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Growth Rate of Production, Productivity and Area of Pepper in India: A Comparative Study in the Pre and Post Globalisation Era

Ratish Mon A.V.*[1] and Scaria R.[2]

[1] Research & P G Department of Economics Government College Kottayam Kerala, India
[2] P G Department of Economics, TMJM Government College,Manimalakunnu, Ernakulam,Koothattukulam, Kerala
*E-mail: kvratishmon@gmail.com

ABSTRACT

This paper analyses the growth performance of pepper in India in terms of area, production, productivity and price for last 50 years (1970-71 to 2019-20), which was not satisfactory. Though the growth rate of pepper in terms of area has accelerated by 5.4 per cent, production has been accelerated barely by one per cent. However, the productivity of pepper has decelerated by one per cent and the real price has accelerated by 0.2 per cent. The instability analysis shows that instability is highest in terms of area and productivity and it is more violent in post-globalisation era. Among pepper producing states in the country, the performance of Karnataka,the largest producer followed by Kerala and Tamil Nadu is satisfactory. The productivity of pepper is highest in Karnataka as compared to Kerala and Tamil Nadu. The deterioration in the area, production, and productivity of pepper in Kerala is very striking and it needs policy follow up. The instability analysis draws inferences about the vulnerability of area and productivity of a major foreign exchange earning cash crop in the post-globalisation period.

Key words: Growth rate of area of pepper, Growth rate of production of pepper, Growth rate of productivity of pepper, Growth rate of real price of pepper, Indo-Sri Lanka Free Trade Agreement (ISFTA), Pre-Globalisation era, Post Globalisation era.

INTRODUCTION

India is widely known as the “land of spices”. India produces a wide range of spices and holds a prominent position in world spice production. Spices are being grown in every state of India. One of the most important spices extensively grown and traded in India is pepper. In ancient times India held an important position in the pepper market and was an important trade destination for many countries in the world. During the 1960s and 70s, India had dominated the production and export of pepper in the world. Recently, India is losing its comparative advantage in the world pepper market, especially after the trade liberalisation under the WTO regime due to competitive disadvantage in the production of pepper in India (Jose, 2018). Vietnam is the largest producer of pepper in the world followed by Brazil and Indonesia. India is the fourth largest pepper producer in the world (International Pepper Community, 2019).

India had dominated in the production and export of pepper in the pre-globalisation era. India had adopted an import

substitution policy after independence. With the introduction of new economic reforms of 1991 and the formation of the World Trade Organisation (1995) comprised "trade-in agriculture" in multilateral trade system and the formulation of the Agreement on Agriculture (AOA) resulted in new economic reforms to emphasise openness, liberalisation, and promotion of exports. India has signed many Free Trade Agreements (FTAs) with various countries, in which the agreements with India-Sri Lanka and India-ASEAN agreements were important. The agreement allowed the duty-free or concessional export and import from the member countries to India. As per FTA, the import of pepper from Sri Lanka to India is duty-free (zero duty import upto 2500 tonnes annually), due to which the import of pepper from Sri Lanka has increased (The Economic Times, 2019). India imports pepper mainly for value addition and re-export.

India is also known as the home of pepper. Nature has given us an upper hand in the world of pepper because of the geographical and climatic particularity of south India. Karnataka, Kerala and Tamil Nadu are the major pepper producing states in India. Other pepper producing states in India are the North-Eastern region, Andhra Pradesh, Orissa, Andaman and Nicobar, which together contributed 4.77 per cent of the area under pepper cultivation and 7.02 per cent of the total production in India 2017 (Spices Board, 2017). In 2019-20 the estimated production of pepper was 61000 tonnes and the area under cultivation of pepper was 137378 hectares and the productivity per hectare was 444 Kg (Spices Board, 2019-20). The contribution of pepper is very important in both agriculture and industry as it generates income, employment and export earnings.

The signs of continuous sluggishness have been reflecting in the performance of the agricultural sector, particularly spices in India (Suresh, 2008). India, being the largest producer and exporter of pepper, it plays a key role in the agricultural economy of the country. In the current global market, black pepper from India has witnessed an increase in cultivation area even though its production and productivity has decreased dramatically. India is the largest consumer of pepper among the producing countries and the import of pepper to India has been increasing over the years. Fluctuations in the price and increased cost of production have rendered pepper cultivation unremunerative in India (Hema, 2007). Many pepper growers in the producing states like Kerala, Karnataka and Tamil Nadu are either ignoring or abandoning or at least restricting further investment in pepper cultivation (Jose, 2018).

In the above context, it is significant to analyse the performance of pepper production in India during the pre-globalisation and post-globalisation periods. It is also important to examine the performance of the largest pepper producing states in India, in quantitative terms.

OBJECTIVES

1. To analyse the growth performance of pepper in terms of area under cultivation, production, productivity and price in India.
2. To examine the growth performance of the major pepper producing states in India.

MATERIALS AND METHODS

The method of study is both explorative and analytical in nature. The long-term growth path was traced by estimating the annual growth rates statistically using annual time series data. The rate of change of growth rate was then measured by the acceleration/deceleration of growth. A semi log-linear function was used to estimate the annual compound growth rate in that the regression coefficient β stands for the exponential growth rate. The acceleration/ deceleration of growth was estimated by using a quadratic model. Fifty years of time series data were collected from 1970-71 to 2019-20 and the information is retrieved from various publications, official reports, research papers/articles, PhD theses etc. The data sources mainly include reports of Spices Board of India, RBI Handbook on Indian Economy, International Pepper Community, internet and other national and international journals. The analysis was carried out for two periods, the pre-globalization period (1970- 71 to 1990-91) and the post-globalization period (1991-92 to 2019-20) and for the overall period (1970-71 to 2019-20). OLS method of regression was used to estimate the growth rates. For estimating the growth rate of real price, the pepper prices and average inflation rates for 50 years (1970 to 2020) have been collected from the websites of World Bank, RBI and Macrotrends. Pepper price of 1970 has been taken as the base price and multiplied by the reciprocal of each year cumulative inflation rate from 1970 onwards to estimate the real price movement from 1970. The variability in the area, production and price have been measured using the Cuddy-Della Valle index (CDVI), (Cuddy and Della Valle, 1978 and Della Valle, 1979) which is used as a measure of variability in time series data (Pre- globalisation 1970-71, post- globalisation 1991-92 2019-20 & overall performance 1970-70 to 1991-2020). The higher the CDVI score, the higher is the instability. The other statistical tools such as percentages, bar diagrams and charts were used for the economic analysis.

ANALYSIS FRAMEWORK

The analysis was carried out to estimate the growth rate of area, production, productivity and price of pepper in India. Time series data relating to the period 1970-71 to 2019-20 were used for estimating the growth rates. The analysis was carried out for two periods, the pre- globalization period (1970-71 to 1990-91) and the post-globalization period (1991-92 to 2019-20) and for the overall period (1970-71 to 2019-20).

To calculate the compound growth rate of area, production, real price and productivity of pepper in India during pre-globalization and post-globalization periods, the following exponential function was used.

$Y = a\, b^{t} e^{e}$ ..... (1)

Where, Y = Area / Production / Productivity a = Intercept b = Regression coefficient t = Time variable e = Disturbance term in the year't'

By transforming equation (1) into log linear form:

$\log Y = \log a + t \log b + e$ ---------- (2)

Compound growth rate can be obtained using:

$$CGR = [\text{antilog } b - 1] * 100$$

The equation (2) has been estimated by applying Ordinary Least Square (OLS) method. The t- test was applied to test the significance of 'b'. This equation presumes that a change in agriculture output each year would depend upon the output in the preceding year.

Table 1. Growth rate of area under cultivation of pepper

Growth rate of area under cultivation of pepper in pre - globalization era							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1970-71 to 1990-91	11.842* (219.69)	-0.065* (-5.79)	0.004* (7.43)	0.835	Decelerating	6.5	1.5
Growth rate of area under cultivation of pepper in post - globalization era							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1991-92 to 2019-20	10.294* (19.71)	0.124* (4.12)	-0.002* (-4.67)	0.648	Accelerating	12.4	0.8
Growth rate of area under cultivation of pepper - 1970-71 to 2019-20							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1970-71 to 2019-20 (Overall)	11.307* (134.18)	0.054* (7.06)	-0.001* (-5.95)	0.573	Accelerating	5.4	0.4

*indicates significant at 5per cent level; Parenthesis indicates t-value; NGR-Nature of growth rate; DW – Durbin Watson

There was a significant decelerating trend in the growth rate of area under cultivation of pepper in the pre-globalization era (1970-71 to 1990-91) because the area utilized for pepper cultivation was mainly concentrated in only one state (Kerala) and the contribution of the other states were negligible. The growth rate decelerated by 6.5 per cent per year during these periods. In the post-globalization era (1990-91 to 2019-20) the growth rate was accelerated by 12.4 per cent per year due to a huge increase in the area utilized for pepper cultivation in the states like Karnataka and Tamil Nadu. Increase in price of pepper and instability in the price of coffee have motivated the farmers to increase pepper production in Karnataka (Jose, Rinu, 2018).Taking the sub periods together, area under cultivation of pepper for 50 years (1970-71 to 2019-20) has shown a significant accelerating trend. The growth rate was accelerated by 5.4 per cent.

There was a significant accelerating trend in the pre-globalization period from 1970-71 to 1990-91 in terms of production of

Table 2. Growth rate of production of pepper

Growth rate of production of pepper in pre - globalization era						
Period	Regression Coefficients		R-Square	NGR	Growth Rate	DW
	a	b				
1970-71 to 1990-91	10.356* (121.19)	0.025* (3.72)	0.421	Accelerating	2.5	2.5
Growth rate of production of pepper in post - globalization era						
Period	Regression Coefficients		R-Square	NGR	Growth Rate	DW
	a	b				
1991-92 to 2019-20	11.193* (79.50)	-0.007 (-1.71)	0.100	Decelerating	0.7	1.9
Growth rate of production of pepper 1970-71 to 2019-20						
Period	Regression Coefficients		R-Square	NGR	Growth Rate	DW
	a	b				
1970-71 to 2019-20	10.566* (169.04)	0.010* (4.71)	0.317	Accelerating	1.0	1.9

* indicates significant at 5per cent level; Parenthesis indicates t-value; NGR-Nature of growth rate; DW – Durbin Watson

pepper.The growth rate was accelerated by 2.5 per cent. Kerala was the largest pepper producing state in India and an average share in the production of pepper from this state alone was more than 75 per cent (Spice Board of India, Cochin) during these periods. The post globalization period has shown a decelerating trend due to declining trend in the production of pepper in Kerala and increase in import of pepper from Sri Lanka. India levies zero duty import on 2,500 tonnes of pepper from Sri Lanka annually under the Indo-Sri Lanka Free Trade Agreement. Any export above the limit is subjected to 8 per cent duty under South Asia Free Trade Agreement, as against the usual customs duty of 70 per cent on pepper import into India(The Economic Times, 2019).The growth rate was decelerated by 0.7 per cent per year. The growth rate of pepper production for 50 years (1970-71 to 2019-20) has shown a significant accelerating trend and the growth rate has accelerated by 1.0 per cent. There was a significant accelerating trend in the growth rate of productivity of pepper in the pre-globalization era (1970-71 to 1990-91). The growth rate was accelerated by 6.5 per cent per year. The post-globalization era (1990-91 to 2019-20) has shown a significant decelerating trend in the growth rate of productivity of pepper (11.7 per cent per year).This is due to the wide gap in the productivity of the largest pepper producing states in India, for example, the highest productivity of Karnataka was 1071 Kg Per Hectare and Kerala was 315 Kg Per Hectare.The productivity of pepper is

Table 3. Growth rate of Productivity of pepper

Growth rate of productivity of pepper in pre - globalization era							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1970-71 to 1990-91	5.475* (36.30)	0.065* (2.16)	-0.002 (-1.813)	0.281	Accelerating	6.5	2.9
Growth rate of productivity of pepper in post - globalization era							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1991-92 to 2019-20	7.617* (8.94)	-0.117* (-2.39)	0.002 (2.55)	0.241	Decelerating	11.7	1.7
Overall Growth rates of productivity from 1970-71 to 2019-20							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1970-71 to 2019-20	5.884* (52.20)	-0.010 (-0.985)	0.0001 (0.961)	0.573	Decelerating	1.0	1.5

***** indicates significant at 5per cent level; Parenthesis indicates t-value; NGR-Nature of growth rate; DW – Durbin Watson

comparatively very low in Kerala from other states because the pepper production practices in Kerala is unscientific and only useful for short run productivity gains. The measures adopted for plant protection and recklesstillage, without taking adequate measures to put a check on soil erosion washed out the fertile nutrient rich top soilwhich had been deposited by nature for centuries on the hill sides.Violent fluctuations in the use of chemical fertilizers, which were mostly responsive to crop price, to reap the immediate price dividend ultimately affected crop productivity (Scaria, 2017). There was statistically significant decelerating trend in the growth rate of productivity of pepper for 50 years (i.e., 1970-71 to 2019-20). The growth rate has decelerated by 1.0 per cent.

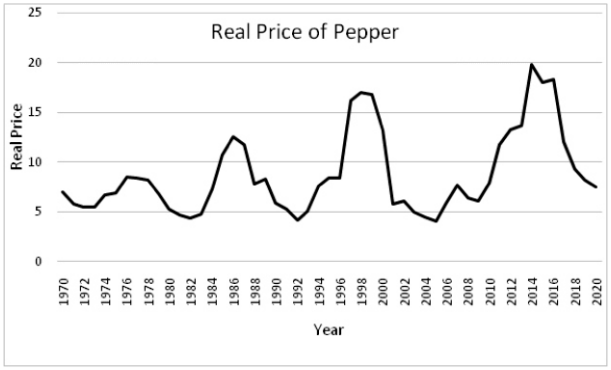


Figure 1. Real Price of Pepper

The price of the pepper has accelerated in the pre-globalizationeraby 0.3 per cent per year and in post- globalization period it has decelerated by 0.1 per cent. Low quality pepper from Vietnam continues to enter in to the market through Sri Lanka, and, aided by a low duty structure under ASEAN trade agreement, SAFTA and ISFTA, was the major reason for the declining price of

Table 4. Growth rate of Real price of pepper

Growth rate of Real price of pepper during pre-globalization era							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1970-71 to 1990-91	0.485 (1.478)	0.003 (0.015)	0.741* (4.181)	0.52	Accelerating	0.3	1.2
Growth rate of Real price of pepper during post-globalization era							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1991-92 to 2019-20	0.441 (1.508)	-0.001 (-0.012)	0.804* (6.772)	0.67	Decelerating	0.1	1.4
Overall Growth rates of Real price of pepper from 1970-71 to 2019-20							
Period	Regression Coefficients			R-Square	NGR	Growth Rate	DW
	a	b	c				
1970-71 to 2019-20	0.391* (2.199)	0.002 (0.852)	0.781* (8.508)	0.66	Accelerating	0.2	1.3

indicates significant at 5per cent level; Parenthesis indicates t-value; NGR-Nature of growth rate; DW – Durbin Watson

pepper. Sri Lanka has circumvented by buying Vietnam Pepper at low prices, adding value and dumping it in India as its own pepper. Any import above 2,500 tonnes under SAFTA from Sri Lanka should be charged at 52 percent at par with other Asian countries. Sri Lanka has circumvented by buying Vietnam Pepper at low prices, adding value and dumping it in India as its own pepper (Thomas,2019). The growth rate of the price of pepper for 50 years (*i.e.*, 1970-71 to 2019-20) has accelerated by 0.2 per cent per year.

Instability Analysis

The instability in the time series data is measured using Cuddy-Della Valle index (CDVI). The Cuddy-Della Valle Index corrects the coefficient of variation by the equation, $I = (CV)(1 - \bar{R}2)0.5$

The above table shows the results of estimated instability in the area, production, productivity and price of pepper in India for 50 years. The result shows that in the pre globalization era (1970-71 to 1990-91), the

Table 5. Instability Analysis

Particulars	Period		
	1970-71 to 1990-91	1991-92 to 2019-20	1970-71 to 2019-20
Area	14.99	18.58	25.64
Production	19.78	17.04	21.54
Productivity	17.96	26.24	24.07

lowest instability was in the area (14.99) of pepper cultivation followed by productivity (17.96). The highest instability was observed in the production (19.78) of pepper. In the post- globalized era (1991-92 to 2019-20) the highest instability was observed in productivity (26.24) of pepper. The instability was lowest in the production (17.04) of pepper followed by the area (18.58) under pepper cultivation. The overall (1970-71 to 2019-20) instability was highest in the area (25.64) and the productivity (24.07) of pepper. The instability was low in the production (21.54) of pepper.

The trend analysis shows that in the pre-globalization period i.e., from 1970-71 to 1990-91, there were a decelerating trend in the area and the accelerating trend in the production of pepper in India. The productivity and price have shown increasing trends. The rate of acceleration was comparatively high in productivity. The post-globalization period trend (1991-92 to 2019-20) shows an accelerating trend in the area, decelerating trend in production, productivity and price of pepper. The overall (50 years) trends of pepper from 1970-71 to 2019-20 show an acceleration in the area and production. The productivity of pepper shows a decelerating trend and the price of the pepper has shown an increasing trend. In the pre globalization era, the lowest instability was in pepper cultivation followed by productivity. The highest instability was observed in the production of pepper. In the post- globalized era, the highest instability was observed in the productivity of pepper and the lowest instability was observed in the production of pepper followed by the area under pepper cultivation. The overall (1970-71 to 2019-20) instability was highest in the area and the productivity of pepper. The instability was low in the production of pepper as compared to the area and productivity of pepper.

The area of production and productivity fluctuate more violently in the post globalisation era compared to pre-globalisation period whereas production remains more stable in the post globalisation era.

Quantitative Description of the top pepper producing states in India

Pepper vines are mainly grown in hilly terrain with well-drained soil under high temperatures (23^0 – 32^0 C and the ideal temperature is around 28^0 C, Spices Board of India) and ample rainfall (annual rainfall of 1250-2000 mm, Spices Board of India). Pepper is grown in the home gardens, as an intercrop in the arecanut and coffee plantations and as a mono crop. Karnataka, Kerala and Tamil Nadu are the major pepper producing states in India.

I. Area

The Table 6 shows that in terms of area utilized for pepper cultivation in India, Kerala is dominating. For about forty years from 1970-71, more than 95 per cent of the area used for pepper cultivation in India was from Kerala alone. From 2004-05 onward, the area used for pepper cultivation in Kerala has shown decreasing trend and it has reached 60 per cent (82540 Hectares) in 2019-20. Next comes Karnataka. For about 40 years from 1970-71, the area used for pepper cultivation in Karnataka was low, below nine per cent. From 2009-10 onwards there was an increasing trend in the area and 2019-20, it has reached to 29 per cent (40170 Hectare). Tamil Nadu is the third largest pepper producing state in India.

Table 6. Area utilized for pepper production in India (Ha = Hectare, Per. = Percentage)

Year	Kerala		Karnataka		Tamil Nadu		Others	
	Area (Ha)	Per.	Area (Ha)	Per.	Area (Ha)	Per.	Area (Ha)	Per.
1970-71	117540	98	2160	2	230	0.2	30	0.03
1974-75	118410	97	3320	3	180	0.1	10	0.01
1979-80	107180	97	2960	3	570	0.5	10	0.01
1984-85	105840	97	2580	2	970	0.9	10	0.01
1989-90	151420	88	2710	2	1640	1.0	15720	9.17
1994-95	186720	97	3080	2	3050	1.6	420	0.22
1999-00	198410	95	6680	3	3970	1.9	610	0.29
2004-05	237670	89	24260	9	4120	1.5	1062	0.40
2009-10	171489	86	19706	10	2786	1.4	5005	2.52
2014-15	85430	69	32670	26	4000	3.2	1800	1.45
2019-20	82540	60	40170	29	5764	4.2	8904	6.48

Source: Spices Board of India, Cochin

However, the area utilized for pepper cultivation in Tamil Nadu was comparatively very low as compared to Kerala and Karnataka. From 1970-71, for about 20 years the area used in Tamil Nadu was less than one per cent. From 1994-95 onwards the area utilized for the cultivation of pepper has increased and in 2019-20 it has reached 4.2 per cent (5764 Hectare). The contribution of other states of India is low. For 20 years the area used for pepper cultivation was 0.01per cent. In the year 1989-90 the contribution was the largest i.e., 9.17 per cent. Thereafter there was a gradual increase in the area under cultivation in other states of India and it has reached 6.48 per cent (8904 Hectare) in 2019-20.

Table 7. Largest Pepper producing states in India [Prod. = Production (Tonnes) and Per. = Percentage (%)]

Year	Kerala		Karnataka		Tamil Nadu		Others	
	Prod.	Per.	Prod.	Per.	Prod.	Per.	Prod.	Per.
1970-71	25030	89	1070	4	50	0.18	1850	6.6
1974-75	27230	71	910	2	40	0.10	9970	26.1
1979-80	26790	71	780	2	120	0.32	10310	27.1
1984-85	17350	64	660	2	210	0.78	8780	32.5
1989-90	37340	57	690	1	350	0.54	26620	41
1994-95	59260	98	760	1	640	1.05	80	0.1
1999-00	47540	82	1650	3	860	1.48	7950	13.7
2004-05	74980	92	5430	7	910	1.12	120	0.1
2009-10	27500	55	15000	30	750	1.50	6750	13.5
2014-15	30000	43	35000	50	3000	4.29	2000	2.9
2019-20	20000	33	30000	49	3000	4.92	8000	13.1

Source: Spices Board of India, Cochin

II. Production

It is observed from the above table that from 1970-71 the production of pepper in Kerala was dominated for about 40 years. Thereafter, it shows a decreasing trend from 2009-10 and the share of Kerala in terms of production has reached 33 per cent (20000 Tonnes) in 2019-20. From 1970-71 the production was very low in Karnataka for 40 years. From 2009-10 onwards there was an increasing trend in the production of pepper in Karnataka and the contribution of Karnataka has reached 49 per cent (30000 Tonnes) in 2019-20. Karnataka has been dominating in the production of pepper and it has become the largest pepper producing state in India. Tamil Nadu is the third largest state in India in the production of pepper. However, the production in Tamil Nadu was very low as compared to Karnataka and Kerala. From 1970-71 for about 30 years the contribution of Tamil Nadu in the production of the pepper was below 1 per cent. The contribution of production has remained the same for about 15 years *i.e.*, below 1.5 per cent. From 2014-15 onwards, the production has increased and its contribution has reached to 4.92 per cent (3000 Tonnes) in 2019-20. The contribution of the other states in India in the production of pepper has shown an increasing trend up to 1989-90 and in 1989-90, the other states have contributed highest *i.e.*, 41 per cent (26620 Tonnes). Thereafter the pepper production started to decrease and the share of production by other states in India has reached 0.1per cent in 2004-05. In 2019-20 the production was 8000 tonnes *i.e.*, 13.1 per cent (8000 tonnes) share.

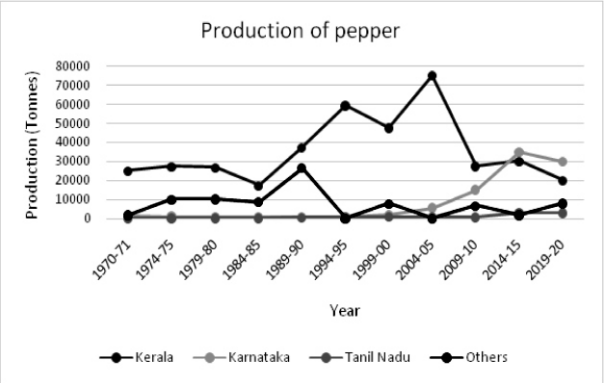


Figure 2. Production of Pepper in India (Tonnes)

III. Productivity

Table 8. Pepper productivity (Kg) of largest pepper producing states in India Pty. = Productivity (Kg)

Year	Kerala Productivity (Kg)	Karnataka Productivity (Kg)	Tamil Nadu Productivity (Kg)	India Productivity (Kg)
1970-71	213	495	217	233
1974-75	230	274	222	313
1979-80	250	264	211	343
1984-85	164	256	216	247
1989-90	247	255	213	379
1994-95	317	247	210	314
1999-00	240	247	217	277
2004-05	315	224	221	305
2009-10	160	761	269	251
2014-15	351	1071	750	565
2019-20	242	747	520	444

Source: Spices Board of India, Cochin

The above table shows that the productivity trend in Kerala remained in the range 215 Kg – 315 Kg for 50 years (1970-71 to 2019-20). In the year 1970-71, the productivity was 213 Kg. The productivity was highest (317 Kg) in the year 1994-95 and lowest (160 Kg) in 2009-10. The productivity was 242 in 2019-20. There was an impressive trend in the productivity of Pepper in Karnataka. In 1970-71 the productivity was 495 Kg, thereafter it started to decline. For about 40 years, the average productivity of pepper was 252 Kg. In 2014-15 the productivity was highest in Karnataka i.e., 1071 Kg. thereafter the productivity has been reduced to 747 Kg. in 2019-20. The productivity trend in Tamil Nadu stood almost the same for 40 years. The average productivity from 1970-71 to 2009-10 was 222 Kg. From 2014-15 the productivity increased and reached its highest in the year 2014-15 (750 Kg.). In 2019-20 the productivity was 520 Kg the productivity trend shows that the productivity is highest in Karnataka followed by Tamil Nadu. The productivity of Kerala is very low as compared to Karnataka and Tamil Nadu. The pepper productivity in other states in India shows an increasing trend. In 1970-71 the productivity was 233 Kg;the productivity was highest in 2014-15 (565 Kg) and in 2019-20 the productivity was 444 Kg.

DISCUSSION

India was the major producer and exporter of pepper in the world. Pepper cultivation is concentrated in the Western Ghats in India. The study shows that the pre-globalization period (*i.e.*, from 1970-71 to 1990-91) have shown a decelerating trend in the area and an accelerating trend in the production of pepper in India. The productivity and price had shown an increasing trend. The rate of acceleration was comparatively high in productivity. The post-globalization period (1991-92 to 2019-20) shows an accelerating trend in the area, decelerating trend in production and productivity of pepper. The price has shown a decreasing trend. The overall (50 years) performance in terms of growth of pepper from 1970-71 to 2019-20 has shown an acceleration in the area, production and price. The productivity of pepper was decelerating. The growth rate in the area has accelerated by 5.4 per cent, production has accelerated by 1.0 per cent, productivity decelerated by 1.0 per cent and the real price has accelerated by 0.2per cent. The result of estimated instability in the area, production, productivity and price of pepper shows the overall (1970-71 to 2019-20) instability was highest in the area and the productivity of pepper and lowest in the production of pepper.

The present status of pepper production is not satisfactory in India. In the post-liberalisation period technical inefficiency, fall in productivity, climatic variations, price fluctuations, the incidence of pests and diseases and increased cost of production had resulted in a decline in pepper production in the country (Jose, 2018). Karnataka and Kerala are the major pepper producing states in India. In India, Karnataka is the largest producer of pepper followed by Kerala and Tamil Nadu. The Performance of pepper in Karnataka was satisfactory. There is deterioration in the area, production, and productivity of pepper in Kerala. An important feature of the present trade of pepper is related to the free import of pepper in India from Sri Lanka through an FTA between India and Sri

Lanka. The FTAs such as the ASEAN and ISFTA were a serious concern to the pepper cultivators as it harms the domestic market and reduces the production of pepper. The government must take special steps to increase pepper production as it is very urgent and important to take appropriate steps to rescue the pepper from the present crises because pepper can contribute much to the exchequer of India in the form of foreign exchange inflow and financial safety to the country.

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Analysis of Marketing Status and Promotional Measures Followed by Hybrid Castor Seeds Companies in Banaskantha District

Dubey L. R.* [1], Kachhva P. H. [2], Kulshreshtha S. K. [3], and Modi R. P. [4]

[1,2,4] College of Agribusiness Management, S. D. Agril. University, S. K. Nagar-Gujarat
[3] Economics, Vardhman Mahaveer Open University, Kota-Rajashthan.
*E-mail:laxmirani.d@sdau.edu.in

ABSTRACT

Castor is one of the oldest cultivated crop and contributes to 0.15 % of the vegetable oil produced globally. The oil produced from this crop is the only commercial source of a hydroxylated fatty acid. The current study has been undertaken in Banaskantha district which has a large area and production under hybrid castor seed in North Gujarat. With the help of multistage sampling, four talukas were selected purposively viz., Dhanera, Tharad, Deesa, and Palanpur having the highest area under hybrid castor cultivation in the district. Total of 20 dealers and 120 castor growers were selected for the study. The study was mainly based on primary data, which were collected through personal interview methods with the help of a structured schedule. The study revealed that the largest market share was captured by Avani Seeds Ltd. company followed by co-operative societies and Western Agri Seeds Ltd. company. The majority of hybrid castor seed growers purchased hybrid castor seed from dealer's shop at the time of sowing with cash payment. Most of the castor growers purchased the seed according to dealers' and fellow farmer's suggestions. Most of the hybrid castor growers expected more field demonstrations from seed companies. It was recommended that the seed companies should give more emphasis on farmer's meetings, field exhibitions, and expert visits as a promotional activity and the companies should also make sure to provide quality seed of particular brand on time and in plenty quantity at a reasonable price. Seed companies should provide better knowledge and awareness for the farmers about the use of seeds and improved farming techniques.

Keywords : Marketing Status, Hybrid, Castor, Promotion and Seed Companies

INTRODUCTION

India occupies 19% of the world's oil seed area and 10% of world's oil seed production, making it one of the leading oil seed-producing countries across the world. However, the productivity in India is only 1067 Kg/ha as compared to the world level of 1773 Kg/ha. India is one of the significant oil seed growers and importers of edible oils. India's vegetable oil economy is the world's fourth-largest after the USA, China, and Brazil. Globally, India ranks first in the production of Castor, Safflower, Sesame, and Niger, second in Groundnut, Rapeseed, and Mustard, third in Linseed, and fifth in Soybean and Sunflower.

The castor bean (*Ricinus cummunis*) is considered native to Tropical Africa and is grown particularly in arid and semi-arid regions. It is grown in 43 countries of the world including Pakistan and it is cultivated

in more than 30 countries on a commercial scale. The major share of the world's castor production comes from a few countries like India, China, and Brazil. The supply of castor and its derivatives is showinga highly fluctuating trend. Any change in the production trend in any of these countries leads to a change in the level of world production. India is the biggest producer of castor seed (62.40 %) followed distantly by China (19.20 %) and Brazil (12.70 %).

Gujarat is the leading state in castor seeds production in India followed by Rajasthan and Andhra Pradesh. Gujarat contributed 75 % of the total production of castor seed in India in 2019-2020, followed by Rajasthan (15.00 %), Andhra Pradesh (06.00 %) and others (04.00%). In Gujarat, castor cultivation comes from 6 districts of North Gujarat, *viz.*, Mehsana, Banaskantha, Surendranagar, Sabarkantha, Patan, and Kutch. The present study aimed to analyze the marketing status and promotional measures followed by hybrid castor seed companies in Banaskantha district.

MATERIALS AND METHODS

As per the objective of the study, a purposive and multistage random sampling technique was chosen. At the first stage, four talukas, Tharad, Deesa, Dhanera and Palanpur from the Banaskantha district were selected on the basis of the highest area under castor seed cultivation. Then five villages from each selected taluka and six castor seed growers were selected from each selected village. Total of 120 hybrid castor growers and 20 dealers were selected as sample respondents for the study.

The primary data were collected through personal interviews of hybrid castor growers by using a well-structured schedule. Secondary data were collected from published materials and websites. Tabular, frequency, and percentage analysis and Garrett ranking technique were used for data analysis purposes.The market share of different hybrid castor seed companies were measured in terms of demand of various companies' hybrid castor seed at dealers' shop, and major companies preferred by the growers.

RESULTS AND DISCUSSION

1. Market share of different hybrid castor seed companies

1.1 Classification of major crop seeds available in dealers' shop

Multiple crops like pulses, oilseeds, and vegetables were cultivated in this region but all seed crops are available according to

Table 1: Classification of major crop seeds available in dealers' shop (n=20)

Sr.No.	Name of crop	Frequency	Percentage
1	Castor	20	100.00
2	Bajra	18	90.00
3	Cumin	18	90.00
4	Mustard	15	75.00
5	Cotton	12	60.00
6	Jowar	12	60.00
7	Groundnut	13	65.00

sowing season. The details of various seeds available in dealers' shops are presentedin Table 1.

In the dealer's shop highest seed crop availability is hybrid castor 100.00 %, whereas bajra and cumin seed availability are the same (90.00 %), followed by mustard seed (75.00 %), groundnut seed (65.00 %) and lowest availability of cotton and jowar seed was found 60.00 % respectively.

1.2 Different companies' hybrid castor seed available in dealers' shop

Dealers are keeping various companies' hybrid castorseedsin their shopsfor various reasons like farmers' demand for particular brands of seed, price of seed, marketing margin associated with seed,*etc.*Therefore, it is important to know which company's seed dealers are keeping in their shop. The data regarding hybrid castor seed availability in dealers' shops are presented in Table 2.

Table 2 : Distribution of dealer according to different companies' hybrid castor seeds available in shop (n = 20)

Sr. No.	Companies name	Frequency	Percentage
1	Western Agri Seeds Ltd.	18	90.00
2	Dantiwada Seeds Pvt Ltd.	12	60.00
3	Avani Seeds Ltd.	19	95.00
4	Sagar Laxmi AgriSeeds Ltd.	14	70.00
5	Gujarat Agro Seeds Corporation (GASCO)	10	50.00
6	Others	05	25.00

The results of the study revealed that almost all dealers have Avni Seeds Ltd.(95 %)Companyseed followed by Western Agri Seeds Ltd. (90%),Sagar Laxmi Agri Seeds Ltd. (70 %), Dantiwada Seeds Pvt. Ltd. (60 %) and Gujarat Agro Seed Corporation (GASCO seeds) (50 %), other companies seeds (like Ganesh Seeds Ltd., Utsav Seeds Ltd., Vasundhara Seeds Ltd., Banas Seeds Ltd. *etc.*), Moreover these results showed thatAvani Seeds Ltd., Western Agri Seeds Ltd. companies accounted majority of availability in hybrid castor seed. Bansal *et. al,* (2013), they were also reported that most of farmers were glued to one variety of hybrid castor seeds *i.e.,* Western Agri Seeds Ltd.

1.3 Sales of different companies'hybrid castor seeds by dealers

The earlier section of this study presented information regarding the various companies'seeds available to dealers. To corroborate the previous section's findings this section of the study showed the information regarding the ranking of different hybrid castor seed companies with respect to the total sales by dealers. The results revealed that Avani Seeds Ltd. was ranked first in hybrid castorseed sold by the dealers followed byWestern Agri Seeds Ltd., Sagar Laxmi Agri Seeds Ltd., Dantiwada Pvt. Seed Ltd., Gujarat Agro Seed Corporation (GASCO), and othercompanies (like, Ganesh Seeds Ltd., Utsav Seeds Ltd., Vasundhara Seeds Ltd., Banas Seeds Ltd.,*etc.*),hybrid castor seeds in the study area.

Table 3 : Ranking of different seed companies based on the highesthybrid castor seeds sold in selected markets (n = 20)

Sr. No.	Companies name	Rank
1	Avani Seeds Ltd.	1st
2	Western Agri Seeds Ltd.	2nd
3	Sagar Laxmi Agri Seeds Ltd.	3rd
4	Dantiwada Seeds PvtLtd.	4th
5	Gujarat Agro Seeds Corporation (GASCO)	5th
6	Other companies	6th

1. 4 Market share of hybrid castor seeds companies in selected markets

Market share is the percent of total sales in the market generated by a particular company. The market share of a particular company determines its reputation and dominance in the market. This study targeted to examine the hybrid castor seeds market share of different companies in the selected market and results are presented in Table 4.

Table 4 : Distribution of hybrid castor growers according to various hybrid castor seed companies based on purchase (n=120)

Sr. No.	Companies name	Frequency	Marker share (%)
1	Avani Seeds Ltd.	27	22.50
2	Western Agri Seed Ltd.	17	14.17
3	Cooperatives	35	29.16
4	Dantiwada Seeds Pvt Ltd.	15	12.50
5	Sagar Laxmi Agri Seeds Ltd.	11	09.17
6	Gujarat Agro Seeds Corporation	09	07.50
7	Others	06	05.00
	Total:	120	100.00

The results showed that the highest hybrid castor seed purchased volume accounted by Cooperatives (29.46 %) followed by Avani Seeds Ltd. *i.e.,* 22.50%,Western Agri Seeds Ltd. (14.17 %), Dantiwwada Seeds Pvt Ltd. (12.50 %), Sagar Laxmi Agri Seeds Ltd. (09.17 %), Gujarat Agro Seeds Corporation (GASCO, 07.50 %) and rest some of the others companies *i.e.,* 05.00 % (Vasundhara Seeds Ltd., Banas Seeds Ltd., Ganesh Seeds Ltd., Utsav Seeds Ltd. *etc.*). The study revealed that hybrid castor growers were mostly growing Avani Seeds Ltd. company hybrid castor seed, maybe because of the easy availability of seed and higher production.

1.5 Sources of purchase for hybrid castor seed by hybrid castor growers

The purchase decision of farmers to purchase the seed depends on a number of factors like proximity, quality, price, brand preference, and discount given by the seller. Hybrid castor growers' decision to purchase the improved seed is presented in Table 5. The result of the study displayed that about 2/3rd hybrid castor growers *i.e.,* 64.17 % have purchased hybrid castor seed from dealers shop and 29.16% of hybrid

castor growers purchased hybrid castor seed from cooperatives society, only a few of them *i.e.,* 05.00% of hybrid castor growers purchased hybrid castor seed from fellow farmers and relatives and very few *i.e.,*01.67 % purchased directly from the wholesaler. Most of the hybrid castor growers purchased the hybrid castor seed from dealers' shop may be because of the easy availability of hybrid castor seed in the proximity and credit facility given by dealers.

Table 5 : Distribution of hybrid castor growers according to source from hybrid castor seeds purchased (n = 120)

Sr. No.	Sources	Frequency	Percentage
1	Dealers shop	77	64.17
2	Cooperatives	35	29.16
3	Wholesaler	02	01.67
4	Others - farmers and relatives	06	05.00
	Total:	120	100.00

4.2.6 Source of purchase of hybrid castor seed for dealers

The dealers are purchasing seeds from various agencies and purchase also depends on a number of factors. This study analyzed various sources of hybrid castor seedfor dealers and the results are presented in Table 6. The result indicated that most of the dealers purchased (95.00 %)hybrid castor seed from wholesalers. Only a few of them *i.e.,* 05.00 per centof dealers made their purchase from the company.

Table 6 : Distribution of dealer's according to source from purchase (n = 20)

Sr. No.	Sources	Frequency	Percentage
1	Company	01	05.00
2	Wholesaler	19	95.00
	Total:	20	100.00

2. Major promotional measures followed by hybrid castor seed companies

2.1 Major factors considered by the hybrid castor growers in purchasing hybrid castor seeds

Farmers generally consider numerous factors while purchasing the seed. To account the factors hybrid castor growers undertaken to purchase the hybrid castor seeds various responses were collected from them and results are presented in Table 7. The results showed that 39.17 % of hybrid castor growers purchased hybrid castorseeds as per the dealer's suggestion followed by 18.33 % of farmers purchased hybrid castor seeds according to the advice of fellow farmers. Similarly, 13.33 % of hybrid castor growers purchased hybrid castor seeds based on media, whereas 12.50 % consulted the progressive farmer. Only 09.17 % of hybrid castor growers purchased the hybrid castor seeds based on their own experience and few of them*i.e.,*04.17 % followed other people who were working in agricultural department or

seed companies and rest *i.e.,* 03.33 % of them consulted marketing officer for taking decision regarding the purchase the hybrid castor seeds.

Table 7 : Factors consider by hybrid castor growers in purchasing of hybrid castor seed

(n = 120)

Sr. No.	Particulars	Frequency	Percentage
1	Dealer	47	39.17
2	Marketing officer	04	03.33
3	Fellow farmers	22	18.33
4	Progressive farmers	15	12.50
5	Media	16	13.33
6	Own experience	11	09.17
7	Others	05	04.17
	Total:	120	100.00

2.2 Promotional activities carried out by the companies

The results regarding promotional activities are presented in Table 8. The study showed that 70.83 % of hybrid castor growers responded that the company organized field demonstrations and 47.05 %of companies adopted radio and television for promotional purposes followed by (41.67 %) utilized social media platforms, and 36.67 % responded that the company organized farmer meetings. Whereas, hybrid castor growers sharedthat only 35.83 % and 21.60 % of companies leveraged the advertisement and exhibition for promotional activities, respectively, and very few farmers responded *i.e.,* 09.17 % regarding organizing other activities like free visits and industrial tours for farmers. The results of the study are in line with the findings of Sharma *et al*. (2009).

Table 8 : Promotional activities carried out by the companies as per hybrid castor growers

(n = 120)

Sr. No.	Particulars	Frequency	Percentage
1	Farmer meeting	44	36.67
2	Radio and Television	57	47.50
3	Field demonstration	85	70.83
4	Fair and exhibition	26	21.67
5	Wall painting, banner, poster	20	16.67
6	Social media	50	41.67
7	News Paper /Advertisement	43	35.83
8	Others	11	09.17

2.3 Dealer's suggestions for hybrid castor seeds to hybrid castor growers

Dealers are the most influential source of information regarding any agri-input marketing-related information. There sults revealed that 50.00 %of dealers suggested Avani Seeds Ltd. company hybrid castor seed to the hybrid castor growers followed by Western AgriSeeds Ltd., Sagar Agri Laxmi Seeds Ltd. and Dantiwada Seeds Pvt Ltd. company hybrid castor seed.

Table 9 : Dealers' suggestions for hybrid castor seed to hybrid castor growers

(n = 20)

Sr. No.	Name of Company	Frequency	Percentage
1	Western Agri Seed Ltd.	06	30.00
2	Dantiwada Seeds Pvt. Ltd.	02	10.00
3	Avani Seeds Ltd.	10	50.00
4	Sagar Laxmi Agri Seeds Ltd.	04	20.00
5	Others	01	05.00

2.4 Expectations of hybrid castor seed dealers from different seed companies

The expectations of hybrid castor dealers from different seed companies are presented in below Table 10. From the results it is reported that high yielding variety is the foremost expectation from the dealers and this finding is in accordance with the finding of Bansal *et. al,* (2013), they were also reported that most of (50 %) farmers preferred high-yieldingvariety seeds.

Table 10 : Expectations of dealers from different seed companies (n = 20)

Sr. No.	Expectations	Garrett's Score	Rank
1	High-yielding variety of seeds	54.80	I
2	Farmer satisfaction	54.60	II
3	Increasing margin	49.05	III
4	Bonus	46.75	IV
5	Easily and timely availability of seeds	45.60	V

Other expectations of dealers were observed as farmer satisfaction, increasing margin, bonus like tour and gifts from company and the last fifth expectation was easy and timely availability of hybrid castor seeds within the time.Kumar *et. al,* (2014) also reported that 72 per cent dealers suggested to release new varieties, and 42 per cent suggested to increase margin for dealers/distributors for improvement of market share of the company.

CONCLUSION

Based on the finding of the present study, it can be concluded that the majority of castor dealers have Avani Seeds Ltd. Company (95.00 %) hybrid castor seed followed by Western Agri Seeds Ltd. company (90.00) and the castor seed growers mostly grown Avani Seeds Ltd. Company's hybrid castor seed, may be because of ease in availability of seed and higher production. The highest hybrid castor seed purchased volume accounted by Cooperatives societies (29.46 %) followed by Avani Seeds Ltd. *i.e.,* 22.50 %, Western Agri Seeds Ltd. (14.17 %). Hybrid castor seed dealers' key expectations from the seed companies were reported as; high yielding variety, farmer satisfaction and increasing margin. The seed companies should give more emphasis on farmer's meeting, field demonstration and expert visit as a promotional activity. The seed companies should provide the quality seed at reasonable price with on time availability. Seed companies should also focus to

provide some promotional schemes against the case payment sales to reduce the problem of credit sales.

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Knowledge level of drip owners towards drip irrigation management practices

Joshi J. K.[1], Deshpande A. R.*[2], Biswas A.[3] and Raval K. N.[4]

Department of Agricultural Extension and Communication
C P College of Agriculture, SDAgricultural University, Sardarkrushinagar-385506
*Email: aniketextension@sdau.edu.in

ABSTRACT

The present study was designed to know the knowledge level of drip owners towards drip irrigation management practices. A multistage random sampling technique was used for selection of talukas, villages and respondents. Sabarkantha district was selected purposively. Among the different talukas of Sabarkantha district Idar, Vadali and Himmatnagar talukas were randomly selected. Five villages were selected from each selected taluka on the basis of highest number of drip owners. Thus, total 15 villages having maximum number of drip owners were selected. A list of farmers who installed drip irrigation system on their farm was prepared for each selected village. Ten respondents from each village were selected by using random sampling techniques and thus making a sample of 150 respondents. Appropriate statistical methods were used for analysing the data. From the result of the study it can be concluded that 64.67 per cent of the drip owners possessed medium level of knowledge. The age, education, social participation and cropping intensity were positively and significantly correlated with knowledge level of drip owners. Whereas, area under DIS, irrigation potentiality, annual income, economic motivation, attitude towards drip irrigation system and extension contact had positive and non-significant relationship with knowledge level of drip owners.

Keywords: Association, Knowledge, Drip owners

INTRODUCTION

More than 70 per cent of the cropped area in the country is depend on the vagaries of monsoon. The agricultural production and productivity are therefore, the challenging task for management of the agriculture to meet the growing needs of the people of nation. For increasing the agricultural production, the importance of irrigation is fully realized, but the proper use of water is seldom practiced in our country. The regularized and controlled irrigation increases crop production, reduce water cost, conserves soil, covers more area under irrigation and thus, brings prosperity at home. World Bank predicted that by the year 2035, three million people will live in the tough conditions because of water shortage. According to the Human Development Report, by the year 2080 climate change would affect the life of many people throughout the world and more than 1.8 billion people would face water shortage.

Rainfall is irregular and uneven in many parts of the country. Gujarat is also facing this situation. Shortage of water has become one of the main problems in Gujarat for farmers. Therefore, efficient use of available water has become extremely important and which can be done through

drip irrigation system.

The total geographical area of Gujarat state is 196.12 lakh ha, out of this,106.3 lakhs ha is under gross cultivation. In Gujarat slightly more than three fourth (76.00 per cent) of the area under irrigation depends largely upon rainfall and remaining about one-fourth (24.00 per cent) of land is under irrigation. The area under drip irrigation in Gujarat state has been increased sizably during last eight years.

Generally, farmers look for a method of irrigation, which is most efficient with less water, labour, fertilizer and power requirements. Among the irrigation methods the drip irrigation system, is the advanced method of irrigation to overcome the various problems of water losses and other problems such as labour, money and water management. This method is rapidly gaining importance in the area where water is scare and high value crops are produced. Drip irrigation is an effective and efficient method of providing water directly to the root zone of plant. Drip irrigation represents one of the fastest expanding technologies in modern agriculture. Water is applied at low rate under pressure to keep soil moisture within the desired range for plant growth. This system saves 40 to 70 per cent of irrigation water. A well drip irrigation system also promotes the utilization of fertilizer, pesticides and other water soluble chemicals along with irrigation water. Research studies conducted worldwide have shown that this method leads not only to appreciable water saving, but also achieving high crop yield as compared to surface irrigation methods. This system is adaptable to most of the crops, under most of the soils and particularly suited to soil under condition of water scarcity. Crops like sugarcane, fruits, vegetables, oilseeds and cotton are ideally suited crops for drip irrigation. The present study was undertaken know the knowledge level of drip owners towards drip irrigation management practices

MATERIALS AND METHODS

The present study was confirmed to "Ex-Post Facto" research design as the independent variables had already operated in the study area. A multistage random sampling technique was used for selection of talukas, villages and respondents. Sabarkantha district was selected purposively. Among the different talukas of Sabarkantha district Idar, Vadali and Himmatnagar talukas were randomly selected. Five villages were selected from each selected taluka on the basis of maximum number of drip owners. Thus, total 15 villages having maximum number of drip owners were selected. A list of farmers who installed drip irrigation system on their farm was prepared for each selected village. Ten respondents from each village were selected by using random sampling techniques and thus making a sample of 150 respondents. Knowledge level of drip owners was considered as dependent variable in the study. The data were collected with the help of structured interview schedule. The collected data were coded, classified, tabulated and analyzed by using the statistical tools such as frequency, per cent, mean, standard deviation and correlation coefficient.

RESULTS AND DISCUSSION

A. Selected attributes of drip owners

Knowledge level of drip irrigation management practices was influenced by different attributes of the farmers. It was beyond the scope of the present study to include all important characteristics of the respondents. However, some important characteristics of farmers were selected and classified into four groups viz., personal, agro-economic, psychological and communication attributes. The findings of these attributes have been presented in the following Table 1.

Table: 1. Selected attributes of drip owners (n=150)

No.	Selected attributes of drip owners		Frequency	Percent
(A)	Personal Attributes			
1	Age	Young age (up to 35 years)	37	24.67
		Middle age (36 to 50 years)	82	54.67
		Old age (above 50 years)	31	20.66
2	Education	Illiterate	19	12.67
		Can read only	06	04.00
		Can read and write	28	18.66
		Primary	27	18.00
		Middle	37	24.67
		High	24	16.00
		Post-Graduate and above	09	06.00
3	Social participation	No membership	15	10.00
		Member of one organization	98	65.33
		Member of more than one organizations	28	18.67
		Office holders	09	06.00
(B)	Agro-economic attributes			
4	Area under DIS	Up to 1.00 ha	19	12.67
		1.01ha to 2.00 ha	63	42.00
		2.01 ha to 3.00 ha	39	26.00
		Above 3.01 ha	29	19.33
5	Irrigation potentiality	Low (Up to 49.40 score)	43	28.67
		Medium (Between 49.40-90.00 score)	71	47.33
		High (Above 90.00 score)	36	24.00
		Mean=69.70	**S.D. = 20.30**	
6	Cropping intensity	Low (Up to 208.35 score)	38	25.33
		Medium (Between 208.35-297.65 score)	76	50.67
		High (Above 297.65 score)	36	24.00
		Mean=253	**S.D. = 44.65**	

7	Annual income	Low (Up to 160039)	16	10.67
		Medium (Between 160039 - 609269)	127	84.66
		High (Above 609269)	07	04.67
		Mean=384654	**S.D. =224615**	
(C)	Psychological attributes			
8	Economic motivation	Low (Up to 23.50 score)	28	18.67
		Medium (Between 23.50-29.18 score)	82	54.67
		High (Above 29.18 score)	40	26.66
		Mean=26.34	**S.D. = 2.84**	
9	Attitude towards DIS	Less favourable (Up to 105.40 score)	42	28.00
		Moderately favourable (Between 105.40-140.20 score)	87	58.00
		Highly favourable (Above 140.20 score)	21	14.00
		Mean=122.80	**S.D.=17.40**	
(D)	Communicational attributes			
10	Extension contact	Low (Up to 1.50 score)	21	14.00
		Medium (Between 1.50-3.60 score)	91	60.67
		High (Above 3.60 score)	38	25.33
		Mean=2.55	**S.D.=1.05**	

The data presented in Table1 indicates that more than half (54.37 %) of the drip owners were from the middle age group. 87.33 per cent of the drip owners were educated whereas, 12.67 per cent were uneducated. Almost two third (65.33%) of the drip owners were member of one organization. Slightly more than two fifth of (42.00%) drip owners had 1.00 to 2.00 ha area under drip irrigation system. Nearly half of the drip owners (47.33%) were having medium level of irrigation potentiality. Whereas, 50.67 per cent of the drip owners possess medium level of cropping intensity and 84.66 per cent of the drip owners had medium level of annual income. More than half of the drip owners (54.67%) possess medium to high level of economic motivation. While, 58.00 per cent had moderately favorable attitude towards drip irrigation system. Slightly more than three fifth of the drip owners (60.67%) had medium level of extension contact.

B. Knowledge level of drip owners towards drip irrigation management practices

Knowledge is a cognitive behavior of an individual. In the present study, it was operationalized as total understanding regarding drip irrigation management practices. The information in this regard was collected from drip owners are presented in Table 2.

Table 2: Distribution of drip owners according to their level of knowledge regarding drip irrigation practices (n = 150)

Sr. No.	Knowledge level	Frequency	Per cent
1	Low (Up to 28.15 score)	29	19.33
2	Medium (Between 28.15-36.75 score)	97	64.67
3	High (Above 36.75 score)	24	16.00
	Total :	150	100.00
	Mean = 32.45 S.D. = 4.30		

It is evident from Table 2 that slightly less than two third (64.67 per cent) of the drip owners possessed medium level of knowledge, followed by 19.33 and 16.00 per cent of drip owners possessed low and high level of knowledge regarding drip irrigation management practices, respectively.

C. Association between selected attributes of drip owners and their level of knowledge

The correlation coefficient 'r' was worked out to know the association between independent and dependent variables. The correlation coefficient was calculated for knowledge level of drip owners with ten independent variables which were grouped into (i) personal attributes, (ii) agro-economic attributes, (iii) psychological attributes and (iv) communicational attribute. The results in this regards are discussed under following sub-titles and presented in Table 3.

The age, education, social participation and cropping intensity were positively and

Table 3 : Association between selected attributes of drip owners and their knowledge level (n=150)

Sr. No.	Independent variables	Correlation coefficient ('r' value)
[I]	Personal variables :	
(1)	Age	0.182*
(2)	Education	0.185*
(3)	Social participation	0.168*
[II]	Agro-economic variables :	
(1)	Area under DIS	0.112NS
(2)	Irrigation potentiality	0.089NS
(3)	Cropping intensity	0.236**
(4)	Annual income	0.087NS
[III]	Psychological variables :	
(1)	Economic motivation	0.061NS
(2)	Attitude towards DIS	0.032NS
[IV]	Communication variables :	
(1)	Extension contact	0.006NS

** = Significant at 1% level; * = Significant at 5% level; NS = Not significant

significantly correlated with knowledge level of drip owners. Whereas, area under DIS, irrigation potentiality, annual income, economic motivation, attitude towards drip irrigation system and extension contact had positive andnon-significant relationship with knowledge level of drip owners.

CONCLUSION

The regularized and controlled irrigation increases crop production, reduce water cost, conserves soil, covers more area under irrigation and brings prosperity at home. It can be articulated that nearly two thirds (64.67 per cent) of the drip owners possessed medium level of knowledge. While in case of association, age, education, social participation and cropping intensity were positively and significantly correlated with knowledge level of drip owners. Whereas, area under DIS, irrigation potentiality, annual income, economic motivation, attitude towards drip irrigation system and extension contact had positive and non-significant relationship with knowledge level of drip owners.

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Exploring the Farmers Adoption of Agri Input Mobile Applications using Tam Model

Shilpa S. K.*[1] and Royal K. L.[2]

Indian Institute of Plantation Management Bengaluru
Jnana Bharathi, Mallathahalli, Bengaluru, Karnataka 560056
*Email: kshilpa@iipmb.edu.in

ABSTRACT

Mobile applications for agriculture has great potential to facilitate farmers in timely decisions. The mobile apps provide information to the stakeholders across the agri value chain. Adoption of mobile applications for purchasing agri inputs are influenced by factors. This study provides an overview of the key features of agri-input mobile applications and examine the adoption of mobile applications for purchasing agricultural inputs by farmers from Kerala and Andhra Pradesh. The study found 29 percent of the sample responds used agri mobile apps. However only 24 farmers used the apps for purchase of agri inputs. The common features of these mobile apps were observed to be multilanguage support, providing package of practices selling the agri-inputs, and agro advisory service. The farmers perceived the apps to be easy to use and usefulness in agri input purchase.

Key words: Mobile apps, Agri inputs, Farmers, TAM model

INTRODUCTION

A macro level examination of farm sector indicates that India accounts for majority of small and marginal farmers below 2 hectares land per household. These farmers account for 86 % of all farmers contributing 47 % of the crop area. Most of these farmers still work for subsistence farming. Indian agriculture sector's contribution to the Indian economy and its existing vulnerabilities has reemphasised the need for structural reforms, adoption of technology and investments in infrastructure. Agri input industry has always strived to ensure availability of good quality seeds and agro-chemicals to the farmers. However, considering the constraints of limited availability of transport and workforce, production and movement of agriculture inputs is not an easy task. Agricultural inputs are a great determinant of yields in any type of agricultural production. In the modern world today, agriculture has become extremely dynamic therefore, making the kind of inputs that are being used in the sector today upgraded.

In this background there are various, Information and Communication technology tools including mobile applications (apps), SMS and voice-based information system (Jain *et al.*, 2015), adeptly support farmers in decision making by providing information related to weather (Mittal, 2016), agricultural input use (Ogutu et al., 2014), cost reduction (Sopegno *et al.*, 2016), pest management (Karar *et al*., 2021), climate adaptation strategies (Baumüller, 2018), market price, extension services (Namyenya, *et al.*, 2021) and

access to credit (Fu and Akter, 2016). Mobile apps also enable efficiency in the agricultural value chain (Halewood and Surya, 2012), monitoring financial transactions (Qureshi *et al.*, 2009) and schemes offered by government (Das et al., 2012; Shannon, 2013). Despite the benefits, smartphone apps usage in agriculture is very limited as compared to apps usage in other sectors (Xin, 2015). In India, technology-enabled agri-service delivery has been evolving considerably (Brugger, 2011; Krishnaswamy, 2020).

The mobile app is one of the platforms, where a farmer can get all solution and information in just one touch (Barh& Balakrishnan 2018). Agriculture mobile applications helps the farmer's with various benefits such as advisory services, weather data and information, input applications (dosages, irrigation inputs, *etc.*), market linkages and connectivity, new varieties information and all the changes related to the Indian agriculture can be found out while using these applications. About 73 different agricultural apps are present for farmers who can utilize them to increase farm yield and get an increased revenue realization (Balkrishna *et al.*, 2020).These apps are provided both by the private companies such as IFFCO Kisan Agriculture App, AgroStar, CropIn, Bharat Agri, etc likewise government organisations such as Krishi Jagran, Kisan Suvidha, Krishi Network, *etc* helps the farmers to increase their disposable income. The huge potential of mobile apps proliferation across the agri value chain needs to be properly utilized by farmers in adopting effective approach in sourcing, procurement, production, distribution and marketing of agri produce. The current study aims at filling the existing research gap by exploring the adoption of mobile apps by farmers.

Prior studies have focused on awareness level of farmers and benefits of the mobile apps, however there lies a gap in understanding the usage of mobile apps for purchasing of agri-inputs. Hence the current study intends to explore the farmers adoption of mobile applications for purchase of agri inputs. More specifically this study aims (1) to examine the usage of mobile applications (2) to identify and compare agri-input mobile applications (3) to explore the farmers adoption of agri-input mobile applications using TAM model. This study provides on overview of the agri-input mobile applications and examine the adoption of mobile applications for purchasing agricultural inputs by farmers. TAM model is used as tool which gives idea on the farmers' adoption level to the technology with perceived ease of use and perceived usefulness of the new technology adopted by farmers.

REVIEW OF LITERATURE

The emergence of mobile apps is creating number of opportunities in developing countries. One of the areas with wide potential impact is mobile applications for agricultural and rural development (mARD apps).The mARD apps provide information to the stakeholders across the agri value chain. The advantages of using mobile apps are wide ownership, affordability, voice communication, speed and convenience (World Bank, 2012). Mobile phones are effective in providing information access among the farmers even in isolated conditions and remote places. They help farmers is sharing knowledge about the

world class agronomic practices and consult agricultural experts (Banerjee, 2010). In most of the countires across the globe, agriculture is the major occupation in rural areas (Salemink *et al.*, 2017) and innovation adoption is the important factor to support agriculture development (McFadden and Gorman 2016). To increase agricultural production farmers need to have good information (Ali-Olubandwa et al., 2011). Use of information and communication technology (ICT) particularly mobile applications helps farmers in availing market information, weather & transportation facilities (Aker 2010). Mobile applications provide market information and information on package of practices for crops (Costopoulou *et al.*, 2016) as well as get information about the changing seasons and climate (Barh and Balakrishnan 2018). Farmers using these applications shown with improved access of quality inputs and reduction in transportation costs (Kumar *et al.*, 2020). Majority of farmers raised savings and decrease rate in taking loans due to M-services (Haider Rizvi 2011).

In Kenya mobile phones are mostly used for diagnosing livestock diseases (Martin & Abbott 2011). Small holder farmers using mobile phones contribute to a more effective value chain in maximising time utilization and lowering transportation costs (Halewood and Surya 2012., Qiang *et al.*, 2012). Individual's perception is important determinant to adopt technology (Cheney 2018 and Crandall 2012) and lack of awareness is the primary reason for non-adoption of mobile applications in Kenya (Thiga and Ndungu 2015). Adoption of mobile applications for purchasing agri inputs was influenced by factors such as perceived usefulness, ease of use, social influence, and trust (Rehman et al., 2020).The price values derived from any particular technology and also the farmers adoption decisions will play an important role in TAM (Qianchan Dai and Kequn Cheng 2022). The major factors influencing TAM are individual innovativeness, perceived enjoyment, social norm, content and technology quality, experience with regards to the technology (Castiblanco *et al.*, 2020). For the farmers the main important factors to be considered while utilizing technology are the usefulness of the technology and the ease of use for that technology (Pierpaoli *et al.*, 2013.)

Kabbiri *et al.* (2018) extended the TAM model with two more constructs, perceived advantage and socio-economic characteristics and stated that perceived ease of use had positive effect on both perceived usefulness and adoption of mobile phones by Ugandan farmers. Pick et al. (2014) identify the factors that increase the use of telecenters by farmers as - relative advantage, compatibility, low complexity and observability, pointing to the TAM factors of perceived usefulness and perceived ease of use. Shah *et al.* (2014) state a slew of disadvantages of mobile apps which hinder adoption by farmers-viz., apps not supporting regional languages, which in turn demands for translation and hence, lesser acceptability; lack of affordability of farmers in the developing nations; applications requiring huge data usage, high network charges, thereby, making it expensive for the farmer to adopt.

Review of literature suggests that a number of studies have been carried out to study the adoption of mobile apps in various vertices

across the agriculture value chain. Moreover most of these studies have identified the types of mobile applications for agriculture, and benefits and mobile apps to farmers in developed countries. The Scopes of most of the existing studies are limited to either as single mobile app benefit on agriculture development or cover limited geographical regions more particularly developed countries. The huge potential of mobile apps proliferation across the agri value chain needs to be properly utilized by farmers in adopting effective approach in sourcing, procurement, production, distribution and marketing of agri produce. This study aims at filling the existing research gap in an emerging potential of mobile app adoption by farmers. Moreover there are no studies on usage of mobile apps for purchase of agri input in India. Farmers invest in agri inputs for enhancing their production and productivity. With change in attitude and perception of farmers regarding the usage and benefits of mobile services, there arise a need to understand the usage of mobile apps by farmers in purchase of agri inputs becomes important.

MATERIALS AND METHODS

The study aimed to explore the adoption of agri input mobile applications by farmers using TAM model. For the purpose of the study data was collected from secondary and primary sources. Apps were downloaded and analysed to get insights about the features of those apps used by sample respondents. Further to understand the adoption of mobile apps, farmers from the states of Andhra Pradesh and Kerala were approached. A total of 291 Farmers were selected randomly from 4 districts of AP and seven districts of Kerala (refer table 1). The information related to mobile apps used and agri inputs purchased through the apps was collected from the sample respondents using structured questionnaire. Information related to the TAM variables perceived usefulness and perceived ease of use using the likert scale was collected.

Table-1 Sample respondents

S.NO	STATE	DISTRICT	NO. OF FARMERS
1	Andhra Pradesh	Tirupati	23
		Kadapa	67
		Anantapur	5
		Guntur	9
		Sub total	104
2	Kerala	Idukki	30
		Palakkad	20
		Wayanad	20
		Kanoor	15
		Tiruvananthapuram	10
		Thrissur	10
		Kottayam	10
		Sub total	115
		Total	219

RESULTS AND DISCUSSION

3.1 Adoption of agri-input mobile applications

As stated the study focused on understanding the adoption of agri-input mobile applications by farmers for purchase of agri inputs. From the discussion with the farmer members from Andhra Pradesh (104) and Kerala (115), it was noted that 39 farmers from Andhra Pradesh and 25 farmersfrom Kerala were using mobile applications. On further discussion with the farmers, it was understood that only 14 members from Andhra Pradesh and 10 members from Kerala were using mobile apps for purchase of agri-input (refer table 2).

Table-2 Sample respondents for mobile apps usage

S. No	State	Mobile application users	Users of agri-input mobile applications
1	Andhra Pradesh	39	14
2	Kerala	25	10
	Total	64	24

Source: Author's description based on interview

4.2. Comparative Analysis

Furthermore, analysis was done to get insights about the features of agri-input apps used by farmers in Andhra Pradesh and Kerala. Common features observed in three mobile apps used by farmers are discussed. Firstly, the apps provided multi language support which is important for the farmers in a country such as India where number of languages are more and illiteracy among farmers is high. Second common feature was, providing package of practices with recommendations to farmers in giving details from production stage to harvest stage for crops. Another common feature across these apps was, selling the agri-input such as seeds, crop protection and crop nutrition products with cash on delivery option (COD) as many farmers were not aware about digital payment methods. Additionally, agro advisory feature which helps farmers in solving their queries through calls and field visits by experts to farms was offered in these apps (Refer table 3).

Table-3 Comparative analysis of mobile applications used

Company Name	Agri App	Rallis India (Krishi samadhaan)	*Napanta*
Logos	AgriApp	Samadhan	
App Notification	✓	✓	✓
Subscription based	×	×	✓
Promoting Different Branded products	✓	×	✓

Crop protection	✓	✓	✓
Seeds	✓	✓	✓
Crop Nutrition	✓	✓	✓
Farm Implements	×	×	×
Demonstration videos to use products in field	✓	×	×
Dealers Information	×	✓	✓
Crop protection kits	×	×	×
Multi-language support	✓	✓	✓
Agri advisory	✓	✓	✓
Cash on delivery Option	✓	✓	✓
Fertilizer calculator	×	✓	×
Subsidy info information	×	×	✓
Package of practices with Input recommendations	✓	✓	✓
Video call with experts in recommending inputs	×	✓	✓
Crop calendar Option	×	×	×
Farm Machinery (Buy/sell/Rent)	×	×	✓
No. of downloads	1M+	50k+	100k+
Rating	3+	3+	3+

Source: Application Analysis of mobile apps (Agri app, Napanta, Krishi samadhan, Bharat Agri)

4.3. Farmers perception of Agri input mobile apps

Adoption of agri-input mobile applications was explored using TAM model, where in the farmers perception using the TAM variables perceived ease of use and the perceived usefulness was captured. With respect to 'Perceived Ease of Use', the farmers agree that the agri input mobile apps are easy to use, with specific reference to learning to use the app, interaction and overall usage with mean ranging between 4.0 to 4.6 (refer table 4). Perceived usefulness talks about how the learning or usage helps the individual in improving their performance towards usage of technology. Perceived usefulness is influenced by perceived ease of use. The farmers agreed that the apps were useful in searching and buying agri-input products with mean 4.4, using the agri input apps enabledthem to search and buy agri-input products faster with mean 4.20 and enhanced their effectiveness in agri-input product searching and buying with mean 4 (refer table 5).

Table 4: Perceived ease of use

S.NO	Perceived ease of use	Average
1	Learning to use the app is easy to me	4.6
2	It's easy to make the app to do what I want to do?	2.0
3	My interaction with app is clear and understandable.	4.2
4	It's easy to use the application.	4.5
5	The app that I am using makes it easier to search for and purchase agri-input products.	3.8

Source: Author's description based on interview

Table : TAM model for perceived usefulness

S.NO	Perceived usefulness	Average
1	The app that I have used is useful for searching and buying agri-input products.	4.4
2	The agri input app that I have used improved my performance in product searching & buying.	3.6
3	The app that I am using enables me to search and buy agri-input products faster.	4.2
4	The app that I am using enhances my effectiveness in agri-input product searching & buying.	4
5	The app that I am using increases my productivity in searching & purchasing products.	3.8

Source: Author's description based on interview

CONCLUSION

Technology plays significant role in changing process of life wherein critical information is available at tips of fingers. As India is broadly divided into urban and rural area, the proposed research focuses to enhance the quality of life of farmers with adoption of technology. The advantages of using mobile apps such as wide ownership, affordability, voice communication, speed and convenience (World Bank, 2012) can easily be passed to the rural mass. Studies across the globe have proved the effectives of mobile apps in terms of changing productivity and incomes, linking poor farmers to urban, regional and global markets.The study demonstrates the usage of mobile apps for purchase of agri inputs by farmers from Kerala and Andhra Pradesh. It was interesting to note 29 percent (64 farmers) of the sample responds used agri mobile apps. However 24 farmers used the apps for purchase of agri inputs. The common features of these mobile apps were observed to be multilanguage support, providing package of practices selling the agri-inputs, and agro advisory service. The farmers perceived the apps to be easy to use and usefulness in agri input purchase.

There are numerous usages of mobile phones reported by rural people. There has been improved access to knowledge in agriculture, including non-grain products, such as vegetables and milk production.

Besides knowledge, information about market prices secured through mobile phones enabled farmers to choose wholesale markets in which to sell their products or even harvesting of vegetables. The farmers, who use mobile phone for seeking information has reported improved marketing because of better price information. Increasing access to price information would seem to improve the functioning of markets, reducing the spread between prices in different locations. Cost savings were realised by both farmers and petty traders. Farmers could reduce spoilage by harvesting when prices in the market were better. All these benefits will in turn lead to better income and lifestyle of the rural people especially farmers.

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Study on Knowledge, Attitude and Practices (KAP) on Microgreens among Self Help Groups

Antony V.*[1] and Radha R.[2]

[1]Dept of Home science, Assumption College, Changanacherry, Kerala.
[2]Dept of FSMD, Avinashilingam Institute for Home science and Higher Education for Women, Coimbatore, Tamil Nadu.
*E-mail- vineethaantony93@gmail.com

ABSTRACT

Microgreens are recognised as "super foods" due to their numerous health and nutritional advantages. In addition, growing microgreens is very simple and practical, needing little space and financial commitment, and therefore, it should be encouraged in urban regions where there is a shortage of space and in peri-urban areas where there is a shortage of resources (money). The knowledge attitude and practice of microgreens were surveyed among the selected subjects, and pre- and post-knowledge assessments were done. An awareness session eliciting the importance of microgreens and a training session were organised for selected self-help groups. The knowledge regarding microgreens among the community was found to be negligible. As microgreens are rich in micronutrients, awareness regarding microgreens was found to be very relevant for the future eradication of micronutrient malnutrition.

Keywords : Microgreens, Super Foods, Resources, Population, Food Security

INTRODUCTION

Microgreens, also known as 'Vegetable Confetti,' are a type of distinguishing crop. It is described as soft juvenile greens grown from the seeds of herbs, vegetables, or cereals, as well as wild forms. As there has been a surge in the popularity of healthy eating, gourmet cuisine, and indoor gardening in developed nations, microgreens have gained notoriety. Even in the refrigerator, this new type of food has a short shelf life and is used in minor amounts as toppings, garnishes, or spices (Riggio *et al.*, 2019). Paradiso *et al.,*2018 argue that microgreens are harvested a few days or weeks after germination, during the formation of cotyledons and the emergence of the first true leaves. Microgreens are distinguished by their diversity of colours, textures, and tastes. These are always fresh and tenderly soft vegetables that come from the seeds of multitudinous varieties of vegetables, aromatic herbs, wild edible plants, and herbaceous plants. Since the availability and consumption of microgreens are significantly influenced by the emergence of culinary trends, the species' selection relies on manufacturer discussions with chefs and on consumer acculturation to their unique sensory qualities. Microgreens can be distributed as freshly cut foods as well as while growing on medium for end users to harvest. The

knowledge level regarding microgreens among homemakers is very low, as the microgreens are not used by them for cooking.

MATERIALS AND METHODS

The study was carried out in two phases:

Phase I: Selection of subjects and assessment of knowledge regarding microgreens using an interview schedule

a. Selection of Subjects

The subjects selected were from the self-help groups situated in Kottayam district, Kerala. Married women were selected for the study. Women in the age group between 35 and 65 were selected. The sample size was determined using the formula by Vishwakarma (2017). Based on the formula, the sample size was determined to be 81, hence the same number of subjects were selected for the study.

The sample size was determined using the formula by Vishwakarma., (2017). Based on the formula, the sample size was determined as 81 numbers, hence the same number of subjects were selected for the conduct of the study.

Sample Size = (Z-score)2 * Std Dev*(1-StdDev) / (margin of error)

The samples were selected using the purposive random sampling method. Judgmental or subjective sampling method, the other term for purposive sampling method, is a form of non-probability sampling. In the purposive sampling method, the participants among the population are selected based on the judgement of the researcher itself (Kothari *et al.*, 2019).

b. Assessment of Pre-Knowledge Attitude Practices (KAP) on Microgreens

The Knowledge Attitude and Practices (KAP) survey is a quantitative method (predefined questions formatted in a standardised interview schedule) that provides access to quantitative and qualitative information.

Knowledge of healthy behaviour is considered to be beneficial. Although it does not guarantee that this behaviour will be followed, The survey's assessment of knowledge assists in identifying areas where information and education activities are to be exerted. Knowledge was assessed using the interview schedule, which contains background information and the socioeconomic status of the subjects. Knowledge regarding the importance of microgreens and the presence of nutrients in them, consumption patterns of greens, and the importance of kitchen gardens were assessed by the selected subjects.

Attitude questions on the need for microgreen farming, general attitude towards microgreen cultivation, and attitude that microgreen seeds are not available for purchase and expensive for cultivation were analysed.

Practices, or behaviours, are the observable actions of an individual in response to a stimulus. The questions regarding the practice of microgreen farming in the home garden, encouraging the consumption of microgreens in the family, and the practice of continuing microgreen farming in the future were recorded.

Before the assessment, the subjects were oriented about the study, and this helped in

the smooth conduct of the collection of data. The majority of the questions were structured as yes-or-no questions. The correct answers were awarded 1 point, and the wrong answers were not given any score (zero). The total score was fixed at 25. The samples who got more than 10 points were considered to have more knowledge, and those with a score of less than 10 were considered to have less awareness.

According to Krueger (2015), the evaluation can be done better if the investigator fixes a score for the pre- and post-knowledge assessments.

Phase II: Imparting awareness to the selected self-help groups and assessment of post-awareness knowledge among selected subjects

a. Imparting Awareness to Selected Subjects on the Cultivation and Importance of Microgreens

A live training session was conducted for the selected subjects on the cultivation techniques of microgreens and their importance for self-help groups. The sessions were conducted with the help of minor tools and the necessary accessories used for the cultivation process of microgreens, like mud pots, microgreen seeds, cocopeat, and water sprayers.

b. Assessment of Post Awareness Knowledge among Self-Help Groupson the Cultivation of Microgreens

Before the training session, an interview schedule was given to the selected samples to assess their knowledge of the microgreens. The live training session has helped the homemakers motivate themselves and do the cultivation process of microgreens in their kitchen garden. This was indeed used for generating information on the cultivation and importance of microgreens among the selected samples. After the live training session, the schedule was given to the same samples to assess their knowledge and feedback on the session. The scoring was done using the same method as it was for the pre-awareness session. The pre-awareness and post-awareness knowledge scores were recorded and analysed.

RESULTS AND DISCUSSIONS

The results of the study are discussed below:

Knowledge, attitude, and practice of microgreens were surveyed among the selected subjects. Knowledge surveys depict what is known about microgreens; attitude portrays beliefs about microgreens and their consumption; and practice denotes all the activities associated with microgreens. A well-structured interview schedule was developed, and the knowledge attitude practices (KAP) of the selected subjects, which were the Kudumbashree self-help groups, were assessed. Based on the assessment, awareness was created through live training sessions.

a. Assessment of Pre-Knowledge Attitude Practices (KAP) on Microgreens among selected subjects.

i. Background Information of Selected Subjects

The background details of the selected subjects, such as age, religion, educational qualification, socioeconomic status, occupation, family type, and marital status, were investigated.

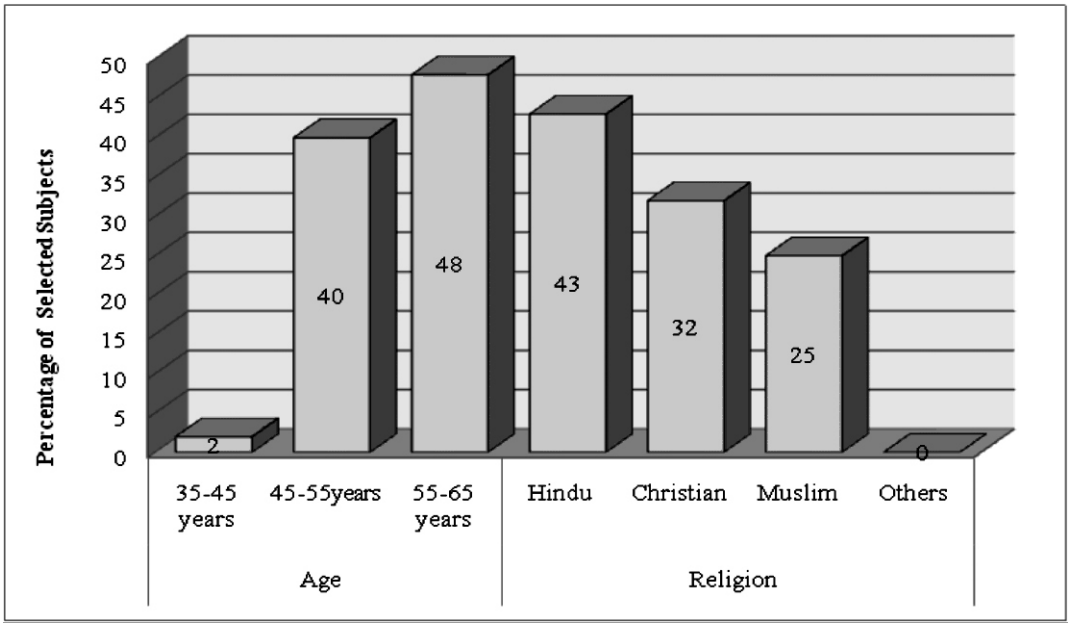


Figure 1: Age and Religion of the Selected Subjects

ii. Age and Religion of the Selected Subjects

Figure 1 projects the age group and religion of the selected subjects. The majority (48%) of the subjects belonged to the age group of 55–65 years; 40 percent of the subjects were in the age group of 45–55 years; and the least (2%) of subjects were between 35 and 45 years. In regard to religion, the majority (43%) of the subjects were Hindus, followed by Christians (32%), and Muslims (25%).

b. Educational Qualification of the Selected Subjects

Table 1 : Educational Qualification of the Selected Subjects

Degree	n = 81	Percentage (%)
SSLC	9	11
HSC	8	10
Degree	20	25
PG	12	14
Diploma	17	21
Professional courses	15	19

Table 1 presents the educational qualification of the selected subjects. Majority of the subjects had an undergraduate qualification (25%). About 11 percent of the subjects had minimal qualification of SSLC. Another 10% had completed the Higher secondary examination/schooling.

c. Occupation of the Selected Subjects

Table II indicates the occupation of the selected subjects.

About 41 percent of the selected subjects were teachers, followed by 22 percent of homemakers. And a least percentage of 3 percent were accountants and 4 percent were farmers, which were the least among

Table 2 : Occupation of the Selected Subjects

Occupation	n = 81	Percentage (%)
Homemaker	18	22
Teacher	33	41
Accountant	2	3
Chemist	6	7
Farmer	3	4
Private Job	8	10
Cent Govt./Govt./Semi Govt.	10	13

others.

d. Socio-Economic Status of the Selected Subjects

Table III highlights the socio-economic status of the selected subjects.

Table 3 : Socio-Economic Status of the Selected Subjects

Socio-Economic Status	n = 81	Percentage (%)
Upper	17	22
Upper Middle	16	20
Lower Middle	15	18
Upper Lower	14	17
Lower	2	3

The socioeconomic states highlight the different economic categories of the selected subjects. Among the selected subjects, 22 percent belonged to the upper class, which was the major category among the others. Further, 20 percent and 18 percent belonged to the upper middle and lower middle classes, respectively. Minor percentage populations of 3 percent belong to the lower class.

e. Type of Family of the Selected Subjects

Table 4 depicts the type of family of the selected subjects.

Table 4 : Type of Family of the Selected Subjects

Family Type	n = 81	Percentage (%)
Joint	6	7
Nuclear	75	93
Extended	0	0

The majority of the subjects belonged to the nuclear family (93%), and none of the subjects belonged to the extended family. A minimum of 7 percent of subjects lived as a joint family.

f. Food Frequency Pattern of the Selected Subjects

Table V shows the food frequency pattern of the selected subjects.

Table 5 : Food Frequency Pattern of the Selected Subjects (n=81)

Food Groups	Frequency of Consumption									
	Daily (N)	Daily (%)	Weekly (N)	Weekly (%)	Fort-nightly (N)	Fort-Nightly (%)	Monthly (N)	Monthly (%)	Never (N)	Never (%)
- Cereals and grains	81	100	0	0	0	0	0	0	0	0
- Pulses and legumes	81	100	0	0	0	0	0	0	0	0
- Milk and milk products	74	91.35	7	8.64	0	0	0	0	0	0
- Roots and Tubers	67	82.71	4	4.93	3	3.70	5	6.17	2	2.46
- Green Leafy Vegetables	81	100	0	0	0	0	0	0	0	0
- Fruits	78	96.29	12	14.81	1	1.23	0	0	0	0
- Meat ,Egg and Poultry	71	87.65	3	3.70	4	4.93	1	1.23	2	2.46
- Spices and Condiments	81	100	0	0	0	0	0	0	0	0
- Nuts and Oil Seeds	81	100	0	0	0	0	0	0	0	0

Cereals, grains, pulses, legumes, vegetables, green leafy vegetables, spices, condiments, nuts, and oil seeds were consumed by all the subjects on a daily basis. The other food groups, such as milk and milk products, roots and tubers, fruits, meat, eggs, and poultry, were also consumed daily by the majority of the selected subjects in comparison with other food groups. Fruits were consumed more than other foods on a weekly basis. About 2.46 percent of the subjects claim they never consume roots, tubers, meat, eggs, or poultry.

g. Assessment of Knowledge on Microgreens

Table 6 depicts knowledge on microgreens among the selected subjects.

Table 6 : Knowledge on Microgreens among Selected Subjects (n=81)

Knowledge on Microgreens	Aware / Yes (%)	Not Aware /No (%)
Knowledge about microgreen seeds	5	95
Knowledge on microgreen seeds availability for sales	5	95
Knowledge on micronutrients present in microgreens	3	97
The subject is a Microgreen consumer	5	95
The subject likes the taste of microgreens	2	98
Awareness on health benefits of microgreens	4	96
Knowledge on growth media of microgreens	5	95
Awareness on shelf life of the microgreens	0	100

Most of the selected subjects had no knowledge of microgreens. 95 percent of the subjects were not aware of microgreen seed, their availability for sales, or the growth media of microgreens, and it is not surprising that they were also not consumers of microgreens. Only 3 per cent were aware that microgreens are rich in micronutrients, and only 2 percent of the subjects claimed that they liked the taste of microgreens. The majority (96%) of the subjects were not aware of the health benefits of microgreens. None of the selected participants had awareness of the

Table 7 : Knowledge Level on Microgreens among the Selected Subjects (n=81)

Criteria	Knowledge on Microgreens	Frequency (f)	Percentage (%)
Knowledge on microgreens	I am very aware of microgreens	4	5
	I am somewhat aware	0	0
	I have no awareness of microgreens	77	95
Knowledge regarding microgreens	It is a leaf	6	7
	It is a sprout	25	32
	It is a small plant	26	33
	Something like vegetables	8	10
	Don't know	15	18
Benefits of microgreens	It can be used as food	34	43
	It is good for health	2	3
	It is easy to grow	4	5
	I don't find any benefits	40	49

shelf life of the microgreens. Hence, creating awareness about microgreens is very essential.

Knowledge Level on Microgreens among the Selected Subjects

Majority (74%) of the subjects had no awareness on microgreens and only 5 percent of the subjects were very much aware about microgreens. The exact Knowledge regarding what a microgreen is was also collected. Maximum of the subjects claim it's a plant (33%) followed by subjects who claim it as a sprout (32%). About 18 percent of the subjects do not know what microgreens are. Knowledge on the benefits of microgreens was also investigated. Most of the participants (40%) claim that they don't find any benefits in microgreens. About 43 percent of the subjects reported that, It can be used as food.

ii. Microgreen Cultivation, Purchase and Nutritional Prospects Awareness among Selected Subjects

Table 8 shows the Awareness on Microgreens among Selected Subjects.

Table 8 : Microgreen Cultivation, Purchase and Nutritional Prospects Awareness among Selected Subjects (n=81)

Information regarding greens		Frequency (f)	Percentage (%)
Types of microgreen seeds commonly used for cultivation	Fenugreek	0	0
	Mustard	3	4
Place where microgreen seeds were purchased	Online shopping site	4	5
	Nursery	0	0
	Seed Sellers	0	0
Nutrients present in microgreens	Carbohydrate and protein	2	3
	Vitamins	0	0
	Vitamins and minerals	0	0
	Don't know	0	0

From the table 8 it is clear that majority of the subjects had no awareness about microgreens. The subjects had nil or very less knowledge on microgreen cultivation, place of purchase and nutrients present in microgreens.

iii. Knowledge on Microgreen Cultivation Methods among Selected Subjects

Table 9 depicts the Knowledge on Microgreen Cultivation Methods among Selected Subjects who cultivate microgreens. The table portrays that the subjects had none or very less knowledge on microgreen cultivation methods. About four percent of the selected subjects opined that coco peat is the suitable medium for the growth of microgreens. Only four percent of the subjects recommended plastic containers for the growth of microgreens. Five of the subjects used just watering for the growth of microgreens and five of the microgreen cultivators had grown the microgreens in their kitchen itself.

iv. Attitude towards Adoption of Microgreens

Among the selected subjects, the majority (91%) strongly agree that microgreen farming is complex; 4 percent agree; 1 percent neither agree nor disagree; 2 percent disagree; and 2 percent strongly disagree. About 87 percent of the subjects strongly agree that without using chemicals, high pest infections may occur. 21 percent of the subjects strongly agree that information on microgreens is very difficult.

Table 9 : Knowledge on Microgreen Cultivation Methods among Selected Subjects.

(n=81)

Knowledge on Microgreen Cultivation Methods		Frequency (f)	Percentage (%)
Medium found to be suitable for the growth of microgreens	Coco-peat	5	4
	Normal Soil	0	0
	Soil+ kitchen waste	0	0
	Soil+ kitchen waste + Cocopeat	0	0
	Hydroponics	0	0
	Vermicompost	0	0
Type of containers used for cultivation of microgreens	Plastic containers	5	4
	Mudpots	0	0
	UV treated trays	0	0
	Glass pots	0	0
	Steel containers	0	0
	Used vegetable /fruit boxes	0	0
The watering methods adopted for cultivation of micro greens	Bottom watering	0	0
	Top watering	0	0
	Just watering	5	4
Environment best suited for growing microgreens	Typical environment (In Kitchen)	5	4
	Green house	0	0
	In shades	0	0

All the selected subjects strongly agree with the statements, such as governmental support for microgreen cultivation, that local consumers would not be willing to pay a high price for cultivation, and on consultations and advice regarding microgreen farming.

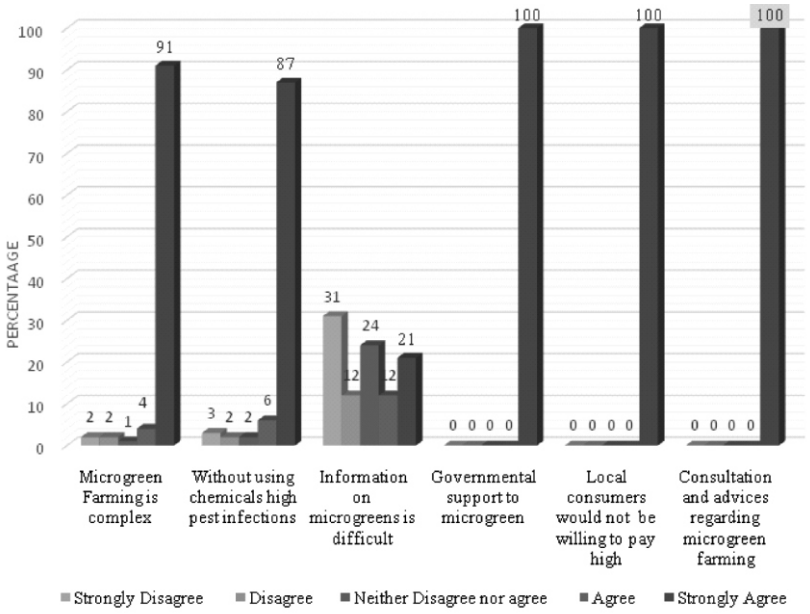


Figure 2: Attitude towards Adoption of Microgreens Farming

h. Imparting Awareness (Live Training) to Selected Subjects on Cultivation and Importance of Microgreensamong Selected Subjects

Awareness of microgreens and their relevance in the present scenario for rural and urban homemakers was raised through live training sessions. The subjects were first given an interview schedule to assess their knowledge regarding microgreens. After the awareness session, an interview schedule was also given to the same subjects to assess their knowledge and feedback on the session. Before creating awareness, the knowledge assessments were done, and the scores were categorised as less than or more than 50 percent with the help of the assessment tool. The knowledge of the subjects was assessed after the session.

Figure 3 presents the scores obtained by selected subsamples before the awareness creation. Majority of the subjects scored 5, which is depicted as 25 percent awareness level. Among the selected subjects only one obtained the maximum score.

ii. Post Awareness Knowledge Assessment

Figure 4 depicts the post knowledge assessment of the selected subjects.

i. Pre-Awareness Knowledge Assessment

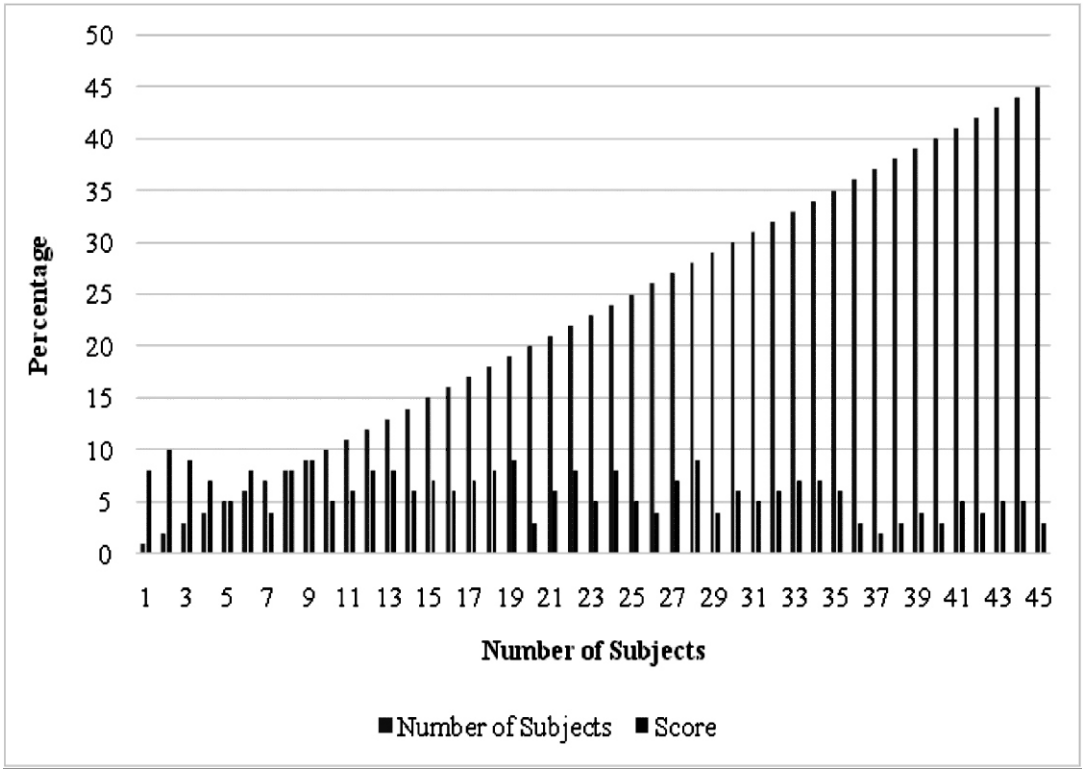


Figure 3: Pre-Awareness Knowledge Assessment

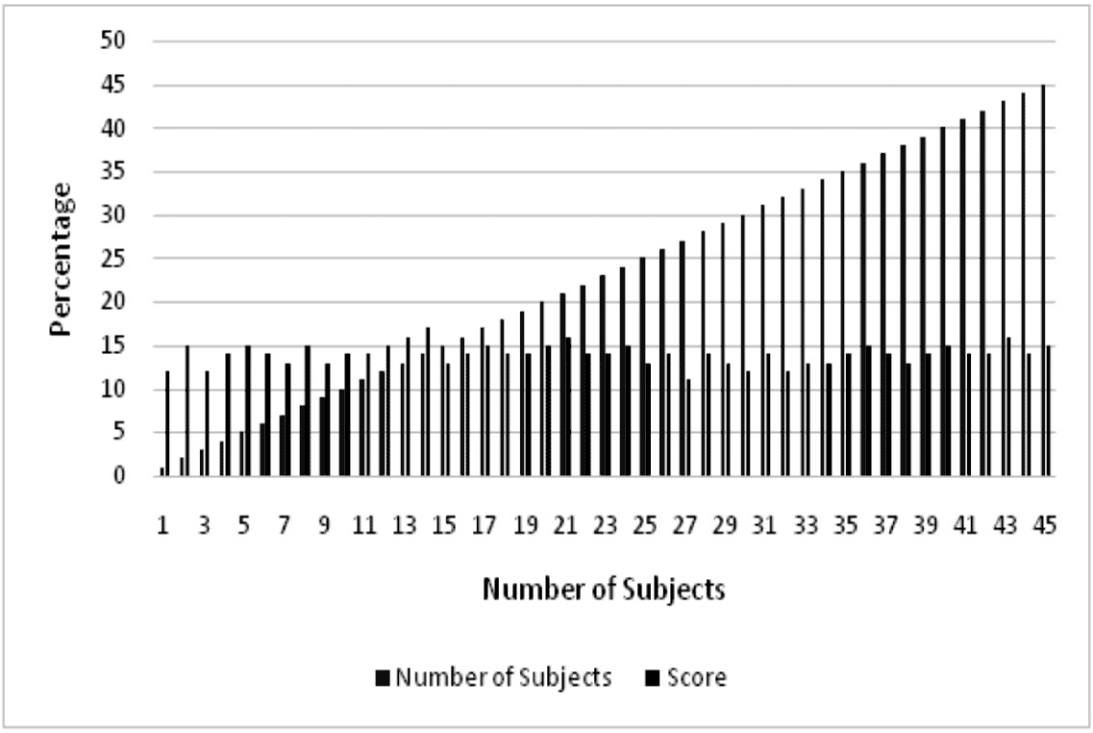


Figure 4: Post Awareness Knowledge Assessment

After the pre-assessment, awareness was given through a live training session to the selected subjects. After the creation of awareness, a post-assessment was done to determine the impact of the awareness given. The majority of subjects scored 60 percent awareness. And most of the subjects had more than fifty percent. The intervention programme conducted has positively influenced the homemakers regarding their knowledge of microgreens and growing methods for microgreens.

CONCLUSION

Microgreens, despite their advantages like minimum area required to grow, less time needed to cultivate, being highly nutritious, flavorful, etc., are still not popular among the public due to low awareness levels. On the other side, people tend to eat healthy and consume a lot of mature greens (normal green leafy vegetables). Hence, more awareness needs to be brought to the attention of the public on the advantages of microgreens to encourage them to convert from regular greens to microgreens.

It is possible for families living in a small area to cultivate adequate microgreens for their family needs. Further large-scale cultivation is also possible. This can be converted into a profession or entrepreneurial opportunity.

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Use of Sensory Evaluation as a Tool for Determining Supplementation Dose of *Jungle Jalebi* (*Pithecellobium Dulce*) Fruit Powder (JJFP) to Type-2 Diabetic Patients

Kachhawa K.*[1], Lakhawat S.[2], Manju[3]

[1&3]Department of Home Science, University of Rajasthan, Jaipur, Rajasthan. India
[2]Department of Food Science and Nutrition, CCAS, MPUAT, Udaipur, Rajasthan, India
*Email : kavitakachhawa0@gmail.com

ABSTRACT

In human interventions, the supplementation dose of any therapeutic food formulations is primarily determined based on body weight and the supportive evidence provided in the review of the literature. The long-term consumption of such newly designed therapeutic food formulations mostly depends on their sensory parameters, the amount of edible dose, and the associated body response of the individual. In traditional Indian wisdom, the use of *Jungle Jalebi* (*Pithecellobium dulce*) fruits as a potential hypoglycemic agent is well established and also proved by several pharmacological analysis animal model studies. But there is still a paucity of scientific evidence for human trials in the treatment of type 2 diabetes. Thus, in this study, sensory evaluation was used to determine the dose *of Jungle Jalebi* fruit powder (JJFP) for long-term supplementation in type 2 diabetes. The findings of the present study suggest that, on the basis of the responses to the questionnaire, a judicious dose for long-term human supplementation can be determined, which can be taken by respondents with ease.

Key words: Dose determination, Therapeutic food formulations, Sensory evaluation

INTRODUCTION

Pithecellobium dulce (*Jungle Jalebi*) fruits have immense therapeutic potential due to the presence of several phytonutrients and active pharmacological agents. It is a very well-known hypoglycemic agent in Indian pharmacopeia, but its uses are still limited due to localized cultivation and consumption (Sharma and Mehta,2013). Along with the traditional wisdom of India, several pharmacological analyses and animal modal studies also prove that the *Jungle Jalebi* (*Pithecellobium dulce*)fruits can be used as an effective hypoglycaemic agent (Pradeepa and Mohan*.,* 2013; Raju and Jagdeeshwar, 2014; Sukantha*et al.,* 2016). In animal model studies, the suggested effective doses for supplementation were 100, 200, and 300mg/kg body weight as minimum, mild and maximum doses, respectively (Megala and Geetha, 2012). The processing of Jungle *Jalebi* (*Pithecellobium dulce*) fruits in effective food formulations (sundried food powder) may act as a cost-effective and suitable therapeutic tool for human supplementation due to its short fruiting season (April-June). However, there is still a paucity or lack of scientific evidence to assess the effective supplementation dose

of *Jungle Jalebi* (*Pithecellobium dulce)* fruit as an effective agent to treat diabetes in humans.

In human interventions, the determination of the supplementation dose of any therapeutic plant food supplements is primarily based on body weight and the supportive evidence provided in the review of the literature (Floyd *et al*., 2022). Although the long-term consumption of such formulations mostly depends on their sensory parameters, the design of food powders requires a study of their sensory parameters so that their overall acceptability can be determined on the basis of certain organoleptic properties and their mouthfeel. Along with sensory evaluation, the amount of edible dose also requires assessment of any changes felt in digestion, body response, and behaviour after consumption of the newly designed therapeutic food formulations. Assessment of all these parameters before the supplementation of any therapeutic food formulations may provide certainty for their long-term consumption. The amount of the daily supplementation dose must be judiciously decided on the basis of responses given by trained or semi-trained professionals and the participants of the study. Thus, this study was planned to use sensory evaluation as a tool for determining the effective dose of JJFP for long-term supplementation in type-2 diabetics.

MATERIALS AND METHODS

Development of Jungle Jalebi fruit powder (JJFP)

The raw fruits of *Jungle Jalebi* were purchased from the local market of Udaipur city and processed to develop *Jungle Jalebi* fruit powder (JJFP) by using pre-standardized methods given by Shukla (2018) and Joshi and Joshi (2019) or their modifications as per need.

Dose determination by sensory evaluation

To determine the dose for long-term supplementation, a structured questionnaire was designed to obtain information on the various sensory aspects of the developed JJFP as follows:

Organoleptic properties: Information related to the organoleptic properties of the developed JJFP, such as colour, flavour, texture, aroma, taste, and overall acceptability was obtained by using a nine-point hedonic rating scale (ISO, 1987). The respondents were asked to fill the following information immediately after consumption of JJFP.

***Mouth and throat feel*:** The participants were also asked to respond about their mouthfeel and throat feel (after two hours of consumption). Mouthfeel included multiple oral sensations like tongue feel, chewability, tongue movement, temperature, wetness, chemical, and after-feel of mouth after consumption (Agorastos *et al*., 2020).

***Changes in digestion, body response, and behaviour*:** To know the side effects of powder supplementation, changes in digestion, body response, and behaviour were also asked in the questionnaire after one day of consumption of the powder.

***Dose determination*:** The respondents were also asked about the amount of JJFP (dose) that can be taken in a single instance or for regular consumption for three months as a functional food powder.

Selection of panel members : The present

study was ethically approved by the Institutional Ethical Committee, MPUAT, Udaipur. And informed consent was obtained from the participants before providing the supplementation dose to them.

The sensory evaluation of the developed JJFP powder done by two groups was designed as follows:

Group I: ***Semi-Trained Panel:*** A panel of fifteen semi-trained individuals was selected from the students and staff members of the College of Community and Applied Science (CCAS), MPUAT, Udaipur. During the selection of panel members, their willingness, knowledge, experience, and sincerity were also considered.

Group II : Diabetic ***Group:*** Fifteen diabetic individuals were selected purposively and were asked to take the developed JJFP powder to assess the feasibility of supplementation.

After considering a review of the literature and the varied body weights of humans, it was decided that 20 g of JJFP powder would be given to each participant. The developed JJFP powder (two ziplock pouches containing 10 g of powder in each packet *i.e.*, 20 g in total) was given to each participant in both groups. They were asked to take the amount of powder as per their convenience and ease and fill out the above-structured questionnaire.

RESULTS AND DISCUSSION

SENSORY EVALUATION

The sensory evaluation of the developed JJFP in terms of organoleptic properties, mouthfeel properties, and dose determination was done by an equal number of normal (N_1=15) and diabetic (N_2=15) individuals aged between 25 to 63 years with an approximately equal distribution of gender.

Organoleptic properties

The mean score of organoleptic properties of developed JJFP powder given by normal and diabetic individuals is presented in Table No. 1. The mean scores of organoleptic properties obtained from diabetic and non-diabetic (normal) individuals showed similar scores with non-significant difference. The obtained mean score for colour, flavour and taste given by both diabetics and non-diabetics is ≥8, corresponding to liked very much. The observed characteristics of the developed JJFP showed a pink-red colour with caramel like flavour and slight sweet taste. The mean score for aroma of developed JJFP is high in diabetics (8.13±1.06) and better than non-diabetics individuals (7.87±1.30) which is in between of liked moderately and very much liked and observed as pleasant. The granular and fibrous texture of the developed JJFP powder showed the lowest mean score for both diabetics (7.87±1.25) and non-diabetics (7.47±1.13) among all the sensory parameters, but it was still in the category of being liked very much. The overall acceptability of the developed JJFP powder was higher in diabetic group (8.47±0.92) as compared to non-diabetic patients (8.13±1.25). Similar to present study, Rao *et al*., (2011) also developed powder from both white and red aryls of *Pithecellobium dulce* fruit and found their excellent acceptability with scores more than eight in sensory parameters such as acceptability, colour, flavour, taste and overall quality.

Table 1: Organoleptic properties of developed JJFP

S. No.	Sensory Parameters	Score by non-diabetics (N1=15)	Scores by diabetic (N2=15)	p value
1	Colour	8.13±0.92	8.33±0.90	0.28NS
2	Flavour	8.13±1.13	8.00±0.93	0.73 NS
3	Texture	7.47±1.13	7.87±1.25	0.36 NS
4	Aroma	7.87±1.30	8.13±1.06	0.54 NS
5	Taste	8.13±1.41	8.47±1.06	0.47 NS
6	Overall acceptability	8.13±1.25	8.47±0.92	0.41 NS

Values are given as Mean ± SD

p value is calculated between score by non-diabetics and diabetics

NS Non-significant

Mouthfeel Properties

The mouthfeel properties of developed JJFP powder reported by normal and diabetic individuals are presented in Table No. 2. For all the mouthfeel parameters, there is a non-significant difference between the responses of diabetic and non-diabetic individuals, except for wetness of the mouth. A significant difference ($p \leq 0.05$) was observed for the wetness of the mouth after eating the JJFP, as diabetics reported normal wetness in the mouth while non-diabetics said they observed no change in their mouth wetness.

A similar number of diabetic and non-diabetic individuals, i.e., 86.66%, reported easy chewability of the developed JJFP powder. More than 50% of participants reported a smooth tongue feel in both the diabetic and non-diabetic groups. During tongue movement, stickiness on the tongue and pasty consistency were reported more in the non-diabetic group (46.67 and 73.33%) as compared to the diabetic group (26.66 and 40%), respectively. In chemical reactions, more than 70% of participants reported no reaction, while the remaining reported a slightly astringent or burning sensation in the mouth. A similar proportion of non-diabetic individuals, i.e., 40%, reported a clean and dry mouthfeel after eating JJFP powder. In diabetics, 80% of respondents reported clean or no mouthfeel after eating JJFP powder. The felt temperature in the mouth was normal for 96.67% of non-diabetic individuals, while 100% of diabetic participants reported a normal or no change in the temperature of the mouth after eating JJFP powder. A total of 60% of non-diabetic individuals reported no change in wetness of mouth, followed by dry (26.67%) or normal (13.33%). In diabetics, approximately a similar proportion of individuals reported normal (53.33%) and dry mouth (46.67%) after eating JJFP powder. Thus, the mouthfeel parameters of the developed JJFP powder are characterized by easy chewability, pasty consistency in the mouth, which tends to stick to teeth, and a slow tongue movement with normal or no change in mouth temperature and wetness followed by a normal and dry afterfeel.

Table 2: Mouthfeel parameters of developed JJFP

S. No.	Mouthfeel parameters	Parameters				Yates *p* value
1.	Chewability	Easy	Average	Hard	None	0.91 NS
	Non diabetics % (N1)	86.66 (13)	6.67 (1)	0 (0)	6.67 (1)	
	Diabetics % (N2)	86.66 (13)	6.67 (1)	6.67 (1)	0 (0)	
	Total % (N)	86.67 (26)	6.67 (2)	3.33 (1)	3.33	1)
2.	Tongue feel	Smooth	Creamy	Sticky	None	0.95 NS
	Non diabetics % (N1)	53.33 (8)	0 (0)	46.67 (7)	0 (0)	
	Diabetics % (N2)	60.00 (9)	6.67 (1)	26.66 (4)	6.67 (1)	
	Total % (N)	56.67(17)	3.33 (1)	36.67 (11)	3.33 (1)	
3.	Tongue movement	Slimy	Syrupy	Pasty	None	0.41 NS
	Non diabetics % (N1)	26.67 (4)	0 (0)	73.33 (11)	0 (0)	
	Diabetics % (N2)	26.67 (4)	13.33 (2)	40.00 (6)	20.00 (3)	
	Total % (N)	26.67 (8)	6.66 (2)	56.67 (17)	10 (3)	
4.	Chemical	Astringent	Burning	Sharp	None	0.91 NS
	Non diabetics % (N1)	13.33 (2)	13.33 (2)	0 (0)	73.34 (11)	
	Diabetics % (N2)	20.00 (3)	0 (0)	0 (0)	80.00 (12)	
	Total % (N)	16.67 (5)	6.66 (2)	0 (0)	76.67	(24)
5.	After feel	Clean	dry	Lingering	None	0.33 NS
	Non diabetics % (N1)	40.00 (6)	40.00 (6)	6.67 (1)	13.33 (2)	
	Diabetics % (N2)	33.33 (5)	13.33 (2)	6.67 (1)	46.67 (7)	
	Total % (N)	36.67 (11)	26.67 (8)	6.66 (2)	30 (9)	
6.	Temperature	Warm	Normal	Cold	None	0.10 NS
	Non diabetics % (N1)	6.67 (1)	96.67 (14)	0 (0)	0 (0)	
	Diabetics % (N2)	0 (0)	53.33 (8)	0 (0)	46.67 (7)	
	Total % (N)	3.33 (1)	73.34 (22)	0 (0)	23.33 (7)	
7.	Wetness	Wet	Normal	Dry	None	0.02*
	Non diabetics % (N1)	0 (0)	13.33 (2)	26.67 (4)	60.00 (9)	
	Diabetics % (N2)	0 (0)	53.33 (8)	46.67 (7)	0 (0)	
	Total % (N)	0 (0)	33.33 (10)	36.67 (11)	30 (9)	

Values are given as % (with corresponding number of frequency)
*Significant at 1% level of significance
p value is calculated between score by non-diabetics and diabetics
NS Non-significant

Dose determination

The suitability of the developed JJFP powder as a daily dose was ascertained by certain responses reported by normal and diabetic individuals and is presented in Table No. III. There was a non-significant difference between all the responses given by non-diabetics and diabetics for the dose ascertainment of JJFP. A total of 85% of individuals in both diabetic and non-diabetic groups easily consumed only one packet, i.e., 10g. A similar number of diabetic and non-diabetic individuals reported easy swallowing (93.33%), no throat irritability (100%), and a clean bowl (93.33%) after one day of taking the developed JJFP powder. To easily take the developed JJFP powder, water is recommended by both the

non-diabetic (33.33%) and diabetic groups (20%). All the respondents, both diabetics and non-diabetics, reported no change in behavior or body response after consuming the JJFP powder. Thus, it can be ascertained that the JJFP powder is safe to intake, and its acceptable dose for long-term supplementation is 10 g/day on the basis of the sensory evaluation tool. All the respondents also agreed to take 10 grams of dose for a period of three months of supplementation.

Table No. 3: Dose determination of JJFP powder

Parameters	Response	Non-Diabetics % (N1)	Diabetics % (N2)	Total	*p* value
Easy to swallow	Yes	93.33 (14)	93.33 (14)	93.33 (28)	0.46 NS
	No	6.67 (1)	6.67 (1)	6.67 (2)	
Throat irritability	Yes	0 (0)	0 (0)	0 (0)	0.86 NS
	No	100 (15)	100 (15)	100 (30)	
Clean bowl	Yes	93.33 (14)	93.33 (14)	93.33 (30)	0.46 NS
	No	6.67 (1)	6.67 (1)	6.67 (2)	
Edible Quantity	Yes	86.67 (13)	93.33 (14)	90 (27)	1 NS
of JJFP (10g)	No	13.33 (2)	6.67 (1)	10 (3)	
Need anything along	Yes	33.33 (5)	20.00 (3)	26.67 (8)	0.68 NS
with JJFP like water	No	66.67 (10)	80.00 (12)	73.33 (22)	

Values are given as % (with corresponding number of frequency)
p value is calculated between score by non-diabetics and diabetics
NS Non-significant

CONCLUSION

Thus, from the findings of the present study, it is clear that the developed JJFP powder has high organoleptic properties in terms of color, flavor, texture, aroma, taste, and overall acceptability, which mostly corresponds to liking it very much. The mouthfeel parameters of the developed JJFP powder are characterized by easy chewability, a pasty consistency in the mouth that tends to stick to teeth and the tongue, indicating slow tongue movement with normal or no change in mouth temperature, and wetness followed by a normal and dry after feel. A dose of 10 g of JJFP powder was easy to swallow without any throat irritation, and it may be taken with water if there is any problem in swallowing. The non-significant difference in sensory evaluation parameters of the developed JJFP for both diabetic and non-diabetic individuals ascertain its ease of use and high acceptability in both groups. Thus, the dose for supplementation was ascertained as 10 g/day on the basis of the developed sensory evaluation tool. Thus, the supplementation of any therapeutic food formulations for humans and dose determination by sensory evaluation tools may determine their feasibility for long-term consumption.

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Woman Entrepreneurship Research in India: Classifications and Scope

Mahajan A. *[1] and Jain S.[2]

[1]Prestige institute of management and research, Indore.
[2]ASPEE College of Nutrition and Community Science, S.D. Agricultural University, S.K. Nagar
Email : Research2205@gmail.com,

ABSTRACT

Analyzing the literature in the past two decades about the women entrepreneurs in developing economies like India present a complex yet interesting study context. The earlier studies largely focused on showcasing the limitations or constraints in doing research while the newer ones (those conducted in the recent years) present more scope than limitations. The purpose of this study is to classify some of the major studies conducted in the domain of women entrepreneurs in India. In the light of the limitations mentioned by various authors, we analyzed some possible scope that can fit in a research context in the present scenario. Based on this selected review, we also tried to set a theme for the scattered topics in a holistic framework by identifying five major research areas of women entrepreneurship in India and classified this study accordingly in the five sections. These are the sections related to study conducted using secondary data, informal economy, socio-cultural aspects, growth intention and measuring business performance specific to Indian women entrepreneurs. We suggest that most of the past studies conducted about the women entrepreneurship in India revolve around these five sections. While studies related to informal economy and socio – culture aspects have been studied largely as a constrain for women entrepreneurship while there is scarcity of studies for analyzing the intention to business performance and its measurement in relation to their competency. This study may prove useful to the readers and researchers looking for a systematic piece of literature on women entrepreneurship research in Indian context. Future researchers in this domain can channelize their focus in the direction suggested through classification of the studies, as the possible scope of future research has been discussed in each section.

Key Words: Women entrepreneurs, Indian women entrepreneurs, Female entrepreneurship research

INTRODUCTION

A simple definition of an entrepreneur is "one who starts a business venture, assume and manage the risk thereby earn profit" (Mitton, 1989). In the research context, entrepreneurship is a complex field of study as it involves multi-dimensional constructs (Ireland, Webb and Coombs, 2005). Different authors define the phenomenon of entrepreneurship in different ways (Zahra, Jennings and Kuratko, 1990). Terms such as strategy, corporate entrepreneurship and venture creation are often used interchangeably with entrepreneurship (Sharma and Chrisman, 1999). The traces of entrepreneurship can be found in various subjects and research domains such as

Sociology, Psychology, Economics and Management. Psychologists define an entrepreneur as one who possesses distinctive personality traits (McClelland, 1965, 1987); economists mentioned the unique role entrepreneur exhibits as an innovator in the new market creation (Schumpeter, 1934). In view of this, some dimensions of entrepreneurship as per different subjects of study are given in Table 1.

Table 1 - Entrepreneurship link with various knowledge fields

Subject	Link with Entrepreneurship
Sociology	Social entrepreneurship. Women empowerment and gender issues in entrepreneurship.
Psychology	Traits and characteristics of entrepreneur such as - need for achievement, persistence, risk - taking and locus of control
Economics	MSME and its contribution to economy, Organized and unorganized business activities, Informal economy
Management	Strategy and innovation in business by entrepreneurs Study about start-ups, venture funding.

Source: Author's compilation.

Despite the convergence of various subjects, entrepreneurship itself is a separate field of research and at the same time there lays a vast scope to research through various dimensions as mentioned in table1.

The subject becomes all the more interesting when it is studied from gender perspective. Considering role of gender as one of the influencing aspects in entrepreneurship, Welter *et al.* (2007) discussed women entrepreneurship in transition economy context. The authors found that though many similarities exist between male and female entrepreneurs as far as businesses are concerned but differences do exist when it comes down to choosing business sectors and performances of businesses.

Suganthi (2009) defines women entrepreneurs as, "When a woman or group of women initiate, organize and manage a business enterprise, they are called as women entrepreneurs". While the Government of India (2012) define them as women who owns minimum 51 percent of the capital invested in the business firm. This definition is applicable for a registered business unit and the informal business enterprises are defined differently by different authors. Unlike defining the terms, many authors mentioned the limitations for the clarity of defining the term entrepreneurship and the construct used in the research (Gartner, 1990; Shane and Venkatraman, 2000). While the limitations of women entrepreneurship research seem more challenging in developing nations. The available literate on Indian women entrepreneurshipis scattered and lack classification in terms of research areas.

The present study conducts the selected literature reviews of research studies conducted on the topic Indian women entrepreneurs. To identify and analyzing the relevant papers and specific women entrepreneurship literature, journals specific to entrepreneurship were primarily referred to. Databases such as EBSCO, ProQUEST, Web of science, Emerald

Publishing and SAGE publications were explored. All these database and journals were searched using search phrases women entrepreneur, women entrepreneurship, women entrepreneurs in emerging economies, women entrepreneurship in India, Indian women entrepreneurs, rural entrepreneurship in India. Since, there is limited number of authentic studies in the Indian context, we follow manual selection process for review.

Related articles were identified after reviewing their abstracts followed by full text reviews pertinent to the subject of interest. The selected papers in the literature were analyzed and tabulated according to the research topics. The tables of the streams provide an overview that is related to present work. Our aim here was to relatively position these studies in the classified manner. A total of 112 papers were analyzed through abstract and initial reading, out of which 44 papers were finalized for the review.

The classified review in the present study is described in five sections. The first section discusses the research on women entrepreneurs based on the secondary data which is limited due to prevailing un-registered/informal micro business units in the country. Although, it provides an initial draft for understanding the basic demographical distribution of women entrepreneurs in the country.

Second section discusses the dominating literature in social-cultural aspects of research in the context of women entrepreneurs, third section includes the analysis of studies posited on the informal economy that largely influences the women entrepreneurship in India. The last two sections cover the studies focusing on the intention of women to become an entrepreneur and their business growth aspiration. Many of these studies were conducted using primary data survey. The last section summarized the issues related to conducting empirical studies in measuring the business performance of women entrepreneurs. The classification provides ample scope to defend the research limitations in this area. Finally, the discussion part summarizes the study.

The motivation to conduct this study through a revised literature review evolved from comparing the contemporary business scenario with the time when these studies were conducted, since advancement in technology for doing businesses in present time is much easier than past. Further, revised government 's policy in favor of women entrepreneurs, changing outlook of society about the women entrepreneurs and women's own perception about it provide considerable reasons to revise such studies and look at the future scope of these studies to get updated results and insights.

Section - 1: Research based on the secondary data

A genuine understanding of the demographic profile of Indian women entrepreneurs is essential to begin and find the scope of the research. Various authors (such as Jha, Makkad and Mittal, 2017) have reported the limitations of authentic secondary data to conduct the research on women entrepreneurs in India, further lack of authentic data about the women entrepreneurs is a challenge to set a theme or have a deeper look inside the domain, being an informal economy at large, this challenge is common in various developing nations (Vita, Mari, & Poggesi, 2014). While most of the micro enterprises are not registered and not easily accessible in India, many authors mention the limitation of obtaining and analyzing the data of

women entrepreneurs for research in India. This limitation has been well overruled by the classified studies of Daymard (2015), Agrawal and Lenka (2017) and Samantroy and Tomar (2018). These authors incorporated the main sources of secondary data of enterprises published by the government agencies of India which are -

The Economic Census

The National Sample Survey (NSSO) socio- economic surveys (NSS)

Annual Survey of Industries (ASI)

ASI provides survey data operating in the organized sector without the classification of gender owned enterprises. While NSSO provides comprehensive sets of the data of enterprises operating in the informal sectors with classifications of men and women owned enterprises.

The study of Samantroy and Tomar (2018) presented the demographic distribution of the women entrepreneurs in India based on the data published by the fifth and sixth economic census (2005 and 2013) and NSSO**.** Data based on the entrepreneurial activities of women in various states of India provide an excellent platform to understand the roots of the studies about the women engaged in work force. The highlights of the study are presented in Table 2.

Table 2. Establishments and workers engaged in total proprietary and women-owned establishments during the 5th and 6th ECs

Type of Establishments	Total Establishments (Million)		Est. with Workers Engaged (Million)	
	5th EC (2005)	6th EC (2013)	5th EC (2005)	6th EC (2013)
Total proprietary	37.34	52.29	77.92	103.06
Women-owned	3.54 (9.50%)	8.05 (15.40%)	6.05 (7.77%)	13.45 (13.05%)

Source: Samantroy and Tomar (2018), Calculated from unit level data published in Economic Census - 2005 & 2013.

It can be inferred from the table 2 that during sixth economic census (2013), there were total 52.29 million establishments under the proprietary firm, of which women owned only 8 million (approx. 15.4 percent) and these women owned proprietary consisted of 83 percent without any hired worker that is the business was run on own account with working herself or with family members. Further, status of top five Indian states in respect of women owned businesses is given in Table 3.

Table 3 - Top five states in India with highest percentage of women's own businesses

Top 5	Economic Census - 2013		Economic Census - 2005	
states	State	% of women enterprises	State	% of women Enterprises
1	Tamil Nadu	13. 50	Kerala	18.51
2	Kerala	11.37	Tamil Nadu	17.80
3	Andhra Pradesh	10.55	Gujarat	12.48
4	West Bengal	10.4	Andhra Pradesh	10.10
5	Maharashtra	8.25	Karnataka	9.58

Source: Samantroy and Tomar (2018), Calculated from unit level data published in Economic Census - 2005 & 2013.

Scope for future research - State wise distributions of women entrepreneurs offer various avenues for further research in this domain. For example, a genuine enquiry about why these five states (Table -3) contributes high in the density of women enterprises and what are the causes of the states showing the lowest (such as Punjab) in the ranking. Is it the psychological, social and cultural or business environment in these states that make it a challenge for women to become self-reliant?

Selecting a sample frame in such a heterogeneous population with extreme variations in demographic variables under the strong influence of informal economy is further a limitation of conducting research. But many authors attempted to overcome this limitation.

Agrawal and Lenka (2017) in their paper titled "Why research is needed in women entrepreneurship in India", set a justified theme based on the secondary data analysis and literature review with focus on two states of India namely Uttar Pradesh and Uttarakhand. The title of this study itself indicates the research demand in this domain. Various policies and practices implemented by the government of India have been presented with existing gaps. The study provides a historical growth of women's business activities from traditional food processing such as pickles(Achaar) and Papad to modern world service enterprises. As all the women engaged in the economic activities cannot be referred as entrepreneurs, since many of them work as a part of livelihood strategy, they are referred as necessity driven entrepreneurs (Unni and Naik, 2018) while there is a different set of women that fall in the category of growth oriented and opportunity - oriented entrepreneurs which are very low in India (Unni and Naik, 2018; Khokhar and Singh, 2016).

Based on the different characteristics of women entrepreneurs, Mitra's (2002) attempt to classify the women entrepreneurs in four categories i.e., family oriented, young achiever, financial need and block factor, is appreciable in this regard. The study by Daymard(2015) classified the women entrepreneurs' population in the self-employed (without hire workers) and women entrepreneur (with hired workers) and provide state wise distribution. His claim to this distinction is crucial to look into the deeper aspects of the dynamic of women entrepreneurship research in the Indian context.

Deshpande and Sharma (2013) analyzed the data of the third and fourth rounds of the Indian MSME census for the year 2001-02 and 2006-07 with a specific focus on caste and gender-based enterprises in India. They segregated the data of enterprises run and owned by schedule caste (SC and Dalits), schedule tribes (ST as marginalized groups of Adivasi), and women in India and reveal a different angle of research in entrepreneurship. Data of sectoral division of male and female owned enterprises of these populations can be the scope for further look in the research as mentioned by the authors.

In all, this study concludes that despite the huge efforts by governments through various policies and planning, women entrepreneurship still deserves more focused research attention in existing contexts (Agrawal and Lenka, 2017).

Tiwari (2017) summarized the various policies implemented by the Government of India for the development of

Table 4 - Summary of the studies on women entrepreneurship based on the secondary data

Author (year)	Data Source	Subject	Main Findings
Unni and Naik (2018)	Economic Census (EC) and NSSO*	Gender Differences and Informal Enterprises in India	Both Necessity driven and Growth oriented enterprises exist in Indian informal sector with no gender differentials in likelihood of growth.
Samantroy and Tomar (2018)	Fifth (2005) & Sixth (2013) EC, India	Distribution, Comparison and classification of women employed in various states of India as per their social (caste) environment.	Women entrepreneurship increased in sixth economic census (2013) compared to 2005 but majorly in own account enterprises (without hire workers), The percentage distribution of women enterprises in SC, ST and OBC is unevenly distributed and need to explore further.
Agrawal and Lenka (2018)	MSME (2016), Bureau, 2016; Sixth EC (2013)	Need for research in the women entrepreneurship in India	Despite the various government efforts, contribution of women enterprises is low and need deserved attention to research state-wise as well as on an aggregate mode.
Tiwari (2017)	Planning Commission of India, Sixth EC, and Literature survey	Literature Review	Various Plans, Policies and Schemes (by Government of India) for development of women is summarized and discussed with data of sixth EC
Daymard (2015)	NSSO - enterprise survey of data	Determinants of women enterprises	Basic characteristics of women entrepreneurship in India. Emphasis on distinction between women enterprises with and without workers.
Deshpande and Sharma (2013)	Registered units' data of third and fourth rounds of MSME census for 2001-02 & 2006-07	Caste and Gender Analysis in the small business units in India	North - eastern states have higher concentration of Schedule caste (SC), Schedule Tribe (ST) with high women owned entrepreneurs in this category while in other states these are under represented with dominance of traditional family business mainly for survival.

Source: Author's compilation; NSSO - National Sample Survey Organization., MSME - Micro Small and Medium Enterprises

entrepreneurship in general and that of women in specific under the various five-year planning programmes. The study exhibits the government's efforts in organized framework. But the effectiveness of these policies and programmes is yet to be explored.

These studies can be considered as the starting point for research about women entrepreneurship in India as the structure and distribution (state and sector wise) of women's economic activities provide a base for looking deeper in the field and to explore the specific part of it. Also, these studies can be taken as a reference point for understanding the big picture about the economic activities of women in India and a source to select the sample for primary research.

Section - 2 - Informal Economy - Synonym to women Entrepreneurship in Developing Nations

The major researches published in the international journals about the Indian woman entrepreneurs largely emphasize on the prevalence of the informal economy (Jha and Bag, 2018; Khokhar, 2019) Analysis of most of the literature on women entrepreneurship synonymous with informal economic activities embedded with socio-cultural context.

Informal economy is one of the dominant factors in the various developing nations. According to the National Commission for Enterprise in or unorganized sector (NCEUS, India) – "A private enterprise unincorporated (not registered with any government agency) engaged in the production of goods or in the service, sales as a proprietary firm or partnership based with employees not more than ten is termed as unorganized or informal enterprise. These enterprises do not pay taxes or other liabilities under law. Jha and Bag (2018) empirically analyzed the reasons for rigidness of transiting from informal to formal enterprise by the owner and reported various relevant causes justifying the constraints and advantage of remaining an informal enterprise.

Despite the various efforts by government, private and social organizations, women entrepreneurs are confined to micro enterprises operating informal businesses (Khokhar and Singh, 2016). Many researchers claim that the lack of growth of women entrepreneurs is associated with informal economy and the challenges associated with the informal economic activities include lack of education, access to bank or finance, socio -cultural norms and business/economic environment (Goel and Rishi, 2012). The heterogeneity of demographic factors often limits the research in this domain and provides in-consistent results (Khokhar, 2019).

Since, rural areas are more influx with the informal markets compared to urban areas, this is also seen as a positive tool for poverty alleviation (Goel and Rishi, 2012) and employment generation for under privileged people. Since the entry to such a market is easy for women with little investment, it offers employment to economically weaker sections of the society characterized by illiteracy, unemployment and poverty (Chaudhuri and Banerjee, 2007). Further, it provides less time constraints as compared to the private jobs along with easy family and work life balance (Goel and Rishi, 2012). Compared to men, women find more challenges in setting up an enterprise mainly in the rural areas. SHGs (Self – help groups) in various rural part of India seems

to be effective as a catalyst for financial and social upliftment of women (Chatterjee, Gupta and Upadhyay, 2017). The role of self- help groups as an effective approach to alleviate poverty and rural development and provides future research scope in the informal economic domain of women entrepreneurship. Similarly base of pyramid approach is promising research enquiry in the future. (Chatterjee *et al.,* 2017).

To differentiate the unorganized enterprises of women with the registered women enterprises, the study of Deshpande and Sharma (2013), show higher growth pattern of registered women entrepreneurs when compared to registered male entrepreneurs in certain areas and show more possibility for such outcomes. Such results provide opportunities to explore such studies on a large geographical spread of India. We recommend to conduct similar studies in future to compare the changes occurring due to growth of digital intervention and ease of doing business in the present business scenario.

Section - 3 - Socio - Cultural aspects of women entrepreneurship

Literature provides various psychological and social issues imposing the limitation of gender as a barrier to women entrepreneurship. Gender in general, divide the two biological sexes in the masculine (aggressive, strength, dominance) or feminine (passive, follower) as a strongly perceived aspect of the various societies (Hyde *et al.,* 2019). Various authors emphasize the influence of gender perception as a major hurdle for women to enter the main stream business and to compete in the businesses which are traditionally run by men entrepreneurs. This issue has been discussed by various authors in terms of justifying the role and image of women entrepreneurs in selecting specific business sector, choice of firm size, hiring employees etc. the perceived influence of gender consideration and social norms influence women's decision in business activities (Unni and Naik 2018).

Kantor (2002) debated the injustice in considering the gender as mere a variable instead of a socio-cultural construct; she explains that very few authors have taken it as a serious construct in women entrepreneurship research and its related aspects in comparing the role and performance of men vs women entrepreneurs.

The Development paper by Shah (2013), in collaboration with ESCAP- South and South-West Asia Office as a part of promoting women entrepreneurship and development program report that “women's entrepreneurship is an important untapped source of growth in India” as only about 13 per cent of enterprises registered in MSME sector is owned or managed by women. The study concludes that socio cultural factors are major constraints for women's entrepreneurship in India, work and family life balance as next big challenge (as reported by 65 percent women).

Section - 4 –Studies related to intention to become an entrepreneur and enterprise growth intentions

Theory of planned behavior (TPB) has been widely adopted as a reference for researching the entrepreneurial intentions among university students and aspiring entrepreneurs. Intention study in women entrepreneurship can be classified in two broad classes, one measuring the intention to become entrepreneur in the future (for female students or unemployed women)

while the other tries to analyze the growth intentions of existing women entrepreneur running micro /small business enterprise, such studies are interlinked with the performance variables.

Some authors established that women largely intend to take charge of business due to pull factors while there are studies which prove the dominance of push factors which drive out of necessity, lack of employment and to earn extra money (Moore and Buttner, 1997). We report the lack of such studies in the context of emerging scenarios of women entrepreneurship in India. The next generation or millennial might report a different outlook for opting entrepreneurial career.

At a global level, Morris et. al (2006) in their research specified the various issues and aspects about the women entrepreneurship that have been discussed since the inception of literature documented in this domain by Hisrich and Brush (1983). They concluded that limited focus is devoted to the causes that determine the growth intention and aspirations of women in business. In the Indian context such studies are limited but interlinked with the various aspects of research such as social -culture aspects and informal economy as discussed in the previous two sections.

Venugopal (2015) emphasized on the role of context in the growth intentions of Indian women entrepreneurs. The author used growth intentions as dependent variables against the attitude toward growth, subjective norms, work and family role identity and self-efficacy as independent variables. Women's self confidence in her own abilities (self - efficacy) was found to be the major hurdle in her business growth intention. The possible reasons may be the lack of education, training and exposure to business world compared to male entrepreneurs. Since the subjective norms was not found to be associated with the performance, we can interpret the changing scenario of family and society to accept the women as an entrepreneur in selected research sample frame of the study. The authors itself report the limitation of generalizing the results for vast geography of India especially for rural areas which require continuous research attentions with respect to changing society.

Literature about the women entrepreneurship of developing nations also reveals that many women willingly do not opt for the business growth and wish to confine to micro business units in order to avoid various business challenges associated with competition, legal and finance (Vita, Mari, &Poggesi, 2014) turning the research attention in yet another direction.

The study of Daymard (2015) discussed the various determinants of being a women entrepreneur in India with emphasis on education, access to finance, children, gender perceptions and social norms. These are the widely discussed determinants which determine the rate of women entrepreneurs in developing nations. The positive and negative associations of these variables with the prevailing growth rate of women entrepreneurs may provide scope to conduct similar research in the present business scenario.

Some Indian researchers tried to identify the factors that may determine the success of women entrepreneurs and so the performance of their enterprises.

Chatterjee, Das and Srivastav (2018) conducted an exploratory study covering the four states of India namely Bihar, West Bengal, Odisha and Jharkhand using the sample frame from district industry centers (DICs) of the selected cities in the mentioned state. The outcome of the study presented four distinct factors associated with the success of businesses run by women entrepreneurs. These factors are related with psychological, socio-cultural, skills and resources. The study found that micro enterprises in these states adopt the existing business models or ideas with little or no modifications; they lack the innovative bent of mind in the business. Their businesses are traditional and do not demand for technical skills for success of business. Further, the support from government counts minimal in their success measures. Although, authors of this study suggested providing education and technical training to empower these women not to grow their business but to survive in the future.

Jha *et al* (2017) explored six factors suggesting growth and success of women entrepreneurs running and managing micro enterprise in the selected cities of India. Similarly,Dhaliwal (2019) explored the causes associated with the underperformance of the women entrepreneurs in India, based on the vast literature survey, data published in the GEM, NASSCOM and economic survey of India, along with an empirical study conducted in Delhi and NCR regions. The exploratory factor analysis identified three factors namely personal orientation; knowledge base and support system largely influence the success of businesses of women. These factors are related to socio-cultural and informal economy of India, along with aspects of intention and business performance implying the inter-connected approach of the studies.

In a recent study conducted by Mahajan and Chowdhary (2022) in major Indian cities, it was found that many women opt for entrepreneurial career for utilizing their social skills with their professional qualifications. Such businesses like human resource (HR) consultancy, yoga training largely require good communications and human relations skills. Women competent in such skills usually intend to set up independent business enterprise. The competency approach in women entrepreneurship is not much explored in India, while in developed nations emphasis on enhancing the entrepreneurial competencies of women entrepreneurs is widely studied topic, since these competencies are associated with business performance (Mahajan and Chowdhary, 2022).

Section - 5 - Studies concerning to Measure the business performance of women's enterprises

Most of the studies mention the financial performance (profit, sales, revenue etc.) as a measure of business performance. But, the question arises does the success of business lies in the financial performance especially for women entrepreneurs in the context of developing nations?

Kantor (2002) debated on ignoring the success factor of gender perception associated with women entrepreneurs especially in the South Asian context. She denied accepting the economic outcomes as the only measure of success of women entrepreneurs, as for women entrepreneurship is the source of gaining

equality, empowerment and achieving work - life balance which is not the case for men being as entrepreneur. Her debate was based on the lack of sensitivity of performance analysis studies by past researchers in such cases which resulted in weak or less detailed knowledge comparing the gender differentiation. She emphasized that satisfaction, social inclusion and empowerment should be the essential parameters of measuring success along with the financial measurement for the women entrepreneurs especially in developing nations. Women's empowerment was overlooked under the economic measures like profit and sales of business. Kantor's questions on performance measurement of women owned enterprises still raise questions and provide scope to take sensitive measures in this case.

Prasad *et. al* (2013) examined the business growth of the Indian women entrepreneurs under the influence of human and social capitals, the result of the study confirms the importance of both the factors in determining the growth of women owned enterprises. While the human factors comprised of education level, previous experience and parent's business, the social capital incorporated the size of the business network and perceived support from family and immediate society. Authors admitted the limitations of measuring business performance.

In view of above, it could be concluded that specific and revised research is required to measure the business performance of women entrepreneurs while comparing it with men entrepreneurs. There is a need to develop a scale to measure the success of first-generation women entrepreneurs emerge out of social and cultural barriers and contribute to the society by employment generation and inspire other women to become an entrepreneur.

DISCUSSION

The present study contradicts that most of the studies focused on the women entrepreneurship is confined to developed nations. The authors in the present study reviewed the literature and analyzed some of the relevant studies conducted in the context of women entrepreneurship in India. A total of 44 papers focused on the research about the Indian women entrepreneurs have been analyzed by filtering 112 papers, also some conceptual review papers concerning international studies were cited to justify the relevance of women entrepreneurship at global and Indian level. Since the subject area of entrepreneurship is complex and diverse, the present study has been divided in the five sections. Although all are interconnected but provide a distinct outlook for conducting future research in the mentioned sections.

The first section discusses the research studies based on the authentic secondary data analysis. Distribution and classification of women entrepreneurs in India offer the starting point for research in this domain. The results of the studies discussed in this section are based on the analysis of authentic secondary data published by the economic census, NSSO and Annual survey of industries (ASI). Studies discussed in this section present the demographic distribution of the women entrepreneurs in India, the state wise distribution provides insights in the

research domain and offer various avenues as a scope for future research. Agrawal and Lenka (2017) in their discussion about the need for research in the domain of women entrepreneurship indicate the importance of authentic data of women entrepreneurship. Tiwari (2017) check the efficiency of the policies and programmes undertaken by government agencies to promote women entrepreneurship with the secondary data analysis. Study of Samantroy (2018) look into the cast wise distribution of women entrepreneurs while study of Deshpande and Sharma (2013) direct our attention toward the women entrepreneurs of north – eastern states of India under the categories of schedule cast (SC) and schedule tribes (ST) which is under represented in the society. The traditional business set ups in the rural areas represented by various groups of self-reliant women such as self-help groups (SHGs) need deserve research attention to promote women entrepreneurship. Despite the lack of authentic secondary data, available data provides ample opportunities to conduct research in this domain. Although, most of the women are running business in the informal business set up, their businesses are not registered as a legal entity which restrict the researcher's ability to generalize the results, this can be improved by bringing more women entrepreneurs in the front line of economic activities by converting their informal small business units into a registered business units.

Second section highlights one of the most common aspects of discussion about women entrepreneurs in emerging economies which is concern of informal economy. Since, most of the businesses owned by women in developing economies are confined to the small business unit (Vita, Mari and Poggesi, 2014), these units are informal and characterized by limited business sectors and profit earning capacity.

The major causes documented in the literature for dominance of such informal businesses include poverty and gender perceptions (Gupta, Goktan and Gunay, 2014; Brush, 2017), lack of education in the areas of business and finance (Smith and Morse, 2005; Learner and Almor, 2002), while Jha *et al* (2018) report the reasons associated with social and economic conditions in the country. Although, results are not consistent but most of them indicate nature of informal business set up as one of the dominant characteristics of women's business enterprises in the country.

Third sections present the views of Indian authors on the prevailing socio-cultural context based on the past literature reviews of cross-national studies. This has been reported as an obstacle to women entrepreneurship; we emphasize to evaluate the caused associated with such obstacles in the present business scenario. As the outlook of society changes with the time and women entrepreneurship is changing with the change outlook of society.

The fourth section discusses the findings of the empirical studies conducted to analyze the business growth intentions of the existing women entrepreneurs from micro / small business units. As, mentioned in the previous sections, most of the authors highlights the socio-cultural and informal business aspects as reasons for low business performance of women entrepreneurs, but there is need to look at the other side of the context, instead of discussing on the obstacles women faces in

doing business due to socio-culture aspects or informal set up, we need to find the ways to enhance the growth intention of the women entrepreneurs in the present business environment which is driven by digital technology. There is a dire need to improve the business performance of the existing women entrepreneurs in the country.

Few studies have been conducted to analyses the reasons for low business performance of women entrepreneurs in the Indian context, while there are studies at global level which reports many competency-based analysis as a major cause for limited business exposure of women entrepreneurs. Few of the recent studies (such as Li et al, 2016) emphasizes on the digital competency of the entrepreneurs as one of the suitable tools to scale up the small businesses and to respond to the competition. In the developing nations like India, many new avenues for creating business ventures in various sectors are emerging via digital platforms (Tandon et. al, 2020).Approx, 44 % of the start - ups in India is technology driven and run primarily on the use of e-commerce or as a B2B market process through digital platforms. Further this number will keep growing and may achieve to more than 65% in the coming time (Grant Thornton, 2016). Digital technology has changed the locus of opportunities identifications and implementations for the entrepreneurs (Autio, 2017). We do recommend to provide the required training to women entrepreneurs to enhance their digital competency relevant to business growth. Further, various social media platforms serve as a business networking platform to promote the small business but such exposure is limited to metros and urban areas.

Last section raises the question of measuring success of business run by women entrepreneurs in the developing economies, as financial indicators such as profit and sales do not justify the contribution of women entrepreneurs. Women in the developing nations symbolize the women empowerment and contribute to the society by employment generation, inspiring other women and taking lead role in the economic growth. A deserving reward and recognition to existing women entrepreneurs may inspire to young generation of female students to opt for entrepreneurial career in near future.

We tried to divide the scope of the research in the five major topics to segregate the literature and channelize the focus of research in the context of Indian women entrepreneurship. Although all are interconnected due to extreme demographic heterogeneous variables, it is hard to explain one without intervention of the other, still we attempted to classify the literature in this domain.

IMPLICATIONS AND FUTURE RESEARCH SCOPE

The study provides an inception to the women entrepreneurship research in India for the readers and budding scholars looking to understand the basics of women entrepreneurship research with associated challenges and limitations. The primary objective was to classify the literature to cover the different aspects in five sections. On the other side it discusses the scope still require deserving research attention in the various sections associated with the women entrepreneurship in the developing context. The business context has changed

vastly in the recent years and so the perception of people toward running and managing it without the consideration of gender. The scholars looking to explore the field can find the scope beyond the limitations that co-exist in the developing nations toward entrepreneurial activities. Aspiring researchers in this domain can find scope of further studies identified and mentioned in each section. The present business scenario, government policy and outlook of society is quite favorable for women entrepreneurs in India, beside women's own perception and involvement in the business provides considerable reasons to revise the past studies to gain better insights.

There are many empirical studies conducted to analyze the causes of low performance or limited business exposure of women entrepreneurs while such studies are rare in India as discussed in section four, which call for a deserved research attention in this area. Whether women especially in non-metro and rural area intentionally do not opt for business growth or they lack in certain crucial competency or institutional support? This can be the base for conducting future research. Further, more studies involving qualitative analysis such as cases studies and focus group approach can be the future research scope in analyzing the intention to become entrepreneurs of aspiring women and university female students. In section five, this study also reports the challenges of measuring the success factors or business performance of women entrepreneurs that is a relevant and crucial research agenda for future researchers.

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Chilli Growers' Brand Preference And Loyalty Towards Insecticide Companiesin Rajkot District Of Gujarat

Faldu N. V. [1], Dubey L. R.* [2], Savaliya N. G. [3] Chudasama V. R. [4] and Modi R.P.[5]

College of Agribusiness Management, S.D.A.U., Sardarkrushinagar-385506
Dist: Banaskantha (Gujarat)
*E-mail: laxmirani.d@sdau.edu.in

ABSTRACT

The study was mainly based on primary data, which were collected through personal interviews with the help of a structured survey schedule. Total of 20 dealers and 120 growers were selected for the study. The factors influencing chilli grower's brand preference towards insecticides were found to be highest with the price and quality of insecticides. Among the most popular insecticide brands, the first preference was given to Profex super of Nagarjuna Agrichem Limited. The majority of chilli growers were loyal towards dealers (80.83%) and brands (85.00%) of insecticides. Credit availability and efficiency were found the most important factors affecting the dealer loyalty and brand loyalty of chilli growers respectively. The majority of chilli growers faced major constraints in purchasing of insecticides *i.e.,* the high price of insecticide followed by the low effectiveness of insecticides. Dealers faced major constraints of competition among dealers followed by low margins. From the study it can be suggested that the insecticide companies should supply good quality insecticide at affordable price with effective field demonstrations which may attract both dealers and growers to become brand loyal and can identify the adulterations in insecticides. Companies should also keep growers updated with the latest schemes and benefits launched.

Key words: Insecticide, Brand Preference, Brand Loyalty, Dealer's Loyalty, Constraints, Garrett's ranking and Chilli, and Growers

INTRODUCTION

Pesticides are extensively used in modern agriculture and are an effective and economical way to enhance yield quality and quantity, thus ensuring food security for the ever-growing population around the globe. Approximately, 2 million tonnes of pesticides are used per annum globally, whereas China is the foremost contributing country, followed by the USA and Brazil. However, by the year 2020, global pesticide usage has been estimated to increase up to 3.5 million tonnes (Sharma *et.al.* 2019). India is the predominant exporter of pesticides to Brazil, USA and Bangladesh with quantities 1,29,942 MT, 85,577 MT and 36,618 MT respectively. Apart from fertilizers, pesticides played an important role in the green revolution during the last five decades. Indian exports of agrochemicals have shown impressive growth over the last five years (DPPQs).

The term vegetable usually refers to the

edible portions of certain herbaceous plants. These plant parts are either eaten fresh or prepared in several ways. Regular and adequate intake of different kinds of vegetables such as edible roots, stems, leaves, fruits, or seeds helps us maintain good health. On the other hand, reduced consumption of quality vegetables often causes communicable diseases including cardiovascular diseases and certain types of cancer. Vegetables are important sources of vitamins, minerals, and antioxidants providing human health benefits. Regular intake of the recommended amount of vegetables leads to sound health (Asaduzzaman and Asao, 2018). China was the leading producer with a production volume of over 600 million metric tonnes, followed by India. West Bengal is the largest state in area and production of vegetables respectively 1511.78 hectare and 30330.77 MT followed by the Uttar Pradesh, Madhya Pradesh, Bihar and Gujarat.

Chilli fruits are rich in vitamins A, C and E. In recent days, apart from its medicinal value, it has gained popularity as a vegetable and spice crop as it prevents heart attack by dilating blood vessels (Madala and Nutakki, 2020). India is the largest producer with 20.49 lakh tonnes and contributes 43.00 per cent of world chilli production, followed by Bangladesh, Thailand, China and Ethiopia during the year 2021. Andhra Pradesh was the largest chilli producer with 177.46 ha area and 796.65 MT production in year 2021 among other states across India, followed by Telangana, Madhya Pradesh, Karnataka and Orissa. Whereas Gujarat has the eighth rank in the production of chilli. Rajkot is one of the famous chilli growing district of Gujarat. Rajkot district occupies first position in terms of area and production of chilli crop. The present study aimed to analyse the insecticide brand and dealer loyalty andstudy the brand preference of chilli growers towards insecticides and constraints faced by chilli growers and dealers.

MATERIALS AND METHODS

The study was mainly based on primary data, which were collected through personal interviews with the help of a structured survey schedule. A multi-stage sampling method was adopted as an appropriate sampling procedure for the study. In the first stage, Rajkot district was purposively selected for the study. Rajkot district had 1st rank in area and production of chilli crop in overall Gujarat state. At the second stage, four talukas from Rajkot district were selected purposively *i.e.,*Gondal, Jamkandorna, Upleta and Dhoraji as these four talukas have higher areas under chilli crop cultivation. In the third stage, from each taluka, five villages were selected on the basis of a pilot survey. From each village, six chilli growers were randomly selected. The dealers were selected based on the extent of purchase of insecticides for chilli crops by the growers. Hence, a total of 20 dealers were selected to obtain the information required for the study. The percentage method was used for the analysis of brand preference and a similar method was used by Moksha *et. al*, (2017). Garrett's ranking method was used for performing an analysis of constraints faced by growers and dealers and similar method was adopted by Kumar *et al.,* (2019), Sharma *et al.,* (2020) and Zalkuwi *et al.,* (2015). As per this method, respondents

were asked to assign the rank for all the factors and the outcome of such ranking was converted into score value with the help of the following formula:

$$\text{Percent position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

Where,

Rij= Rank given for ith factor by jthindividual

Nj = No. of factors ranked by the jth individual

RESULTS AND DISCUSSION

1) Brand preference of chilli growers towards insecticides

The chilli grower's brand preference towards insecticides found to be highest with price (74.17%) followed by quality (66.67%), readily available (65.00%), effective and easy to use (61.67%), brand image (60.83%), retailer's influence (55.00%), packaging (29.17%) and advertisements (19.17%).

Table 1: Distribution of factors influencingon chilli growers' preference for the selected insecticide brands (n=120)

Sr. No.	Factors	Frequency	Percentage
1	Retailers influence	66	55.00
2	Quality	80	66.67
3	Price	89	74.17
4	Readily available	78	65.00
5	Brand image	73	60.83
6	Packaging	35	29.17
7	Effective and easy to use	74	61.67
8	Advertisements	23	19.17

Table 2: Distribution of insecticide brands preferred by chilli growers (n=120)

Sr. No.	Brands	Frequency	Percentage
1	Proking	19	15.83
2	Acephate	06	05.00
3	Profex super	31	25.83
4	Fosmite	08	06.67
5	Star gazette	12	10.00
6	Movento	26	21.67
7	Others	18	15.00
	Total:	120	100.00

The Table 2 indicats that among the most popular insecticide brands, the first preference was given to Profex super of Nagarjuna Agrichem Limited (25.83%) by the sample chilli growers followed by Movento brand of Bayer Crop Science company (21.67%) and Proking of United Insecticide Pvt. Ltd. company (15.83%) as their second and third preference respectively. The other brands like Omite and Fix of DhanukaAgritech Limited (15.00%), Star gazette brand of SWAL Corporation Limited (10.00%), Fosmite brand of PI Industry Ltd. (06.67%) and

Acephate brand of United Insecticide Pvt. Ltd. company (05.00%) were also popular among the chilli growers in the study area.

2) Insecticide brands and dealers loyalty of chilli growers

Table 3: Distribution of the chilli growers according to dealer loyalty (n=120)

Sr. No.	Dealer loyalty	Frequency	Percentage
1	Loyal	97	80.83
2	Disloyal	23	19.17
	Total:	120	100.00

Results showed that 80.83 per cent of farmers were loyal towards dealers whereas 19.17 per cent were disloyal. Thus, it is inferred that most of the chilli growers preferred buying insecticides from the same dealer rather than buying from different dealers.

Table 4: Distribution of factors affecting on loyalty of chilli growers towards dealers (n=97)

Sr. No.	Factor	Frequency	Percentage
1	Credit availability	84	86.60
2	Availability of brand	73	75.26
3	Goodwill of dealer	70	72.16
4	Discount	61	62.89
5	Price	50	51.55
6	Distance	21	21.65

Results depicted that credit availability was the most important factor affecting dealer loyalty with 86.60 per cent followed by availability of brand (75.26%), goodwill of the dealer (72.16%), discount (62.89%), price (51.55%) and distance (21.65%).

Table 5: Distribution of the chilli grower according to brand loyalty (n=120)

Sr.No.	Brand loyalty	Frequency	Percentage
1	Loyal	102	85.00
2	Disloyal	18	15.00
	Total:	120	100.00

Table 6: Distribution of factors affecting on loyalty of chilli growers towards brand (n=102)

Sr. No.	Factor	Frequency	Percentage
1	Price	77	75.49
2	Efficiency	90	88.24
3	Availability of brand	87	85.29
4	Packaging	41	40.20
5	Advertisement	41	40.20

Results revealed that most of the chilli growers (85.00%) were brand loyal, whereas 15.00 per cent were not loyal to the brand. This finding is in accordance with the finding of Rohini and Padmanaban (2000), they were also reported that most of the growers were loyal towards brands.

From Table 6, efficiency was found the most important factor affecting brand loyalty with 88.24 per cent followed by availability of brand (85.89%) and price (75.49%). It can be further seen from the table that the advertisements (40.20%) and packaging (40.20%) have a small role in brand loyalty and similar results were reported by Rohini and Padmanaban (2000).

3) Constraints faced by the chilli growers and dealers

Table 7: Constraints faced by chilli growers during the purchase of insecticides (n=120)

Sr. No.	Constraints faced by growers	Garrett's score	Rank
1	High price of insecticides	61.50	I
2	Low effectiveness of insecticides	57.33	II
3	Unavailable on time	55.58	III
4	Unavailability of particular brand	52.65	IV
5	Packaging	48.29	V
6	Wrong information	47.42	VI
7	More distance to point of purchased of insecticides	24.03	VII

The results of study showed that chilli growers faced the major constraint as high price of insecticides followed by low effectiveness of insecticides, unavailable on time, unavailability of particular brand, packaging, wrong information and more distance to point of purchased insecticides and similar results have been reported by Prajapati *et. al.* (2016).

Table 8: Constraints faced by dealers during selling of insecticides used for chilli crop (n= 20)

Sr. No.	Constraints faced by dealers	Garrett's score	Rank
1	Competition among dealers	67.75	I
2	Low margin	60.40	II
3	Lack of field staff	58.25	III
4	Growers unable to pay back on time	56.80	IV
5	Less number of brands available	45.25	V
6	Lack of promotional schemes	31.35	VI
7	High cost of advertisement	29.20	VII

The results of the study revealed that major constraints faced by dealers were competition among dealers followed by low margin, lack of field staff, growers unable to pay back on time, less number of brands available, lack of promotional schemes and high cost of advertisement.

CONCLUSION

The study found that price and quality factors play crucial role in influencing chilli growers' preference towards insecticide brands for chilli crops. Profex super of Nagarjuna Agrichem Limited company and

movento brands of Bayer Crop Science company insecticides majorly preferred by chilli growers. Most of the chilli growers were loyal towards dealers and brands of insecticides. Credit availability was the most important factor that affected the sampled chilli growers' loyalty towards dealers. Efficiency and availability of brands both the factors have a greater percentage and maximum role in the brand loyalty of chilli growers. The factors influencing chilli grower's brand preference towards insecticides were found to be highest with the price and quality of insecticides. The insecticide companies should supply good quality insecticide at affordable price which may attract both dealers and growers to become brand loyal. The majority of chilli growers faced major constraints in purchasing insecticides *i.e.,* high price of insecticide followed by low effectiveness of insecticides. It is observed that dealers faced major constraints of competition among dealers followed by low margins. Companies should plan for effective field demonstrations, so that, chilli growers can get the knowledge to identify the adulterations in insecticides and important steps to be taken care of before use. Companies should also keep growers updated with the latest schemes and benefits launched time to time.

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Development of Multimedia CD on Value-Addition of Mango

Manju*[1], Upadhyay R. [2] and Solanki D.[3]

[1]Department of Home Science University of Rajasthan, Jaipur. 302004.
[2&3]Department of EECM College of Community and Applied Science, MPUAT, Udaipur
*E-mail: manjuch059@gmail.com

ABSTRACT

Investing in the creation and dissemination of quality content has a profound role in the process of empowerment. With time communication media have evolved in society which has brought drastic change in the way people seek and share information. Significance of quality content is no less for rural communities as traditional communication medias have not reached the far-flung areas. The new communication media has the advantage that it reaches every nook and corner as well as it reaches to people with a rocket speed. Looking at the importance of new media, a multimedia CD has been developed on the value-addition of mango for rural women. Results of the expert evaluation of the multimedia CD confirm the audio and visual quality of the CD as it has been rated excellent (>4 out of 5) in all aspects by the panel of experts. The study concluded that the developed multimedia CD effectively conveyed its content with clarity and engagement, and it was organized well.

Keywords: Value-addition, Multimedia CD, Communication material, Rural women

INTRODUCTION

As society develops over time, so do the communication media. In recent years, the manner in which individuals learn, receive, and share information has significantly changed as social media has become an important global communication tool. For the farming community as well, information-sharing techniques have changed. Social media offers a new platform for exchanging ideas and connecting with other farmers, businesses that serve farmers and agricultural experts over vast distances.

E-content which is appropriate and easy to understand can bring the required change in farmers' knowledge regarding various technologies and methods of farming. Despite having higher agricultural production, high post-harvest losses make agriculture a loss-making enterprise because farmers do not have access to processing technologies and the information required for processing and value-addition of agricultural crops. Women farmers are the major stakeholders of agriculture and allied activities but they do not have ownership of agricultural inputs. Women do not even have a say in decision-making in any of the major decisions taken both at the farm and at home. She has less access to different kinds of trainings organized regarding agricultural inputs like seed treatment, fertilizers, improved technologies and sowing methods and various techniques to reduce post-harvest

losses and processing of farm products to add value to the final product.

The increased internet and smartphone access has also increased the woman's chance to have scientific information at home.She can overcome the phenomenon of going out of the home to a faraway place to get training on different aspects of agriculture as this has largely been men's space to get trained. Availability of quality e-content at their own space will help women to access it at their own convenient time and it also saves their energy and time to get any kind of information and knowledge. Looking at the significance of the value-addition of agricultural crops at the farm level, a multimedia CD has been developed on the value-addition of mango for rural women. India is one of the highest mangoes-producing country. This high production and low shelf life of the fruit makes it the perfect fruit for value-addition. The market has a variety of value-added mango products available and demand is high for mango products. Seven popular products that could easily be prepared at home were selected for the video production of multimedia CD.

REVIEW OF LITERATURE

Subhash et al (2018) conducted a study to assess the effectiveness of a web module on dairy innovations in improving the knowledge levels of dairy farmers in India and found that the interactive web module was effective in improving the knowledge of dairy farmers on dairy innovations.

Chatterjee et al (2019) conducted a study titled “Effect of Multimedia on Preparation of Traditional Dairy Products at the Household Level” in eight villages of Karnal district of Haryana and reported that there was a significant gain in the knowledge level and considerable change in retention of the gained information regarding production procedure of the traditional dairy products due to exposure to the multimedia. The major changes were observed in the method of preparation of *Dahi*, *Ghee* and paneer which were highly desirable for the quality dairy product.

Nithya Shree (2019) conducted a pre-post experimental study to discover efficient methods to disseminate information about the health and hygiene of adolescent girls in rural areas of Dharwad district in Karnataka, India. Four different mobile learning modules (m-learning modules) were developed including Lecture, Video-Lecture, Video-Drama, and Video-Animation. Outcomes of the study were measured using pre and post-test for knowledge gain and results affirmed that all four formats were effective in enhancing knowledge. The study also suggested that mobile learning modules are an economical and effective means of imparting knowledge to rural adolescent girls.

Rani and Lal (2019) conducted a study to analyse the effectiveness of a Compact Disc (CD) as a media tool to empower rural women in vegetable cultivation and found the CD to be highly effective in imparting knowledge and positively influencing the attitudes of rural women towards vegetable cultivation.

Tripathi et al (2019) developed a mobile app on buffalo reproduction and summarized that the mobile app was well-received by its target audience, with a highly perceived utility and effectiveness. It provided valuable information and guidance on buffalo reproduction, addressing common problems and offering practical solutions. Despite some initial technophobia and varying perceptions about precision and

coverage, the app had the potential to contribute positively to the knowledge and practices of buffalo owners, VLDA professionals, and veterinarians.

MATERIALS AND METHOD

Multimedia CD development process was accomplished in two phases: designing of multimedia CD and expert evaluation of multimedia CD.

Designing of multimedia CD on value-addition of mango

A video script was written using scientific information available on the value-addition of mango through primary and secondary data sources. The content of the script was classified into chapters i.e., Introduction, Preparation of values added products of mango like *Amchoor*, raw mango *murabba*, mango pickle, raw mango squash, mango jam, *Aam-papad* and preservation of mango as pulp and closure. A separate template of experience sharing by a successful women entrepreneur was added to the script. The necessary video scenes, photographs, illustrations etc., as per the script developed were first captured and assembled according to the storyboard created using Pinnacle Studio version 9 video editing software. The storyboard presented the visual description of long, medium and close-up shots. The audio editing software used for the off-camera narration was recorded and edited using Sound Forge version 8.0. The assembled video clippings were edited and incorporated with off-camera narration audio, background music and sound effects. The development of the video CD took four months, with one month for preparation of the video script and three months for video editing and disc authoring.

Expert evaluation of multimedia CD on value-addition of mango

The developed video CD was then evaluated by a panel of experts from the Department of Extension Education & Communication Management and Foods & Nutrition. An evaluation sheet was prepared by the researcher which included visual and audio aspects of evaluation. The visual evaluation aspect had 10 evaluation criteria *i.e.*, purpose accomplished, content coverage, logical sequence, organization/ layout, illustration. visual clarity, attention-catching, self-explanatory, synchronization of audio and video and overall presentation. The audio evaluation aspect included 5 evaluation criteria such as content clarity, voice, pace & speed of narration, background music and overall presentation. Experts evaluated the multimedia CD on a 5-point continuum i.e., excellent, very good, good, fair and poor scoring 5,4,3,2 and 1 respectively. Suggestions given by the experts were incorporated, scores were compiled in MS Excel and mean-weighted scores were calculated.

RESULTS AND DISCUSSION

I. Visual evaluation of multimedia

Ten different criteria were used for visual evaluation of the multimedia CD on a five-point continuum with scores such as 5,4,3,2 and 1 respectively. Results of the visual evaluation are presented in Tables 1.1 and 1.2.

II. Overall visual evaluation of multimedia CD

Results of the overall visual evaluation of the multimedia CD as presented in Table 1.1 reflect that the mean weighted scores of all the evaluation criteria were between 4.50 to

4.80 and in synchronization of audio and visuals and the overall presentation of the multimedia CD the mean weighted score was 4.80. It shows that the CD was marked as excellent by the experts.

Table 1 : Overall visual evaluation of multimedia CD

S.No.	Item	Mean Weighted Score
1.	Purpose accomplished	4.70
2.	Content coverage	4.60
3.	Logical sequence	4.65
4.	Organization/ Layout	4.65
5.	Illustration	4.50
6.	Visual Clarity	4.75
7.	Attention Catching	4.60
8.	Self-Explanatory	4.60
9.	Synchronization of audio and visuals	4.80
10.	Overall Presentation	4.80

Results are in conformity with Jain (2017) where visual perception of developed e-book was rated very good by the experts.

1.2 Component-wise visual evaluation of multimedia CD

Table 2 delineates the component-wise scores given to different aspects of multimedia CD and data given in the table clearly depict that the CD was well received by the experts and it was felt effective and engaging for the audience. A close observation of the table reveals that all the criteria were rated between 4.5-4.80 out of 5 reflecting the well-prepared, organized, and visually appealing properties of the developed multimedia CD.

Table 2 Component wise visual evaluation of multimedia CD

Component	Purpose accomp-lished	Content cover-age	Logical sequ-ence	Organi-zation/ Layout	Illus-tration	Visual Clarity	Attention Catching	Self-Expla natory	Synchro-nization of audio and visuals	Overall Presen-tation	Mean Weighted Score
Need and benefits of value-addition	4.60	4.60	4.70	4.80	4.20	4.80	4.70	4.60	4.80	4.80	4.66
Mango products	4.80	4.60	4.60	4.50	4.80	4.70	4.50	4.60	4.80	4.80	4.67
Overall visual representation	4.70	4.60	4.65	4.65	4.50	4.75	4.60	4.60	4.80	4.80	4.67

It also confirms that the multimedia CD scored consistently well across different components and the average score allotted by the experts was 4.66 and 4.67 in all aspects of multimedia CD. It reflects that the multimedia CD covered the content comprehensively and it achieved the intended purpose.

ii. Audio evaluation of multimedia CD

2.1 Overall audio evaluation of multimedia CD

The audio quality of the multimedia CD was assessed on the basis of 5 evaluation

criteria such as content clarity, voice, pace and speed of narration, background music and overall presentation. A close analysis of Table 3 conveys that the overall audio quality of the multimedia CD was rated excellent scoring 4.58 to 4.89 out of 5 in all the criteria. The overall presentation of the CD highly convinced the experts about its audio quality and it scored 4.89 out of 5.

Table 3: Overall audio evaluation of multimedia CD

S.No.	Item	Mean Weighted Score
1.	Content clarity	4.87
2.	Voice	4.78
3.	Pace and speed of narration	4.71
4.	Background music	4.58
5.	Overall presentation	4.89

2.2 Component wise audio evaluation of multimedia CD

Table 4 describes the component-wise audio evaluation of multimedia CD and affirms that the audio quality of all the components of multimedia CD was considered excellent by the experts. The mean weighted score was 4.76 and 4.77 for all the components. Mean weighted scores of overall presentation of audio evaluation were highest in all the components which asserts the audio quality of the multimedia CD.

Table 4 Component wise audio evaluation of multimedia CD

Component	Content Clarity	Voice	Pace and speed of narration	Background music	Overall presentation	Mean Weighted Score
Need and benefits of value-addition	4.96	4.72	4.72	4.50	4.96	4.77
Mango products	4.74	4.80	4.78	4.71	4.81	4.77
Overall audio representation	4.90	4.82	4.62	4.54	4.91	4.76

CONCLUSION

Both the audio and visual components of the multimedia CD received high scores, suggesting that the CD effectively conveyed its content with clarity, engagement, and good organization. It could be concluded from the study that good quality content can be delivered to the rural community through the media which is easy to comprehend. Multimedia CD bridge information gaps, offer opportunities for learning and growth, and can contribute to overall community development and improvement in the quality of life. It can be a powerful tool for empowerment, education, and development in rural communities.

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Impact of Mulch and Biomolecules on Growth and Yield of Tomato

Jammihal S.* [1] and Sharada M. S.[2]

[1,2] DOS in Botany, Manasagangotri, University of Mysore-570005
*Email: shivaag65@gmail.com

ABSTRACT

A field experiment was conducted to study the impact of mulch and biomolecules on plant height, number of fruits per cluster, average fruit weight, marketable yield and non-marketable yield of Tomato (*Solanum lycopersicum* L.) under irrigated condition. The experiment was laid out in split splitplot design with two replications with four main plots consisting of hybrids, three subplots consisting of mulching practices and four sub-sub plots consisting of different levels of biomolecules application. The results revealed that TO-1057 hybrid, application of polythene mulch and Ratchet @ 240 ml/acre recorded significantly higher plant height, fruits per cluster, fruit weight, marketable yield per plant, marketable yield per acre and non-marketable yield per acre. Hybrid X Biomolecules practice resulted in significant difference on growth attributes, yield attributes and yield.

Keywords : Tomato, Mulching, Plant Height, Marketable Fruit yield

INTRODUCTION

Tomato belongs to *Lycopersicum* genus under family Solanaceae. Tomato fruit has special nutritive value and is one of the most important and versatile vegetable crops which is used by Indians for culinary purposes. Tomato fruits are oval to flat and round having prominent features with or without green coloured shoulder. An average yield of tomato is about 30-35 tonnes per hectare having an average crop duration of about 135 days (recent reference).

Proper understanding of characteristics and selection of right planting material plays a very important role in yield optimization. TO-1057 (Syngenta) hybrid is a semi-indeterminate type with high plant vigour and yielding potential showing uniform fruit ripening whose fruit harvesting starts 60-65 days after transplanting (Sidrah *et al.,* 2017). Tomato hybrid Garv (Monsanto) has strong and determinate plant type, quick maturity and higher yield potential with fruit weight of 90-100 grams (Nishkruti *et al.,* 2018). Whereas, Ashoka (Monsanto) is a strong and highly determinate plant type with medium fruit weight of about 80-90 gram. Hybrid Arka Rakshakis a strong plant, fruits are square round and deep red in colour with an average fruit weight of about 90-100 grams. It is a high yielding hybrid and has good post harvest life which is suited for the fresh market (Sadashiva *et al*., 2017). All these four hybrids are high yielding, resistant to diseases and will produce good quality fruits and hence the ultimate yield obtained will be highly

satisfying.

Agronomic practices are very much essential in improving the yield of the crop. Mulching is one of such a practice wherein the soil is covered by organic or inorganic materials, this practice helps in decreasing the soil deterioration as it prevents the soil runoff. It also hinders the weed growth as there is no light for the weed seeds to emerge and thereby reduce the weed infestations and reduces the loss of water through evaporation. It also helps in retaining the soil moisture and controls the fluctuations in temperature, enhances all the physical, chemical and biological soil properties, as the organic mulches adds nutrients to the soil upon decomposition and ultimately increases the growth and yield (Ausra*et al.,* 2009).

Humic acid will act as plant growth stimulator and plays a direct role in enhancing the formation of plant and help in increasing the seed germination. Humic acid when applied to the root zone improves the nonspecific resistance among the plants towards various stress conditions like abnormal increase in temperature, drought conditions and against strong radiations on plants. These humates will have influence on plant nutrient uptake, respiration process, amount of amino acids, sugars and reduces the nitrate accumulation. It improves the fruit setting, decreases the fruit drop and accelerates the ripening of fruits. This also helps in enhancing the transfer and availability of all the nutrients and micronutrients in the plants (Hoang and Michael, 2001).

Lipo Chito Oligosaccharides (LCO) when applied on plants have the capacity to enhance the seedling emergence, promote somatic cell embryo mutant rate, stimulate plant photosynthesis, increase the leaf area and dry matter plants (Chen *et al.,* 2007). Foliar application of LCO is known to alleviate yield losses under water deficit condition and facilitate in improving root biomass. Initially LCO application helps in increasing the flowering, fruiting and subsequently prevents flower abortion, which inturn result in obtaining higher fruit yield and biomass of fruits or vegetable crops.

MATERIALS AND METHODS

A field experiment was conducted to study "Impact of mulch and biomolecules on growth and yield of tomato" at farmers' field, Settahalli, Kolar during summer season for two years, 2016 and 2017 under irrigated conditions. Shettihalli in Kolar district which falls in the Eastern Dry agro-climatic zone in Karnataka state and it experiences a semi-arid climate, characterized by typical monsoon tropical weather with hot summers and mild winters. The site has an elevation of 839 meters from mean sea level (MSL). The details of the materials used, methods and experimental techniques adopted during investigation are presented in this article.

Treatment and Experimental Design:

The experiment was laid out in split-split plot design consisting of 48 treatment combinations replicated twice. First factor consisted of four hybrids namely TO-1057 (H1), Garv (H2), Ashoka (H3) and Arka Rakshak (H4) in Main plot, second factor comprised of three types of mulches viz., Polythene Mulch (M1), Crop Mulch (M2) and No Mulch (M3) as a control in Sub plot

and third factor consisted of four biomolecules namely Ratchet @ 120 ml/acre (B1), Ratchet @ 240 ml/acre (B2) and Proventus @ 1000 g/acre (B3) and no biomolecules (B4) as a control in sub-sub plot.

Crop management

Tomato seedlings were raised using healthy treated seeds in 98 cavity seedling trays during January 2016 and 2017 with proper nursery management. At the time of sowing, the land was prepared to a fine tilth which is red sandy loam soil having pH of 6.5. FYM and fertilizers were applied at the recommended dose of 250:250:250 Kg/Ha NPK during bed preparation and throughout the crop duration. Drip laterals were laid after preparing raised beds with the discharge of 4 L/Hr. Planting beds were covered with silver-black coloured30-micron poly mulch, crop mulch using finger millet straw materials and no mulch as per treatments.

Thirty days old seedlings were transplanted on 16.2 m2 gross plot size (2.4 X 6.75 m) with spacing of 120 X 45 cm between rows and plants respectively. Mulching was done before transplanting and small holes were made as per the spacing on the mulching beds for planting of each seedling. Thirty plants were planted in each treatment and a drip irrigation system was followed for the uniform watering. Wooden poles and GI wires were used for the proper staking of each plant.

Application of Biomolecules

Ratchet @ 120 ml/acre (B1), Ratchet @ 240 ml/acre (B2) and Proventus @ 1000 g/acre (B3) were applied at the crop stage of 20 and 40 days after planting.

Observations recorded

Ten plants were selected randomly from each treatment and tagged with label for taking various biometric observations. Height of tagged plant was measured from ground level of plant to tip of main shoot and mean plant height was worked out and expressed in centimetres (cm). Yield attributes *viz.*, number of fruits per cluster was counted from tagged ten plants at full fruit load (at 85 days after transplanting) and average fruit weight (gram) was recorded three times during third, sixth and ninth harvests. Sample sizes of 40 fruits per treatment were collected and mean fruit weight was recorded. Total marketable yield and unmarketable yield were recorded separately (kg/plant) by grading based on their size, shape, colour, diseased and damaged fruits at each harvest and cumulative marketable and unmarketable yield was recorded out of total 12 harvests and total plot yield was divided by number of plant to record yield per plant (kg).Per acre yield data was calculated by multiplying per plant yield to number of plants per acre.

Statistical Analysis

Analysis of variance (ANOVA) was calculated by using Tukey HSD software and treatment means were separated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Various factors influence the growth and yield of crop. Hybrid selection, response to biomolecules and mulching practices were studied. Selection of good hybrids suitable for location has been ongoing research with respect to desirable traits (yield and quality). Further, variations in response of

different hybrids to varied practices are well established facts. Efforts were initiated to study the interactions of hybrids and biomolecules under different mulching practices. The results of the experiment were conducted to illustrate the effect of mulch and biomolecules on yield and fruit quality of tomato (*Solanum lycopersicum* L.) During summer 2016 and 2017 at the location details are presented in this article.

An experiment with four tomato hybrids (TO 1057, Garv, Ashoka and Arka Rakshak) was conducted in the summers of 2016 and 2017. The experiment was conducted by taking hybrids as main plot, mulching as sub-plot and biomolecules as sub-sub-plot. Various yield and yield related traits were measured and subjected to ANOVA (Analysis of Variance).For all the plant growth and yield parameters, pooled data from two years were taken into consideration for comparing results.

Plant growth parameters

Plant height (cm)

Among the hybrids, pooled values of TO-1057 (H1) recorded significantly higher plant height of tomato (136.8 cm)as compared to other hybrids. Garv (H2) and Arka Rakshak (H4) recorded at par with each other (119.4 and 117 cm respectively) but significantly higher than Ashoka (H3) which recorded lowest plant height (113.3 cm). Similar trend was observed in 2016 and 2017 in individual years (Table 1). Physiological difference associated with the hybrids is attributed to variation in genetic traits (Bhattarai *et al*., 2018)

Mulching practices influenced the plant height significantly (Table 1). Polyethylene mulch (M1) recorded significantly higher plant height *i.e.*, 138.8 cm followed by Crop mulch (M2) (116.2 cm) when compared with no mulch treatment M3 (109.3 cm).Results are in corroboration with findings of Singh, (2005) which resulted in differential response of tomato plants accounted due to differential physiological changes on account of mulching.

However, among the biomolecules, pooled values of Ratchet @ 240 ml/acre (B2) and Proventus @ 1000 g/acre (B3) recorded significantly higher plant height(126 and 126.8 cm respectively) than B1, Ratchet @ 120 ml/acre (118 cm) and B4, Control (114.2 cm) but no significant difference in plant height between B1 and B4 (Table 1).Application of LCO (lipo-chito-oligosaccharide) molecule enhances the plants nutritional capabilities that drive natural growth processes, enhances seed germination, enhances photosynthetic rates in both legume and non-legume crops (Prithiviraj *et al.,* 2000). Large leaf surface for better light absorption and photosynthesis, earlier canopy closure for soil moisture preservation and reduced weed competition, improved plant health for better stress tolerance and higher yield potential (Chen *et al.,* 2007). Similar results were observed by (Aracon *et al*., 2003) who also observed increased plant height, leaf area, dry matter weight of shoots and roots in crops and increased fruit number in plants when the humic acid obtained from plant wastes, food wastes, vermicompost and cattle waste was applied. Recent literature has shown that humic acid could be used as growth regulator to regulate hormone levels, improves plant growth and enhance stress tolerance (Serenella *et al.,* 2002).

Table 1: Comparative performance of hybrids, mulching practices and biomolecules on plant growth and fruits per cluster traits in summer 2016, 2017 and pooled year

		Plant Height (cm)			Fruits Per Cluster		
		2016	2017	Pooled	2016	2017	Pooled
Hybrid	H1	138.3 a	135.5 a	136.9 a	4.67a	4.73 a	4.7a
Treatment	H2	122.7b	116.2 b	119.4 b	4.73a	4.50 b	4.61a
	H3	120.9b	113.1 b	113.3 c	4.7a	4.65 ab	4.68a
	H4	113.5c	113.1 b	117.0bc	4.71 a	4.58 ab	4.65a
Mulching	M1	144.7 a	132.9 a	138.8 a	4.93 a	4.73 a	4.83 a
Treatment	M2	121.7b	116.2 b	118.9 b	4.67 b	4.70 a	4.69 b
	M3	105.1 c	109.3 c	107.2 c	4.51 c	4.40 b	4.45 c
Bio Molecules	B1	121.0 b	115.1 b	118.0 b	4.67 b	4.63 b	4.64 b
Treatment	B2	128.7 a	123.2 a	126.0a	5.03 a	4.88 a	4.95 a
	B3	128.0 a	125.4 a	126.8a	4.78 b	4.72 ab	4.75 b
	B4	117.4 c	114.2 b	115.8 b	4.34 c	4.23 c	4.28 c

Same letters indicate non-significant at 0.95 level of significance.

H1: TO-1057; H2: Garv; H3: Ashoka; H4: Arka Rakshak;

M1: Polythene Mulch; M2: Crop Mulch; M3: No Mulch;

B1: Ratchet @ 120 ml/acre; B2: Ratchet @ 240 ml/acre; B3: Proventus @ 1000 g/acre; B4: Control

Effect of hybrids, mulching practices, biomolecules and their interactions on plant height of tomato during both the seasons of experimentation are presented in Table 2. Among the various hybrids, mulching practices and biomolecules treatment interactions, Hybrid X Mulching practice alone resulted in significant difference but interaction between Hybrid X Bio Molecules, Mulching X Bio Molecules and Hybrid X Mulching X Bio Molecules has shown no significant difference on plant height in both the seasons. Effect of Hybrid and Mulching on plant height recorded highly significant in both the seasons.

Fruits per cluster

Among the hybrids, TO-1057 (H1), Garv (H2), Ashoka (H3) and Arka Rakshak (H4) there was no significant difference recorded with respect to average fruits per cluster in tomato (Table 1).

Polyethylene mulch (M1) recorded significantly higher fruits per cluster (4.8) than Crop mulch (M2) and No Mulch (M3).Number of fruits per cluster in M2 recorded 4.69 which was significantly higher than M3 (4.45) as shown in the Table 1.

However, among the biomolecules, pooled data of Ratchet @ 240 ml/acre (B2) recorded significantly higher fruits per cluster (4.95) than remaining treatments. Proventus @ 1000 g/acre (B3) recorded 4.75 and Ratchet @ 120 ml/acre (B1) recorded 4.64 fruits per cluster which were on par with each other and significantly lower fruits per cluster was recorded in control 4.28 (B4). Similar trend was observed in 2016 and 2017 as well (Table 1). This was mainly due to the drastic increase in the photosynthetic efficiency and by this higher accumulation of dry matter was observed. Similar results were observed by Minami *et al*., (1996). This also

helped in the formation of new nodules and organs and helped in initiating the plant morphoses as observed by Perret *et al.,* (2000).

Effect of hybrids, mulching practices, biomolecules and their interactions on average fruits per cluster of tomato during both the seasons of experimentation are presented in Table 2. Among the various hybrids, mulching practices and biomolecules treatment interactions, Hybrid X Biomolecules practice alone resulted in significant difference during 2016 and 2017 but interaction between Hybrid X Mulching, Mulching X Bio Molecules and Hybrid X Mulching X Bio Molecules has shown no significant difference on fruits per cluster in both the seasons.

Fruit weight (g)

Pooled values of TO-1057 (H1) fruit weight recorded significantly higher at 3rd, 6th and 9th harvests(99.71, 86.91 and 80.04 respectively). Garv (H2), Ashoka (H3) and Arka Rakshak (H4) were shown on par each other at 3rd harvest (94.57, 93.53 and 93.31 respectively)but similar trend was observed only with H2at 6th harvest (84.29) and 9th harvest (74.56)but H3 shown 73.2 gat 9th harvest which was significantly higher than H4.Whereas fruit weight of H4at 6th and 9th harvest (82.45 and 69.89 respectively) shown significantly lower than rest of the treatment (Table 3).

Mulching practices have played a crucial role in fruit weight retention across harvests. Polythene mulch (M1) recorded significantly higher fruit weight at 3rd, 6th and 9th harvest (99.63 g, 88.15 g and 78.48 g respectively) than Crop Mulch (M2) (93.86 g, 83.04 g and 73.03g) and No mulch (M3) (92.34 g, 80.92 g and 71.75 g).Fruit weight in M2 observed significantly higher than M3. Similar trends observed in 2016 and 2017 in each mulching practice (Table 3).

Table 2: Analysis of variance (mean type III sum of squares) for plant growth characters studied in four tomato hybrids in the summer seasons of 2016, 2017 and pooled.

Source	df	Plant Height	Fruits Per Cluster	Plant Height	Fruits Per Cluster	Plant Height	Fruits Per Cluster
		2016		2017		Pooled	
Hybrid (H)	3	2618.40**	0.018	2784.22**	0.24*	5263.86**	0.06
Mulching (M)	2	12687.92**	1.47**	4692.31**	1.08**	16329.13**	2.32**
Biomolecules (B)	3	741.00**	1.98**	771.56**	1.83**	1482.94**	3.79**
H X M	6	186.97**	0.13	251.61**	0.15	174.12	0.16
H X B	9	13.54	0.16*	20.2	0.16*	24.11	0.15
M X B	6	28.43	0.13*	22.57	0.06	28.18	0.15
H X M X B	18	9.152	0.059	41.33	0.14*	24.13	0.1
Error	48	20.802	0.06	33.95	0.06	58.59	0.08
Total	96						
Corrected Total	95						

*Indicate 95% confidence

** indicates 99% confidence.

All the statistical analyses were performed using Tukey HSD software.

However, among the biomolecules, Ratchet @ 240 ml/acre (B2) recorded the highest fruit weight 97.15 g, 88.9 g and 73. 89g at 3rd,6th and 9thharvest respectively. Proventus @ 1000 g/acre (B3) recorded (95.83 g, 85.56 g and 75.31g at 3rd, 6th and 9thharvests respectively) which showed on par with B2 at all the three harvest stages but therewere no significant difference values between Ratchet @ 120 ml/acre (B1) and Control (B4)as shown in the Table 3.

Effect of hybrids, mulching practices, biomolecules, and their interactions on fruit weight of tomato during both the seasons of experimentation are presented in Table 4. Interaction between hybrid and mulching showed significant difference during 2016, 2017 and pooled analysis at 3rd, 6th and 9th harvests but no significant difference observed between hybrid and biomolecules similarly in mulching X biomolecules and hybrid X mulching X biomolecules.

Table 3 : Comparative performance of hybrids, mulching practices and biomolecules fruit size at 3rd, 6th and 9th harvests in summer 2016, 2017 and pooled year

		Fruit Weight (g) 3rd Harvest			Fruit Weight (g) 6th Harvest			Fruit Weight (g) 9th Harvest		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Hybrid	H1	100.40 a	99.01 a	99.71 a	87.43 a	86.40 a	86.91 a	78.74 a	81.34 a	80.04 a
Treatment	H2	96.64 b	92.50 b	94.57 b	84.65 b	83.92 b	84.29 b	74.24 b	74.89 b	74.56 b
	H3	93.69 c	93.36 b	93.53 b	82.13 c	82.89 b	82.51 c	72.02 b	74.39 b	73.20 b
	H4	93.81 c	92.80 b	93.31 b	81.87 c	83.02 b	82.45 c	68.93 c	70.85 c	69.89 c
Mulching	M1	102.28 a	96.99 a	99.63 a	89.47 a	86.83 a	88.15 a	78.29 a	78.67 a	78.48 a
Treatment	M2	94.18 b	93.54 b	93.86 b	82.56 b	83.53 b	83.04 b	71.30 b	74.77 b	73.03 b
	M3	91.95 c	92.73 b	92.34 c	80.03 c	81.82 b	80.92 c	70.85 b	72.65 c	71.75 c
Bio	B1	94.42 b	92.92 c	93.67 c	82.72 b	82.87 b	82.80 b	72.47bc	74.85 ab	73.66 ab
Molecules	B2	98.35 a	95.95 a	97.15 a	85.67 a	86.11 a	85.89 a	75.17 a	76.62 a	75.89 a
Treatment	B3	96.41 ab	95.25 ab	95.83 ab	85.57 a	85.54 a	85.56 a	74.59 ab	76.04 a	75.31 ab
	B4	95.36 b	93.56bc	94.46bc	82.11 b	81.72 b	81.91 b	71.70 c	73.95 b	72.83 b

Same letters indicate non-significant at 0.95 level of significance.

Marketable yield per plant (kg) and yield per acre (tons)

Among the hybrids, significantly higher pooled marketable yield from TO-1057 (H1) obtained per plant and per acre of tomato (3.27kg and 24.53tons respectively) as compared to other hybrids. Garv (H2) yielded2.56 kg/plant and 19.17 tons/acre significantly higher than Ashoka (H3) (2.25 kg and 16.87 tons) and Arka Rakshak (2.17 kg and 16.26 tons) respectively but both H3 and H4 were recorded lower side yield and non-significantly each other. However, a similar trend was observed in 2016 and 2017 years as well (Table 5). Similar results were obtained by Chapagain *et al.,* (2020) where the genotype TO-1057 recorded the highest marketable yield.

We have observed greater yield advantages on polythene mulch compared to crop and without mulch in the experiment. Pooled values of Polythene mulch (M1) recorded significantly higher yield/plant (3.13) and yield/acre (23.44) than Crop mulch (M2) and No mulch (M3) which were yielded (2.33 kg and 17.48 tons) and (2.23

Table 4: Analysis of variance (mean type III sum of squares) for fruit weight at 3rd, 6th and 9th harvests studied in four tomato hybrids in season of 2016, 2017 and Pooled years.

Source	df	Fruit Wt. 3rd Harvest	Fruit Wt. 6th Harvest	Fruit Wt. 9th Harvest	Fruit Wt. 3rd Harvest	Fruit Wt. 6th Harvest	Fruit Wt. 9th Harvest	Fruit Wt. 3rd Harvest	Fruit Wt. 6th Harvest	Fruit Wt. 9th Harvest
		2016			2016			Pooled		
Hybrid (H)	3	238.92**	161.95**	408.53**	228.05**	63.36**	458.18**	433.30**	211.28**	857.66**
Mulching (M)	2	944.91**	764.80**	556.67**	163.65**	207.44**	298.38**	947.36**	883.12**	816.84**
Biomolecules (B)	3	68.34**	83.67**	66.13**	48.31**	106.45**	34.16**	113.31**	188.68**	97.22**
H X M	6	66.85**	30.57*	24.36*	52.62**	47.74**	12.48*	106.70**	58.67**	30.56**
H X B	9	2.08	6.59	1.52	1.73	11.62	3.18	2.89	12.09	3.09
M X B	6	4.73	3.98	3.17	1.1	7.31	1.55	3.7	3.42	3.96
H X M X B	18	1.2	1.58	4.21	1.08	3.81	2.9	1.61	3.52	5.32
Error	48	7.42	7.72	7.29	4.67	8.07	5.27	8.79	8.59	6.77
Total	96									
Corrected Total	95									

*Indicate 95% confidence and
** indicates 99% confidence.
All the statistical analyses were performed using Tukey HSD software.

kg and 16.7 tons) yield/plant and yield/acre respectively. Fruit yield per plant and acre was recorded lowest in no mulch which is significantly lower than M1 and M2 (Table 5). Similarly, Hedau *et al.,* (2002) recorded that application of silver polythene mulch recorded higher yield as compared to pea straw as mulch. Reduced growth and yield in crop mulch might be due to some crop species used as mulch might become weed problem, these organic mulches can keep the soil too moist, restricts oxygen in the root zone in poorly drained soils (Lal *et al.,* 2003).If the mulch is applied close to the stem of the plant, trapped moisture creates a conducive environment for the development of pests and diseases. Most of the organic mulches provide home for the breeding of snails, slugs, rats etc., which might attack the plants and hence reduce the growth and yield of the crop. Similar reports were obtained by Patil *et al.,* (2013) showing that the application of crop mulches increased the diseases, pests and rodents attacking the crop and thereby there was a drastic yield reduction on tomato crop. Non mulching treatments usually showed less growth and yield because there was less water and nutrient use efficiency, less soil nutrient status, more weed competition which can be overcome by plastic mulching, the same experimental result was obtained by Singh *et al.,* (2005) that mulching practices will increase the fruit yield. Plastic mulches conserve the soil moisture, enhance the nutrients status of soil, regulate soil temperature, control the erosion losses, suppress the weeds in crop plants, and remove the residual effects of pesticides, fertilizers, and heavy metals. Similar results were recorded by Chakraborty and Sadhu (1994).Further, reported that mulching boosts the yield by 50-60 % over no mulching (Dilipkumar *et al*., 1990).

However, among the biomolecules, pooled values of Ratchet @ 240 ml/acre (B2) recorded highest marketable yield per plant

Table 6: Analysis of variance (mean type III sum of squares) for yield characters studied in four tomato hybrids in the summer season of 2016, 2017 and pooled.

Source	df	Mark. Yield /Pl	Mark. Yield/ Acre	Non-Marke. Yield/Pl	Non-Mark. Yield/ Acre	Mark. Yield/ Pl	Mark. Yield/ Acre	Non-Marke. Yield/Pl	Non-Mark. Yield/ Acre	Mark. Yield/ Pl	Mark. Yield/ Acre	Non-Mark. Yield/Pl	Non-Mark. Yield/ Acre
		2016				2017				Pooled			
Hybrid (H)	3	6.27**	352.90**	0.12**	6.76**	5.82**	327.66**	0.10**	5.75**	12.07**	679.02**	0.11**	10.87**
Mulching (M)	2	9.24**	519.92**	0.23**	13.28**	6.40**	360.29**	0.17**	9.69**	15.46**	870.06**	0.09**	22.81**
Bio-Molecules (B)	3	0.32**	18.13**	0.02*	1.40*	0.49**	28.08**	0.009	0.51	0.81**	45.62**	0.03	1.77
H X M	6	0.13**	7.79**	0.007	0.36	0.15**	8.91**	0.008	0.43	0.27**	15.33**	0.009	0.67
H X B	9	0.01	0.6	0.003	0.146	0.012	0.65	0.001	0.05	0.009	0.49	0.002	0.1
M X B	6	0.01	0.71	0.008	0.43	0.008	0.44	0.003	0.15	0.018	1.01	0.008	0.32
H X M X B	18	0.006	0.311	0.007	0.374	0.007	0.41	0.001	0.08	0.009	0.48	0.003	0.18
Error	48	0.041	2.305	0.009	0.532	0.03	1.69	0.011	0.69	0.038	2.12	0.015	0.5
Total	96												
Corrected Total		95											

*Indicate 95% confidence,
** indicates 99% confidence.
All the statistical analyses were performed using Tukey HSD software

and yield per acre(2.69 and20.2 respectively) followed by Proventus @ 1000 g/acre (B3) recorded (2.65 and 19.86), Ratchet @ 120 ml/acre (B1) (2.48 and18.58) and Control (B4) 2.42 and 18.18 respectively but all the four treatments (B1, B2, B3 and B4) were showed non-significantly each other as shown in the Table 5.Similarly, Eyheraguibel *et al.,* (2008)and Mora *et al*., (2010) observed when humic acid is applied to the plants, it helps in enhancing the rate and percentage of speed germination, elongates the roots of seeds, enhances plant growth, root, shoot and leaf biomass and in total there will be increased uptake of water, nutrients and minerals there by increasing the overall yield attributes.

Effect of hybrids, mulching practices, biomolecules and their interactions on marketable yield per plant and yield per acre of tomato during 2016, 2017 and pooled data are presented in Table 6. Among the various hybrids, mulching practices and biomolecules treatment interactions, Hybrid X Mulching practice alone resulted in significant difference but interaction between Hybrid X Biomolecules, Mulching X Bio Molecules and Hybrid X Mulching X Bio Molecules has shown no significant difference on marketable yield per plant and yield per acre in both the seasons and pooled. Panthee *et al.,* (2013) and Osei *et al.,* (2018) have reiterated differential response of the hybrids to the changes in environment mainly due to genotype to environment interaction.

Non-Marketable yield per plant (kg) and yield per acre (tons) :

Non-marketable yield was obtained by grading harvested fruits based on their size, shape, colour, diseased and damaged fruits at every harvest. Amount of non-marketable yield recorded here is showing negative

traits and lesser value indicates better performance in each treatment. Pooled values of 2016 and 2017 were considered for the comparison. Among the hybrids, TO-1057 (H1) recorded lower non-marketable yield per plant and per acre of tomato which was found beneficial (0.76 and 5.51 respectively) as compared to other hybrids. Garv (H2), Ashoka (H3) and Arka Rakshak (H4) recorded on par results with each other and observed (0.84 and 6.33), (0.86 and 6.47) and (0.85 and 6.37) non-marketable yield per plant and per acre respectively, however highest non-marketable yield was observed in Ashoka compared to other hybrids (Table 5).

Polythene mulch (M1) influenced the non-marketable yield per plant and per acre significantly lower (0.78 and 5.54 respectively) compared with other mulching treatments i.e., Crop mulch (M2) and No mulch (M3) which are showing non significantly each other. We have observed higher non-marketable yield per plant and per acre in M2 (0.85 and 6.37) and M3 (0.84 and 6.3) as shown in Table 5.

Among the biomolecules, Ratchet @ 120 ml/acre (B1), Ratchet @ 240 ml/acre (B2), Proventus @ 1000 g/acre (B3), and Control (B4) on non-marketable yield per plant and per acre recorded nonsignificant difference among the treatments as shown in the Table 5.

Effect of hybrids, mulching practices, biomolecules, and their interactions on non-marketable yield per plant and per acre of tomato were shown in Table 6. but there were no significant interaction differences observed among Hybrid X Mulch, Hybrid X Biomolecules, Mulching X Biomolecules and Hybrid X Mulching X Biomolecules.

CONCLUSION

Hybrid TO-105 was found to be optimum for higher productivity, performance with respect to tomato plant growth and yield parameters as compared to Garv, Ashoka, and Arka Rakshak as it produced higher yield and better-quality fruits of tomato. Among application of mulch, application of polythene mulch produced an effective result with respect to growth, yield, quality fruits, thereby the productivity and profitability increased. Among the applications of biomolecules, the application of Ratchet @ 240 ml/acre recorded optimum with respect to growth and yield parameters during all the growing seasons.

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