, pulses and oil seeds, respectively.

Figure 1: Statistical analysis of major horticultural crops in Meghalaya, India

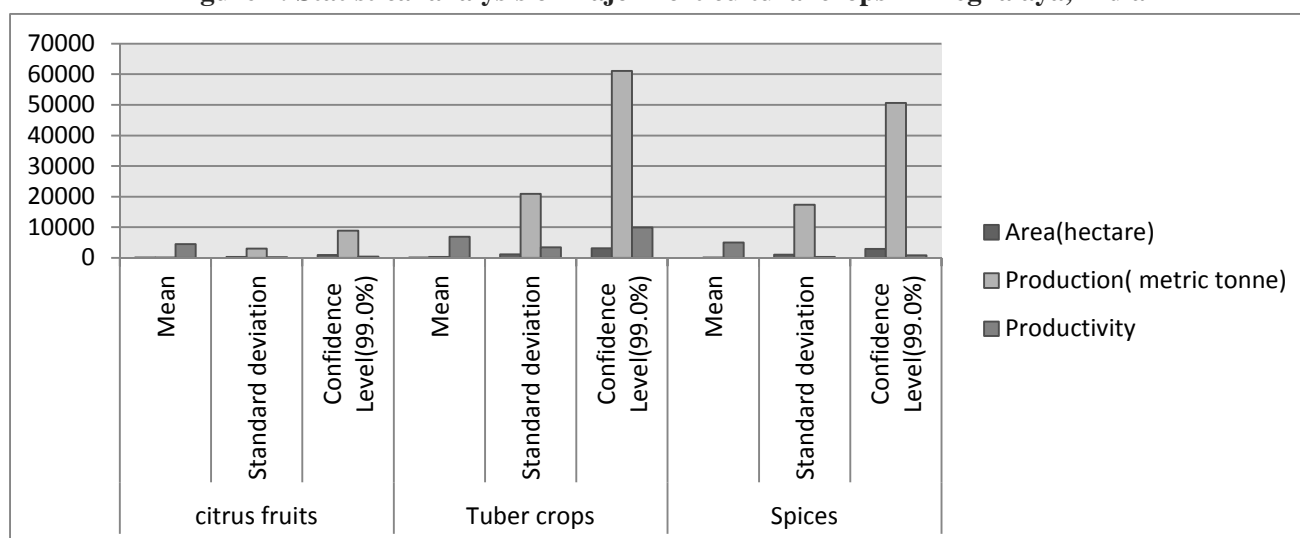
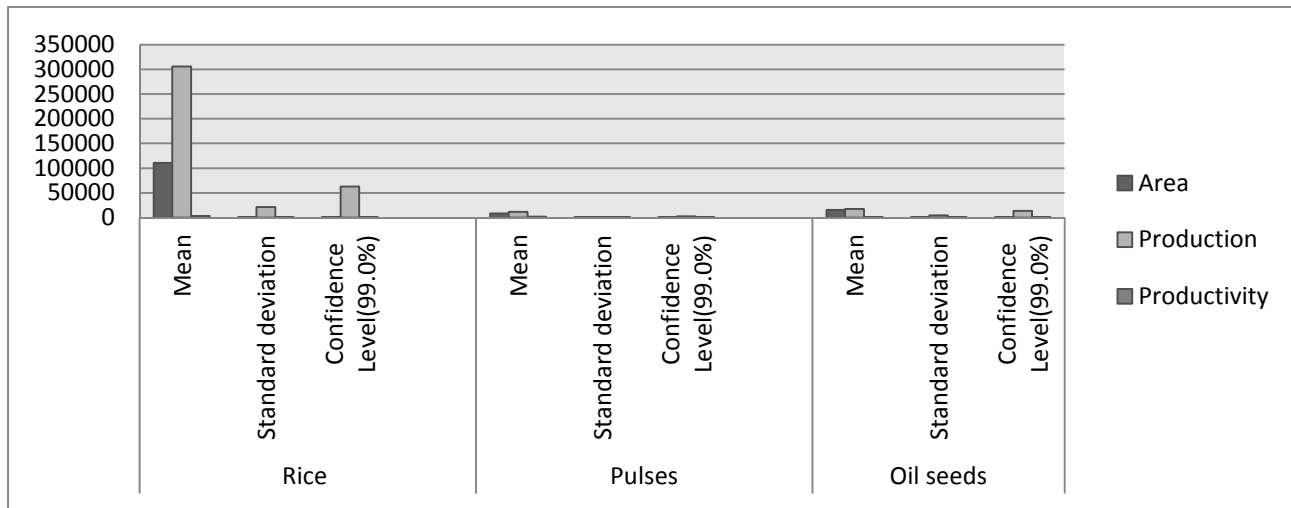
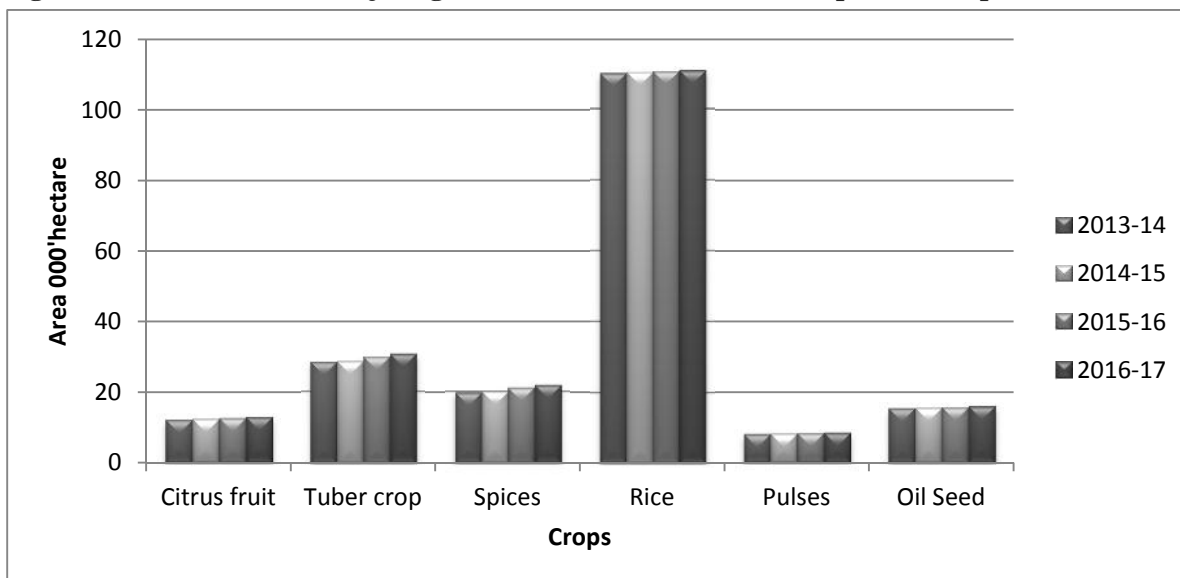


Figure 2: Statistical analysis of major agricultural crops in Meghalaya, India



SD is a measure that used to quality the amount of variation of a set of data values from its mean value. The maximum Standard Deviation (SD) in area under the cultivation and production amongst the horticultural crop showed by the tuber crops 1.072 and 20.915, respectively during period that means the highest variability showed by the tuber crops in the trend of area and production in the state. While, value of SD for area under the cultivation and production of citrus fruit showed the lowest value 0.325 and 3.020, respectively over the studied period that means citrus fruits have stable trend of area under the cultivation and production. Whereas, The maximum standard deviation (SD) in area under cultivation and productivity showed by rice 0.369 and 21.431 respectively during period that means rice having highest variability in trend of area of production and productivity of rice. While, pulses showed minimum standard deviation 0.144 and 0.773, respectively in area under the cultivation and production that means trend in the production and area under the cultivation of pulses is highly stable.

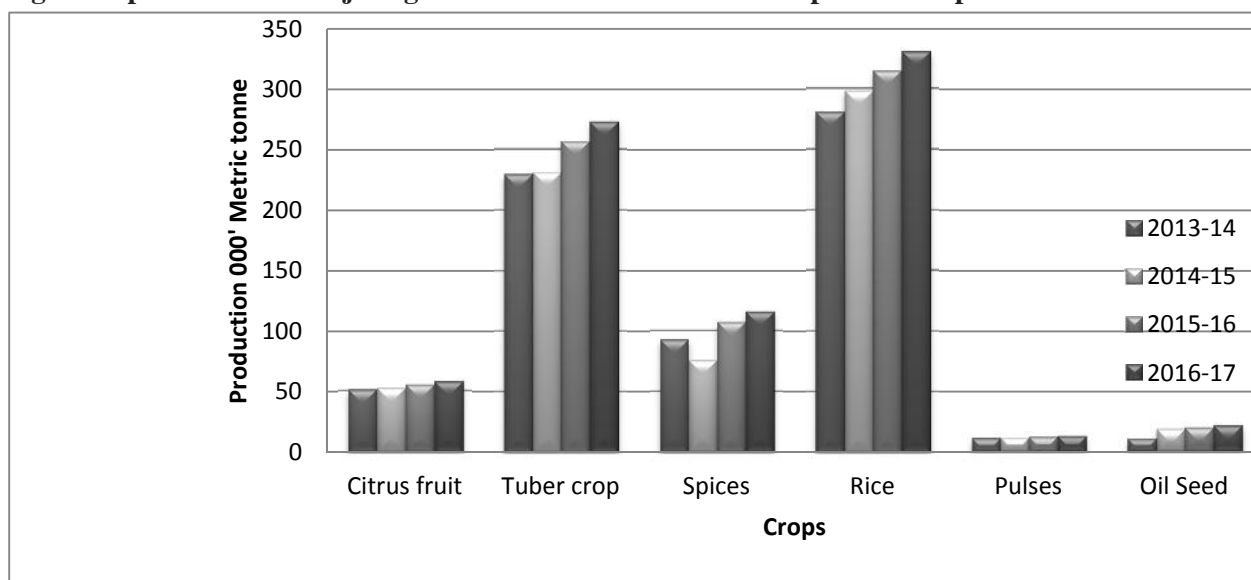
Figure 3: Area under the major agricultural and horticultural crops over the period of 2013-17



The study of area under the cultivation of different agriculture and horticulture crops showed highly stable trend over the period of 2013-17. The area under the cultivation of agriculture crops in the state of Meghalaya showed highly tends only slight increase observed in the area under the production rice were observed.

Similar result also found in the trend of area in the area under the cultivation of horticulture crops observed. All three crops showed insignificant increase over the period of 2013-17.

Figure 4: production of major agricultural and horticultural crops over the period of 2013-17



Different linear and non-linear (exponential and logarithmic) models were employed for the trend identification of major agricultural and horticultural crops in the state Meghalaya and results are shown in the Table 3 and 4. The best fitted models were identified by comparing the values of R^2 of different models. Highest value of R^2 showed the goodness fit for the observed and the predicted values of the major crops. In the model y is the area and production of crops and x is the time points whereas a and b are parameters or constant. The coefficient of determination is the square of the Pearson's product-moment correlation coefficient and describes the proportion of the total variance in the observed data that can be explained by the different statistical models like: linear, exponential and logarithmic model. The value of R^2 ranges from 0 to 1, with higher values indicating better conformity or best suitable model.

Table 3: Trend analysis of major crops by using Linear, Exponential and Logarithmic statistical modelling

Crops	Linear Model	Exponential Model	Logarithmic Model
Citrus Fruit	$y = 0.2516x + 11.539$ $R^2 = 0.9946$	$y = 11.552e^{0.0207x}$ $R^2 = 0.9956$	$y = 0.5223\ln(x) + 11.753$ $R^2 = 0.9294$
Tuber crop	$y = 0.7989x + 27.175$ $R^2 = 0.9249$	$y = 27.234e^{0.0273x}$ $R^2 = 0.9251$	$y = 1.6056\ln(x) + 27.897$ $R^2 = 0.8101$
Spices	$y = 0.7433x + 18.745$ $R^2 = 0.9428$	$y = 18.816e^{0.0359x}$ $R^2 = 0.944$	$y = 1.5015\ln(x) + 19.41$ $R^2 = 0.8343$
Rice	$y = 0.2864x + 109.75$ $R^2 = 0.9999$	$y = 109.75e^{0.0026x}$ $R^2 = 0.9999$	$y = 0.6039\ln(x) + 109.99$ $R^2 = 0.9639$
Pulses	$y = 0.1109x + 7.8625$ $R^2 = 0.9754$	$y = 7.8663e^{0.0136x}$ $R^2 = 0.9756$	$y = 0.2298\ln(x) + 7.9572$ $R^2 = 0.9081$
Oil Seeds	$y = 0.1748x + 14.993$ $R^2 = 0.9867$	$y = 14.998e^{0.0113x}$ $R^2 = 0.9878$	$y = 0.3593\ln(x) + 15.144$ $R^2 = 0.9042$

The result shown trend of area and production of different crop fitted in the different statistical model. As shown in the tabular form in the table 3, exponential model showed the best fitted model for trend analysis of area under the production of all the agricultural and horticultural crops like citrus fruit, tuber crops, spices, rice, pulses and oil seeds with the highest R^2 value 0.9956, 0.9251, 0.944, 0.9999, 0.9756 and 0.9878, respectively. While, for the trend analysis of area under the production of rice in the state linear and exponential both model showed the same value of R^2 . Thus, both models can be used for the trend analysis of area under the production of rice.

Table 4: Trend analysis of major crops by using Linear, Exponential and Logarithmic statistical modelling

Crops	Linear Model	Exponential Model	Logarithmic Model
Citrus Fruit	$y = 2.322x + 48.24$ $R^2 = 0.985$	$y = 48.50e^{0.042x}$ $R^2 = 0.988$	$y = 4.770\ln(x) + 50.25$ $R^2 = 0.901$
Tuber crop	$y = 15.51x + 208.5$ $R^2 = 0.918$	$y = 211.1e^{0.062x}$ $R^2 = 0.917$	$y = 31.02\ln(x) + 222.7$ $R^2 = 0.795$
Spices	$y = 9.906x + 72.85$ $R^2 = 0.543$	$y = 75.07e^{0.1x}$ $R^2 = 0.487$	$y = 17.91\ln(x) + 83.38$ $R^2 = 0.385$
Rice	$y = 16.59x + 264.3$ $R^2 = 0.999$	$y = 266.4e^{0.054x}$ $R^2 = 0.998$	$y = 35.07\ln(x) + 277.9$ $R^2 = 0.967$
Pulses	$y = 0.592x + 10.29$ $R^2 = 0.977$	$y = 10.36e^{0.050x}$ $R^2 = 0.979$	$y = 1.216\ln(x) + 10.80$ $R^2 = 0.895$
Oil Seeds	$y = 3.208x + 9.507$ $R^2 = 0.808$	$y = 10.12e^{0.207x}$ $R^2 = 0.762$	$y = 7.394\ln(x) + 11.65$ $R^2 = 0.930$

According to result in table 4 revealed the trend of production of different agricultural and horticultural crop in the state of Meghalaya, best suited by different model for different crops. Exponential model most excellent fitted for the analysis of citrus fruits and pulses with the highest R^2 value 0.988 and 0.979, respectively. Whereas, similar result found for the tuber crop, spices and rice with the value 0.918, 0.543 and 0.999, respectively. But quite different result found in the trend of oil seeds, logarithmic model best fitted for oil seed.

Conclusion:

According to the findings of this study, it was concluded that Meghalaya's all district having different agricultural status. Some region has superior agricultural condition while some part has worse agricultural condition in context of area under cultivation and production of different crops. For example East Khasi Hill have the highest area under the production of citrus fruits approx 5780.75 hectare with the highest production of 28730.25 metric tonnes while West Khasi Hills have the lowest area under the cultivation and production of citrus fruits with approx 125.25 hectare and 506.75metric tonnes, respectively. Moreover, state's area under the cultivation and production of different agricultural and horticultural crops has stable condition, not much variation was observed. Finding shown that significantly positive sign because of the stability in the area

under the cultivation and production of major crops in the state. End result of the study also showed that SD have small degree of range that means not much variation found among the different crops in area under the cultivation and production. The maximum Standard Deviation (SD) in area under the cultivation and production amongst the horticultural crop showed by the tuber crops 1.072 and 20.915, respectively and maximum standard deviation (SD) in area under cultivation and productivity showed by rice 0.369 and 21.431 respectively during period that means rice having highest variability in trend of area of production and productivity of rice.

Reference:

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