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USE OF GEOSPATIAL TOOLS TO IDENTIFY SOIL RELATED CONSTRAINTS IN MANGO GROWING SOILS OF THE YSR KADAPA DISTRICT OF ANDHRA PRADESH

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ABSTRACT

Using a GPS-based survey, the detailed soil fertility status of mango-growing soils in twelve mandals of the YSR Kadapa district (Andhra Pradesh) was explored in 2019-20 to discover soil-related crop production restrictions. pH, EC, OC, and accessible N, P, and K were measured in geo-referenced composite surface(0-30cm) soil samples. In terms of response, almost all soils were neutral to mildly alkaline. The electrical conductivity (EC) of the soil was within acceptable limits for crops (0.48 dSm^{-1}). The average content of soil organic carbon was 4.2 g kg^{-1} , with a range of 1.3 to 7.2 g kg^{-1} . The accessible soil nitrogen, phosphorus, and potassium were found to be 229.65 , 21.28 , and $264.11 \text{ kg ha}^{-1}$, respectively. Using the ArcGIS programme, thematic soil fertility maps were created for each soil parameter to provide ready-to-understand information about soil fertility status and act as a decision-making tool for effective mango production.

Keywords: Geospatial Tools, GIS, GPS, GIS, GPS, mango, Soil fertility maps, YSR Kadapa district

INTRODUCTION

India is the world's largest mango producer and one of the world's top producers in terms of both area and production. India produces approximately 18.431 MT of mangos, accounting for roughly 64% of global mango production. Mangoes are grown on more than 40% of India's total fruit land. Mangoes cover 22.58 lakh hectares in India. Uttar Pradesh leads the way with 45.51 lakh MT produced, followed by Andhra Pradesh (NHB, 2019-20). Mango dominates the

YSR Kadapa district of Andhra Pradesh, outnumbering other fruit crops such as banana, papaya, and sweet orange. The subject of this study is the YSR Kadapa district, which is located in the southern tract of Andhra Pradesh and is classified as a horticulture district. The district has a tropical climate with medium rainfall (average annual rainfall of 763 mm) and is located between the latitudes of 14.280 and 14.666 N and the longitudes of 78.490 and 78.816 E . It is irrigated and rainfed.

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The usage of fertilisers and insecticides in an unbalanced manner has impeded mango yield. Fruit plant nutrition is determined by the soil's intrinsic ability to give nutritious elements. The appropriate application of fertilisers based on soil testing is the key to plant mineral nutrition. Plant analysis is also used to confirm nutrient deficits and toxicities, as well as to evaluate fertiliser dose efficacy. If mango productivity is to be raised, it is critical to concentrate on soil nutrient availability and other nutrient-related features. Soil fertility is determined by the total nitrogen, phosphorous, potassium, and sulphur content of soils, as well as their availability to plants. Mango orchard management strategies include monitoring the soil nutrient condition (Joshi *et al.*, 2015). Both soil and plant analyses are required to determine this, as they are complementary to one another and each provides information that the other may not. The nutritional quality of both the soil and the plants aids in determining the orchard's fertiliser requirements. There has been no comprehensive study of the nutritional value of Andhra Pradesh's mango orchards. The findings could aid in the design of future nutritional status based fertiliser recommendations in the aforementioned regions.

Using the Global Positioning System (GPS) and Geographical Information System (GIS) tools, the study evaluated some physico-chemical and chemical parameters of mango-growing soils in the YSR district of Andhra Pradesh.

MATERIALS AND METHODS

Detailed soil surveys were conducted in 12 mandals of the YSR Kadapa district in the years 2019-2020, with Sambepalle, Rayachoty,

Chinnamandem, Galiveedu, Chakrayapeta, Lakkireddypalle, Ramapuram, Veeraballi, T.Sundupalle, Koduru, Penagaluru, and Chitvel being chosen to prepare GPS and GIS based thematic soil fertility maps and to identify soil related constraints for Mango production. For soil sample sites in mango-growing areas, a GPS instrument (GARMIN, GPS map 60CSx) was used to collect location details. Using a hand-held GPS instrument, the latitude and longitudes of soil sample locations were gathered in the study region (GARMIN-GPS60CSx). GPS technology proved to be quite effective in improving the spatial precision of data in the GIS. This research made use of the ArcGIS 1.10.3 programme. Prepared point feature displaying the position of samples in MS-excel format and linked with the spatial data using the join option in Arc Map based on the location data acquired. For the development of spatial distribution maps and the resulting map, the spatial and non-spatial databases created are combined.

Interpolation of point data was used to create maps of soil spatial variability. ARC/Info software was used to map the geo referenced soil test data for all parameters such as pH, EC, available N, available P, available K, available sulphur, and micronutrients. The cutoff values indicating the mean one SD were used to divide the soil test results into separate zones (Standard deviation). The point data was then interpolated to produce a continuous surface. Ordinary kriging was employed as an interpolation approach.

250 surface soil samples (0-30 cm) were collected, air-dried, visible roots and debris were eliminated, huge aggregates were smashed with a wooden hammer, pulverised, and sieved using

a 2 mm sieve. The samples were kept in plastic bags with correct labelling and transported to the lab for analysis, where they were stored in fabric bags with proper labelling. While processing the soil samples in the laboratory, all measures were taken. Using pH and EC metres, the pH and EC of the soil samples (soil and distilled water ratio 1: 2.5) were determined (Jackson, 1973). Wet oxidation was used to determine the organic matter content of soils (Walkley and Black, 1934). Available nitrogen was assessed using the alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus was determined using the colorimetry method (Olsen et al., 1954), and available potassium was determined using the neutral normal ammonium acetate method (Subbiah and Asija, 1956). (Jackson, 1973). The research area's base map was scanned and geo-referenced. On the geo-referenced map, polygons were overlay. Thematic soil fertility maps (Figs. 1–3) were created by entering the latitude and longitude of the point data generated by the soil study into an attribute table and processing it with ArcGIS software.

RESULTS AND DISCUSSION

Physico-chemical properties

Soil reaction (pH) and electrical conductivity (EC)

The soil reaction (pH) of the surface soils of several fields in the YSR district ranged from 7.44 to 8.15, with an overall mean value of 7.66 (Table 1), indicating that the soils are moderately alkaline in reaction. The electrical conductivity of the soils ranged significantly from 0.11 dS m⁻¹ to 0.68 dS m⁻¹, with an overall mean value of 0.27 dS m⁻¹ (Table 1), and was found to be within

safe limits with no risk of salinity. The lower pH of surface soils could be attributed to the presence of more organic matter, which resulted in the release of organic acids during decomposition, lowering the pH of surface soils. Low organic matter and leaching of exchangeable bases to lower layers could explain the higher pH in subsurface soils. The higher pH values in orchard soils can be linked to the fact that fine-textured soils like sandy clay and sandy clay loam have less base leaching. Chetna and Prasad (2011), Surwase *et al.* (2016), and Adak *et al.* (2016) all reported similar findings (2019).

The soil samples electrical conductivity (EC) ranged from 0.11 to 0.68 dS m⁻¹, with a mean value of 0.27 dS m⁻¹ (Table 1). The EC of the orchard soils was much below 4.0 dS m⁻¹, indicating that they were non-saline in nature. The normal electrical conductivity (1.0 dS m⁻¹) observed in this investigation was beneficial to plant growth.

ORGANIC CARBON

The organic carbon status of the surface soils of various fields in the YSR district ranged from 0.13 to 0.72 percent, with a mean value of 4.20 g kg⁻¹ (Table 1). The soils of Chitveland Penagaluru mandals had the highest mean value of organic carbon (0.52%), while the soils of T.Sundupalle had the lowest mean value (0.34%). The organic carbon level of the soils ranged from low to medium (Awanish *et al.* 2014).

Organic carbon levels in the study area soils were low to medium, and they were higher in the surface soil than in the sub-surface soil. They decreased with depth, which could be due to the accumulation of organic carbon in the

surface layer as opposed to the lower layers, because organic matter additions in mango growing soils were confined to the surface layer. (Swathi *et al.*, 2018).

AVAILABLE MACRONUTRIENTS

The available nitrogen content of several YSR Kadapa district mango orchards ranged from 125 to 388 kg ha⁻¹, with a mean value of 229.65 kg ha⁻¹ (Table 2). Chitvel mandal soils had the highest mean value for accessible nitrogen (267.79 kg ha⁻¹), whereas Chinamandem mandal soils had the lowest mean value of 204.05 kg ha⁻¹. Phosphorus availability in soils ranged from 5 to 70 kilogramme ha⁻¹, with a mean of 21.28 kg ha⁻¹ (Table 2). The soils of Chinnamandem mandal had the highest mean value of accessible phosphorus (26.00 kg ha⁻¹), while the soils of Galiveedu mandal had the lowest, at 15.48 kg ha⁻¹. Soil potassium availability ranged dramatically from 74 to 666 kg ha⁻¹, with a mean of 264.11 kg ha⁻¹ (Table 2). Ramapuram mandal soils had the most accessible potassium (444.73 kg ha⁻¹), whereas Veeraballi mandal soils had the lowest (119.49 kg ha⁻¹). Low in accessible nitrogen, low to medium in available phosphorus, and medium to high in available potassium, the soils were classified. Nitrogen losses by leaching, surface runoff, denitrification, and ammonia volatilization, differences in natural fertility, variations in cultural practises, and variations in applied N fertilisers could all contribute to variations in N content. The available nitrogen content in the surface soil was higher than in the lower depths of the soil, possibly due to the presence of more organic matter in the surface soil than in the sub-surface soil. Variations in P content owing to crop culture restriction to the rhizosphere and external P

supplementation (fertilisers), fixing of released P by clay minerals and iron and aluminium oxides. Weathering, release of relevant K from organic residues, use of K fertilisers, and upward translocation of K from lower depths combined with capillary rise could all contribute to differences in K concentration. Ranjhaet al. (2002) and Joshi *et al.* (2003) both reported similar findings (2015).

Out of all the soils investigated in mango orchards, 38.8% were neutral, 41.2 percent were weakly alkaline, 19.2 percent were moderately alkaline, and 0.8 percent were very alkaline, although all the orchards were non-saline. 75.6 percent of soils had a low level of organic carbon, whereas 24.4 percent had a medium level of organic carbon. Furthermore, 86 percent of soils had low available nitrogen, 14 percent had medium available nitrogen, 5.6 percent had low available phosphorus, 92 percent had medium available phosphorus, and 2.4 percent had high available phosphorus. In terms of accessible K, 32 percent of soils had low levels, 35.2 percent had medium levels, and 32.8 percent had high levels.

CONCLUSION

The soil reactivity of mango-growing soils in the YSR Kadapa district is neutral to moderately alkaline, non-saline in character, and low to medium in organic carbon concentration. Low in accessible nitrogen, low to medium in available phosphorus, and medium to high in available potassium, the soils were classified. For optimum mango production, this fertility state of mango orchard soils necessitates regulation of N and P fertiliser treatments with native available K. It also emphasises the necessity of mapping

Table1. Physico-chemical properties of selected mango growing soils of YSR Kadapa district

S. No.	Name of the village(*)	pH		EC(dSm ⁻¹)		Organic carbon(%)	
		Range	Mean	Range	Mean	Range	Mean
1	Sambepalle (20)	6.95-8.15	7.44	0.11-0.27	0.18	0.30-0.53	0.38
2	Rayachoty(22)	7.1-8.25	7.71	0.18-0.31	0.24	0.29-0.53	0.42
3	Chinnamandem (21)	7.15-8.25	7.70	0.16-0.37	0.28	0.27-0.55	0.44
4	Galiveedu (21)	7.35-8.5	7.82	0.18-0.41	0.31	0.25-0.57	0.41
5	Chakrayapeta(21)	6.72-8.35	7.50	0.11-0.58	0.28	0.27-0.72	0.48
6	Lakkireddypalle (20)	6.75-8.25	7.60	0.17-0.48	0.32	0.27-0.52	0.38
7	Ramapuram (21)	7.78-8.45	8.15	0.12-0.66	0.32	0.23-0.63	0.40
8	Veeraballi(21)	7.28-8.54	7.88	0.17-0.67	0.40	0.13-0.51	0.35
9	T.Sundupalle (23)	7.57-8.62	7.92	0.14-0.68	0.27	0.2-0.49	0.34
10	Penagaluru (21)	6.8-7.7	7.26	0.12-0.56	0.26	0.27-0.72	0.52
11	Koduru (19)	6.9-7.9	7.42	0.16-0.28	0.21	0.26-0.69	0.41
12	Chitvel (20)	7.2-8.0	7.53	0.13-0.34	0.20	0.3-0.72	0.52
	Mean	-		0.27		0.42	
	SD	0.24		0.06		0.06	
	CV%	3.15		21.71		13.59	

(*) Note: Figures in parenthesis indicate the number of samples

Table2. Available NPK nutrient status in selected mango growing soils of YSR Kadapa district

S. No.	Name of the village(*)	Available Nitrogen(kg ha ⁻¹)		Available Phosphorus(kg ha ⁻¹)		Available Potassium(kg ha ⁻¹)	
		Range	Mean	Range	Mean	Range	Mean
1	Sambepalle (20)	156 - 295	219.99	10-36	19.46	78 -160	119.93
2	Rayachoty(22)	175 – 275	228.22	13-39	23.11	98 -186	134.3
3	Chinnamandem (21)	161 - 231	204.05	18 -38	26.00	110-186	143.27
4	Galiveedu (21)	166 - 269	206.02	9 - 28	15.48	145 - 610	363.10
5	Chakrayapeta(21)	183 -388	257.97	10 - 39	22.26	118 - 426	276.96
6	Lakkireddypalle (20)	137-300	237.14	8- 38	20.15	177 - 384	300.27
7	Ramapuram (21)	198 -321	255.76	12 - 35	23.13	348 – 666	444.73
8	Veeraballi(21)	139 - 307	225.36	7 - 44	19.80	74 -188	119.49
9	T.Sundupalle (23)	125 - 307	214.42	5 -39	19.11	86 -531	154.37
10	Penagaluru (21)	175-277	227.04	9 - 70	24.10	250 - 436	345.90
11	Koduru (19)	159 - 290	212.14	10 - 41	22.60	205 -458	338.06
12	Chitvel (20)	213 - 316	267.79	9 – 44	20.20	246 - 616	428.94
	Mean	229.65		21.28		264.11	
	SD	20.14		2.68		118.47	
	CV%	8.77		12.58		44.86	

(*) **Note:** Figures in parenthesis indicate the number of samples

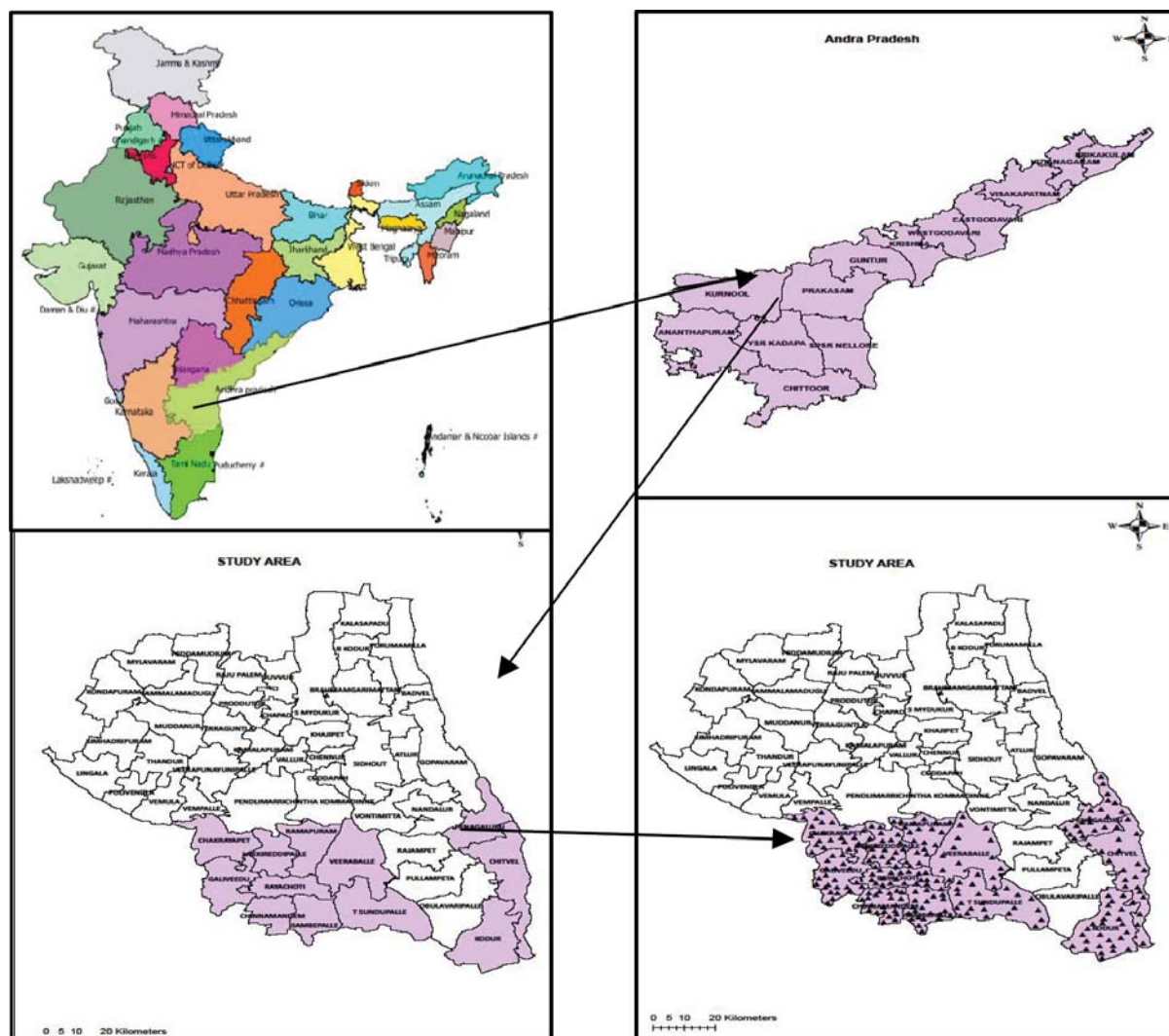


Fig. 1. Map of the study area

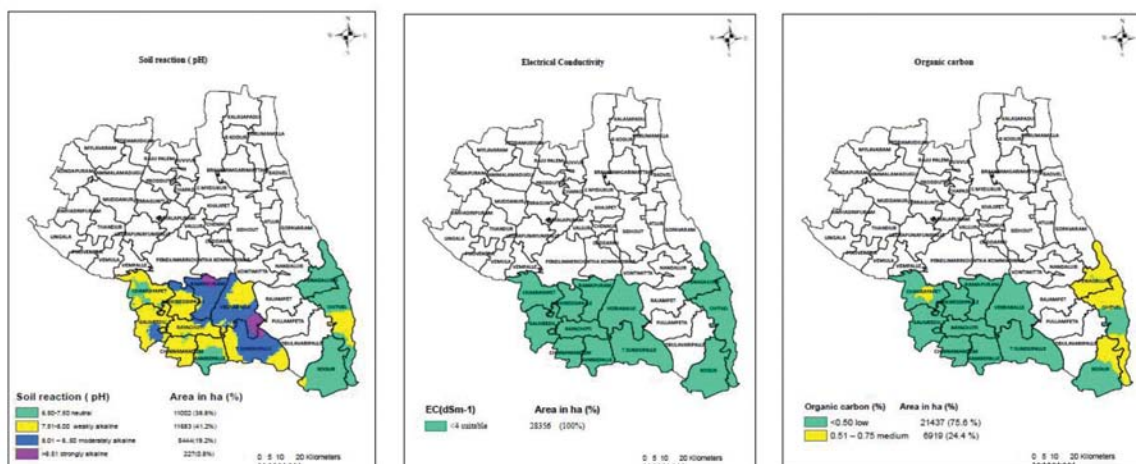


Fig. 2. Soil pH, EC and OC maps of study area of YSR Kadapa District

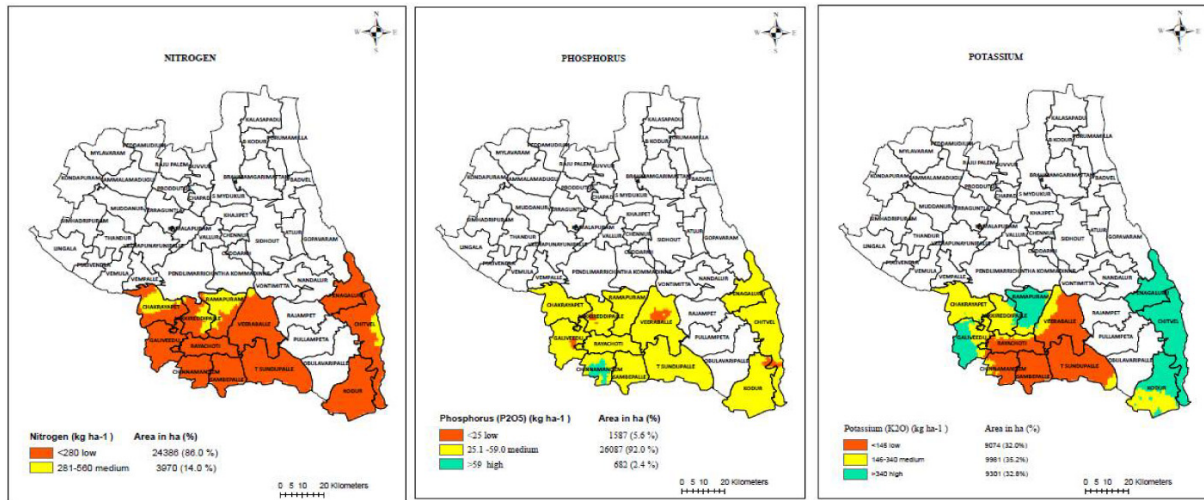


Fig. 3. Soil available N, P and K maps of study area of YSR Kadapa District

different soil fertility metrics over the traditional method of assessing soil fertility using mean values for the factors in question. The employment of a GPS instrument and a Geographic Information System (GIS) for collecting soil samples and creating spatial variable fertility maps in the study region will benefit the local farming community in a variety of ways. It aids in the ongoing monitoring of soil health by bringing soil samples from the same locations as those used in the current inquiry. Changes in soil fertility status can be monitored and corrective methods advised to preserve soil health for sustained mango crop production by collecting and analysing geo-referenced soil samples at defined intervals.

REFERENCES

- Awanish, K., Mishra, V.N., Srivastava, L.K and Rakesh, B. 2014. Evaluations of soil fertility status of available major nutrients (N, P and K) and micro nutrients (Fe, Mn, Cu and Zn) in vertisol of Kabeerdham district of Chhattisgarh, India. *International Journal of Inter-disciplinary and Multidisciplinary Studies*. 1(10): 72-79.
- Chetna, K.L and Prasad, J. 2011. Characteristics and classification of orange-growing soils developed from different parent materials in Nagpur district, Maharashtra. *Journal of the Indian Society of Soil Science*. 59 (3): 209-217.
- GoI. 2015. Indian Horticulture Database of National Horticulture Board -2015. Retrieved from the website (www.nhb.gov.in).
- Jackson, M.L. 1973. *Soil Chemical Analysis*. Oxford IBH Publishing House, Bombay. pp. 38-40.
- Joshi, N.S., Vaidya, K.P and Pawar, C.D. 2015. Assessment of physico-chemical properties in soil from Mango orchards of Ratnagiri district. *International Journal of Agricultural Science and Research (IJASR)*. 5(2):131-136.
- Olsen, S.R., Cole, C.V., Watanabe, F.S and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular 939, March

- 1954 Washington DC, USDepartment of Agriculture. pp. 19-20.
- Ranjha, A.M., Akram, M., Mehendi, S.M., Sadiq, M., Sarfraz, M and Hasan, G. 2002. Nutritional status of citrus in Sahiwal district. Online Journal of Biological Sciences. 2(7): 453-458.
- Subbiah, B.V and Asija, C.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. Current Science. 25: 32.
- Surwase, S.A., Kadu, P.R and Patil, D.S. 2016. Soil micronutrient status and fruit quality of orange orchards in Kalmeshwar Tahsil, District Nagpur (MS). Journal of Global Biosciences. 5: 3523-3533.
- Swati Sharma, Mamjeet Kaur and Verma, M.L. 2018. Soil fertility and leaf nutrient status of macronutrients in mango orchards under Kangra district of Himachal Pradesh. International Journal of Chemical Studies. 6(3):1317-1322.
- Tarun Adak, Kailash Kumar and Vinod Kumar Singh. 2019. Assessment of soil micronutrients from a mango based agroecology of Malihabad, Uttar Pradesh, India. Tropical Plant Research. 6(2): 176–182.

IN SILICO ANALYSIS PREDICTS AN AMINO ACID PERMEASE FAMILY PROTEIN AS THE PUTATIVE CANDIDATE GENE UNDERLYING A MAJOR QTL FOR TILLER NUMBER IN RICE (*Oryza sativa* L.)

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ABSTRACT

Rice (*Oryza sativa* L.) yield and its component traits are known to have complex inheritance and are controlled by several genes with small effects. Although several genomic regions or quantitative trait loci (QTLs) are identified for a galaxy of traits in rice, only a few candidate genes underlying these QTLs have been functionally characterized as involvement of the laborious and time-consuming fine mapping and map-based cloning strategies. However, with the advances in sequencing technologies, now a wealth of information related to genomics, transcriptomics, proteomics and metabolomics has been publicly available. Exploiting these databases, in the present investigation, we predicted amino acid permease (AAP) (LOC_Os01g71720), as a candidate gene underlying a major effective QTL for tiller number. The candidature of the OsAAP for tiller number QTL has been endorsed by the literature mining, QTG finder, GO analysis, sequence variation, and gene expression analysis. Therefore, this OsAAP could be targeted for further functional analysis before being exploited in future rice breeding.

Keywords: Amino acid permease, Candidate gene Rice, *In silico* analysis, QTL, Tiller number

INTRODUCTION

Rice (*Oryza sativa* L.) yield is primarily determined by its key component traits such as grain number, panicle number, and grain weight. Decades of research in rice, explicitly state that these yield component traits are controlled by several genes with small effects often called quantitative trait loci (QTL). Tiller number is one of the key yield traits that determine the final panicle number in a plant thereby yield as well.

The tiller number is a genetically complex and low heritability trait with quantitative inheritance and is controlled by several genes with epistatic and pleiotropic effects.

As of now, several genes regulating tiller number have been identified in rice. Some of the important candidate genes governing tiller number are the bHLH transcription factor (Oikawa and Kyoizuka 2009), GA20 oxidase (Wu *et al.*,

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2016), Pseudo-response regulator (Yan *et al.*, 2013; Ye *et al.*, 2018), Acceptor kinase (Suzaki *et al.*, 2004), PEBP family protein (Nakagawa *et al.*, 2002), CCT domain protein family (Xue *et al.*, 2008; Itoh *et al.*, 2010), Phospholipase (Qiao *et al.*, 2011), HAP3 subunit of the CCAAT box-binding transcription factor (Wei *et al.*, 2010) and amino acid permease family (OsAAP) proteins (Fang *et al.*, 2021). As of now, 14 QTLs have been identified for tiller number as per the QTARO database (Yonemaru *et al.*, 2010) and much more might have been identified in the literature since 2012. However, very few genes underlying these QTLs have been cloned for tiller number mainly due to the laborious and time-consuming fine mapping and map-based cloning approaches. However, it is necessary to identify candidate genes in the QTL regions for a complete mechanistic understanding of the tiller number trait.

The completion of high-quality reference rice genome led to the numerous publicly available databases for genomics, transcriptomics, proteomics, and metabolomics together referred to as multi-omics approaches. The important databases for genomics are gramene (Tello-Ruiz *et al.*, 2017), RAP-DB (Ohyanagi *et al.*, 2006), RiceVarmap (Zhao *et al.*, 2015), etc. and for transcriptomics RiceXPro (Sato *et al.*, 2013), RED (Xia *et al.*, 2017), etc. and for proteomics PRIN (Gu *et al.*, 2011), RiceNet (Lee *et al.*, 2015), etc. and for metabolomics RICECYC (Jaiswal *et al.*, 2006). These databases comprising of a wealth of information such as gene sequence variation, gene expression, protein structure and function, protein-protein interaction (PPI), gene ontology (GO), KEGG pathways, and metabolite information. By exploiting these databases, now

it is easy to prioritize the candidate genes underlying the QTL regions for which obviating the need for the complicated fine-mapping strategy. Earlier, Bargsten *et al.* (2014) used gene ontology (GO) analysis to prioritize the candidate genes. Later, Karnatam *et al.* (2020) also shortlisted putative candidate genes in the major effect QTL, qDTY1.1 employing publicly available rice genome databases.

Recently, software called QTG-Finder 2 (Lin *et al.*, 2020) has been developed to prioritize the candidate genes in the QTL regions in the rice and Arabidopsis system. This QTG-finder exploits the publicly available information on sequence variation, gene expression analysis, GO analysis, and orthologous regions to prioritize the candidate genes in QTL regions.

In the present study, we aimed to prioritize the candidate gene(s) underlying a major effect QTL *qTN*, which governs tiller number (Courtois *et al.*, 2003) for which so far no candidate genes have been identified. To this end *in silico* approaches such as QTG-Finder, RiceVarmap, GO analysis, etc., have been used.

MATERIALS AND METHODS

Selection of the QTL for tiller number

In the present investigation, we have retrieved all the QTLs governing tiller number from the QTARO database. Of them, a major QTL for tiller number with LOD 4.8 and explain the phenotypic variance of 18.4% (Courtois *et al.*, 2003) have been considered. This QTL is located on chromosome 1 with a marker interval of RZ801 and RZ14. We have retrieved all the annotated genes within this marker interval based on the coordinates (41444285 and 42364623) provided in the QTARO, from the RAP-DB database.

Prioritization of candidate genes in the tiller number QTL (qTN)

In order to prioritize the candidate genes in the targeted QTL qTN, we have explored several publicly available in silico databases and tools in rice. First of all, literature mining was explored using the keywords of each annotated gene in the QTL region after excluding alternately spliced transcripts of the same gene, hypothetical and expressed proteins besides transposon-related genes. For instance, the keywords used were “tiller number”, “rice” and “name of the annotated gene”. We predicted a candidate gene whenever a gene with the same function was associated with the tiller number in any of the crop plants or model plants in the search results. Later QTG-Finder 2 was also used for gene prioritization. The top three annotated genes were considered for gene prioritization. In addition, gene ontology (GO) analysis using PlantRegmap (Tian *et al.*, 2020), gene expression analysis using the RED, and protein-protein interaction (PPI) data using PRIN were carried out. Also, we used RiceVarmap to find the sequence variation, gene expression, and haplotype analysis. Additionally, we have retrieved the differentially expressed genes from previous reports and also used them for gene prioritization. Finally, the gene that is present in the majority of the databases has been considered as a candidate gene for the targeted QTL.

RESULTS AND DISCUSSION

The targeted QTL for tiller number, qTN, in the present study is a major QTL with LOD 4.8 and PVE 18.4% and located on chromosome 1 with a marker interval of RZ801 and RZ14. This QTL was developed using the Recombinant

inbred line (RIL) population derived from a cross of IAC165 × Co39 (Courtois *et al.*, 2003). As per RAP-DB, this QTL has 175 annotated genes. The candidate gene(s) underpinning this QTL region were prioritized or predicted based on the available rice genome databases or tools employing various criteria such as literature mining, QTG Finder, GO analysis, gene expression, PPI, and sequence variation. Among total annotated genes, after exclusion of alternately spliced transcripts of the same gene, hypothetical, expressed, and transposon related genes 87 genes were used finally for gene prioritization (Table 1).

First, using the literature mining method, we identified six genes found to be related to the tiller number (Table 2). The QTG finder tool prioritized three annotated genes viz., LOC_Os01g72370 (helix-loop-helix DNA-binding domain-containing protein), LOC_Os01g71720 (amino acid permease family protein), and LOC_Os01g72970 (DUF630/DUF632 domains containing protein) (Table 2).

Among them, one amino acid permease family protein gene was found to be promising as it was already reported to regulate tiller number (Fang *et al.*, 2021). GO analysis of the annotated genes in the QTL region revealed single-organism process, the single-organism cellular process, and the single-organism metabolic process are the top three GO terms. In the annotated genes, the OsAAP gene i.e., LOC_Os01g71720 also found in the top GO term single-organism process and single-organism cellular process (Fig. 1). The gene expression analysis employing the RiceVarmap database suggests that the OsAAP gene identified in the present study is highly expressed in leaf tissues

Table 1. Annotated genes in the QTL region as per RAP-DB after excluding unknown/hypothetical genes

S.No.	Locus ID	Coordinates	Gene annotation
1	LOC_Os01g71558	41485349-41486014	phototropic-responsive NPH3 family protein
2	LOC_Os01g71650	41525723-41526415	glycosyl hydrolases family 17
3	LOC_Os01g71670	41533273-41535619	glycosyl hydrolases family 17
4	LOC_Os01g71680	41536977-41538320	glycosyl hydrolases family 17
5	LOC_Os01g71690	41539690-41545870	recA protein
6	LOC_Os01g71700	41549008-41551494	amino acid permease family protein
7	LOC_Os01g71710	41552037-41554504	amino acid permease family protein
8	LOC_Os01g71720	41554884-41559339	amino acid permease family protein
9	LOC_Os01g71740	41563978-41566629	amino acid permease family protein
10	LOC_Os01g71760	41570750-41573307	amino acid permease family protein
11	LOC_Os01g71770	41573907-41578834	RNA recognition motif containing protein
12	LOC_Os01g71780	41582224-41583944	WD domain, G-beta repeat domain containing protein
13	LOC_Os01g71790	41584367-41585318	NAM
14	LOC_Os01g71800	41585905-41587063	lecithin cholesterol acyltransferase
15	LOC_Os01g71810	41592216-41594985	glycosyl hydrolases family 17
16	LOC_Os01g71820	41597270-41598692	glycosyl hydrolases family 17
17	LOC_Os01g71830	41603297-41604680	glycosyl hydrolases family 17
18	LOC_Os01g71860	41629299-41631914	glycosyl hydrolases family 17
19	LOC_Os01g71930	41677883-41681805	glycosyl hydrolases family 17 protein
20	LOC_Os01g71960	41691174-41698706	endonuclease
21	LOC_Os01g71970	41711881-41713811	GRAS family transcription factor containing protein
22	LOC_Os01g71980	41716009-41717755	rho-GTPase-activating protein-like
23	LOC_Os01g71990	41718016-41721574	pyrroline-5-carboxylate reductase
24	LOC_Os01g72000	41722424-41726252	armadillo repeat-containing protein
25	LOC_Os01g72020	41741160-41744666	BTBA3 - Bric-a-Brac, Tramtrack, Broad Complex BTB domain with Ankyrin repeat region
26	LOC_Os01g72080	41818279-41819489	calmodulin-like protein 1
27	LOC_Os01g72090	41822269-41825087	phycoerythrobilin ferredoxin oxidoreductase
28	LOC_Os01g72100	41825882-41827156	OsCML10 - Calmodulin-related calcium sensor protein
29	LOC_Os01g72120	41839949-41841440	glutathione S-transferase
30	LOC_Os01g72130	41841760-41842549	glutathione S-transferase
31	LOC_Os01g72140	41844009-41845691	glutathione S-transferase
32	LOC_Os01g72150	41846413-41847370	glutathione S-transferase
33	LOC_Os01g72160	41847705-41849080	glutathione S-transferase
34	LOC_Os01g72170	41853850-41854883	glutathione S-transferase

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35	LOC_Os01g72205	41867501-41869645	prolinesynthetase co-transcribed bacterial homolog protein
36	LOC_Os01g72210	41869930-41874402	early-responsive to dehydration protein-related
37	LOC_Os01g72220	41873949-41880601	WD domain, G-beta repeat domain containing protein
38	LOC_Os01g72230	41882488-41886410	stromal membrane-associated protein
39	LOC_Os01g72240	41887067-41890850	uridine 5-monophosphate synthase
40	LOC_Os01g72250	41892678-41896242	uridine 5-monophosphate synthase
41	LOC_Os01g72260	41896504-41898331	cytochrome P450
42	LOC_Os01g72270	41900002-41901651	cytochrome P450
43	LOC_Os01g72280	41904210-41907453	tetratricopeptide repeat containing protein
44	LOC_Os01g72300	41917699-41919129	Cupin domain containing protein
45	LOC_Os01g72310	41919630-41925302	OsFBO7 - F-box and other domain containing protein
46	LOC_Os01g72320	41925595-41931602	FYVE zinc finger domain containing protein
47	LOC_Os01g72330	41948952-41952388	OsRR4 type-A response regulator
48	LOC_Os01g72340	41954633-41962787	beta-galactosidase
49	LOC_Os01g72350	41964126-41970144	amidohydrolase
50	LOC_Os01g72370	41971444-41978408	helix-loop-helix DNA-binding domain-containing protein
51	LOC_Os01g72390	41986078-41988856	NBS type disease resistance protein
52	LOC_Os01g72410	41997451-42000861	Leucine Rich Repeat family protein
53	LOC_Os01g72420	41999585-42002803	C2 domain-containing protein
54	LOC_Os01g72430	42003931-42009785	NADPH quinone oxidoreductase
55	LOC_Os01g72450	42012737-42013581	DNA binding protein
56	LOC_Os01g72460	42018059-42019514	NADPH quinone oxidoreductase
57	LOC_Os01g72480	42025672-42027986	zinc finger, C3HC4 type domain-containing protein
58	LOC_Os01g72490	42037167-42039107	LRP1
59	LOC_Os01g72510	42058936-42060584	eukaryotic aspartyl protease domain-containing protein
60	LOC_Os01g72520	42063181-42067788	phosphoesterase family protein
61	LOC_Os01g72530	42073984-42074982	OsCML31 - Calmodulin-related calcium sensor protein
62	LOC_Os01g72540	42078682-42079137	OsCML23 - Calmodulin-related calcium sensor protein
63	LOC_Os01g72550	42080116-42080556	OsCML19 - Calmodulin-related calcium sensor protein
64	LOC_Os01g72600	42122517-42123788	spotted leaf 11
65	LOC_Os01g72610	42128326-42130347	glycosyltransferase
66	LOC_Os01g72650	42149710-42156852	RNA recognition motif-containing protein
67	LOC_Os01g72680	42169412-42172204	disease resistance protein RPS2
68	LOC_Os01g72690	42177832-42183727	NAD kinase
69	LOC_Os01g72730	42202447-42203895	cytochrome P450
70	LOC_Os01g72740	42206304-42208513	cytochrome P450
71	LOC_Os01g72760	42211882-42213692	cytochrome P450
72	LOC_Os01g72790	42229506-42232641	cyclin-dependent kinase

73	LOC_Os01g72800	42234584-42237458	signal recognition particle receptor
74	LOC_Os01g72810	42238811-42240567	secreted glycoprotein
75	LOC_Os01g72820	42240786-42245248	CRS1/YhbY domain-containing protein
76	LOC_Os01g72834	42247696-42255403	RNA recognition motif-containing protein
77	LOC_Os01g72850	42255655-42257190	GDSL-motif lipase/hydrolase family protein
78	LOC_Os01g72860	42260295-42264942	MAC/Perforin domain-containing protein
79	LOC_Os01g72870	42265021-42268518	BAS1
80	LOC_Os01g72880	42268880-42274913	DNA mismatch repair protein Mlh1
81	LOC_Os01g72900	42281272-42281973	abscisic stress-ripening
82	LOC_Os01g72910	42282832-42283632	abscisic stress-ripening
83	LOC_Os01g72930	42297255-42300253	pentatricopeptide
84	LOC_Os01g72940	42303454-42311177	phosphatidylserine decarboxylase
85	LOC_Os01g72970	42325823-42329066	DUF630/DUF632 domains containing protein
86	LOC_Os01g72980	42329246-42335754	tRNA uridine 5-carboxymethylaminomethyl modification enzyme gidA
87	LOC_Os01g73000	42350927-42355398	copine

(Fig. 2). The sequence variations in the OsAAP identified 292 variations as per RiceVarmap (Fig. 2). The majority of the variations were found in the intronic regions and only one SNP was found in the exonic region. However, the co-expression and protein-protein databases did not provide any clues about the candidature of the OsAAP gene. Based on the above criteria amino acid permease gene (LOC_Os01g71720) was found to be the putative candidate gene for qTN, as it was supported by literature mining, QTG finder,

GO, and gene expression. Amino acid permease (AAP) is a member of the amino acid transporter (AAT) and the family is known to be involved in amino acid uptake, phloem loading, xylem-phloem transfer, and seed loading (Tegeder and Rentsch 2010). In rice, there are 19 AAP transporters have been identified (Fang *et al.*, 2021). However, the AAP in the targeted qTN in the present study appears to be novel as it was not listed in the reported amino acid permease transporters. Previously blocking the expression

Table 2. List of annotated genes found in the literature mining and QTG finder

Gene ID	Gene function	Reference
LOC_Os01g71700	amino acid permease family protein	Fang <i>et al.</i> , 2019
LOC_Os01g71710	amino acid permease family protein	Fang <i>et al.</i> , 2019
LOC_Os01g71720	amino acid permease family protein	Fang <i>et al.</i> , 2019
LOC_Os01g71740	amino acid permease family protein	Fang <i>et al.</i> , 2019
LOC_Os01g71760	amino acid permease family protein	Fang <i>et al.</i> , 2019
LOC_Os01g72410	Leucine Rich Repeat family protein	Zou <i>et al.</i> , 2013
LOC_Os01g72370	helix-loop-helix DNA-binding containing domain-containing protein	QTG finder
LOC_Os01g71720	amino acid permease family protein	QTG finder
LOC_Os01g72970	DUF630/DUF632 domains containing protein	QTG finder

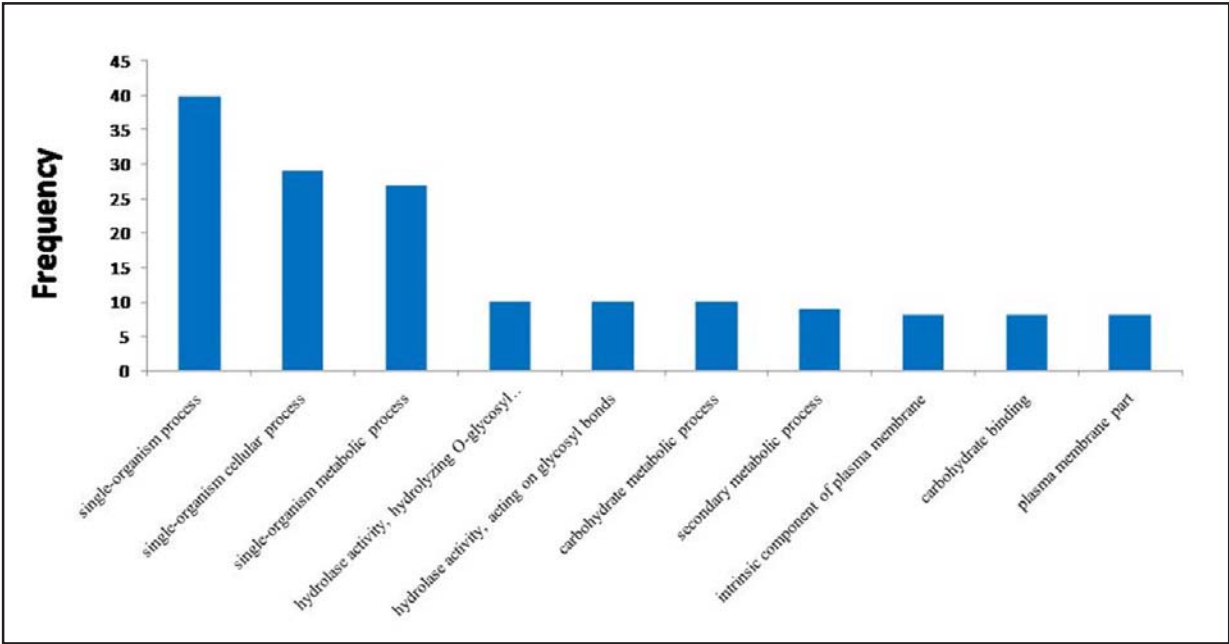


Fig.1. Top 10 GO terms of the annotated genes in the QTL region

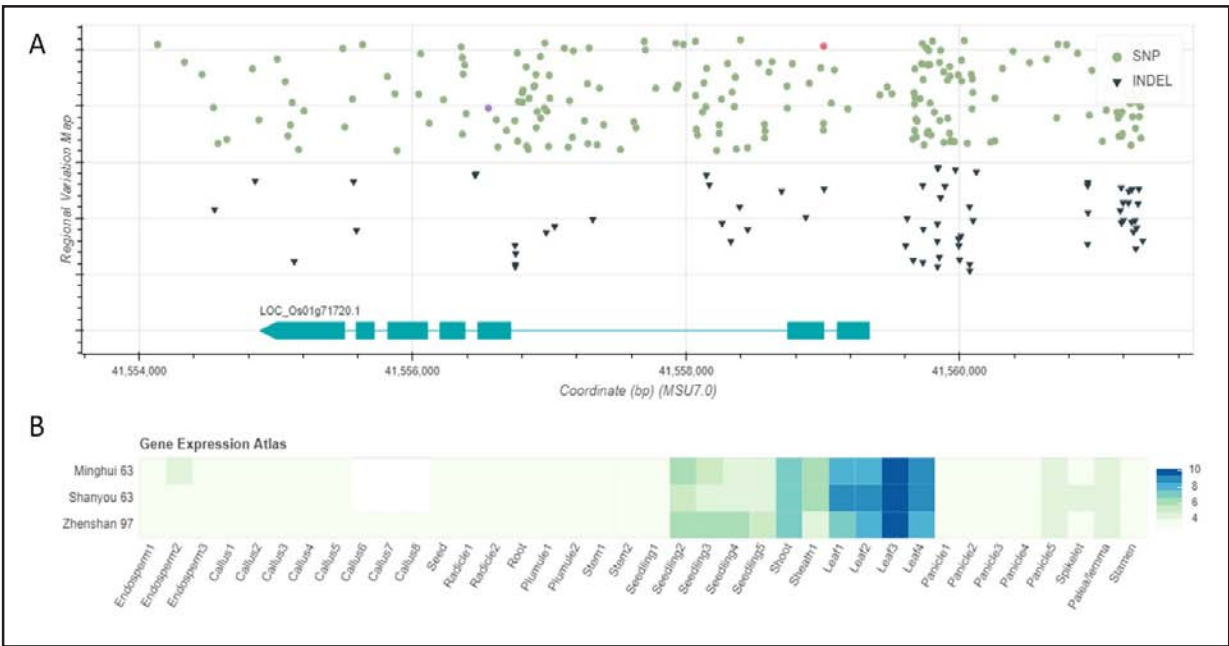


Fig. 2. Sequence variations (A) and expression analysis (B) of the candidate gene as per RiceVarmap

of OsAA3 and more expression of OsAA1, OsAA5 and OsAA4 were found to increase the grain yield (Fang *et al.*, 2021).

CONCLUSION

In the study, a major effect QTL controlling tiller number, qTN was targeted for gene

prioritization. The in silico analysis employing various rice genome databases revealed that amino acid permease (LOC_Os01g71720) is the candidate gene underlying the QTL. Therefore, this OsAAP gene is a potential candidate for further functional analysis. However, an unquestionably thorough examination of the OsAAP is imperative to confirm its role in controlling tiller number for subsequent exploitation in rice breeding for yield enhancement. The gene prioritization criteria used in the present study using different rice genome databases is an excellent approach to dissecting the QTL governing complex traits.

REFERENCES

- Bargsten, J.W., Nap, J., Sanchez-Perez, G.F and Dijk, A.D.J.V. 2014. Prioritization of candidate genes in QTL regions based on associations between traits and biological processes. *BMC Plant Biology*. 14:330.
- Courtois, B., Shen, L., Petalcorin, W., Carandang, S., Mauleon, R and Li, Z. 2003. Locating QTLs controlling constitutive root traits in the rice population IAC 165 × Co39. *Euphytica* 134: 335-345.
- Fang, Z., Wu, B and Ji, Y. 2021. The Amino Acid Transporter OsAAP4 Contributes to Rice Tillering and Grain Yield by Regulating Neutral Amino Acid Allocation through Two Splicing Variants. *Rice*. 14:2.
- Gu, H., Zhu, P., Jiao, Y., Meng, Y and Chen, M. 2011. PRIN: a predicted rice interactome network. *BMC Bioinformatics*. 12:161.
- Itoh, H., Nonoue, Y., Yano, M and Izawa, T. 2010. A pair of floral regulators sets critical day length for Hd3a florigen expression in rice. *Nature Genetics*. 42(7):635-638.
- Jaiswal, P., Ni, J., Yap, I., Ware, D., Spooner, W., Youens-Clark, K., Ren, L., Liang, C., Zhao, W., Ratnapu, K., Faga, B., Canaran, P., Fogleman, M., Hebbard, C., Avraham, S., Schmidt, S., Casstevens, T.M., Buckler, E.S., Stein, L and McCouch, S. 2006. Gramene: a bird's eye view of cereal genomes. *Nucleic Acids Research*. 34: D717–D723.
- Karnatam, K.S., Jaganathan, D., Dilip, K.R., Boopathi, M.N and Muthurajan, R. 2020. Shortlisting putative candidate genes underlying qDTY1.1, a major effect drought tolerant QTL in rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*. 11(3):916-924.
- Lee, T., Oh, T., Yang, S., Shin, J., Hwang, S., Kim, C.Y., Kim, H., Shim, H., Shim, J.E., Ronald, P.C and Lee, I. 2015. RiceNet v2: an improved network prioritization server for rice genes. *Nucleic Acids Research*. pp. 1-6.
- Lin, F., Lazarus, E.Z and Rhee, S.Y. 2020. QTGFinder2: A generalized machine-learning algorithm for prioritizing qtl causal genes in plants. *Genes, Genomes, Genetics*. 10(7): 2411-2421.
- Nakagawa, M., Shimamoto, K and Kyoizuka, J. 2002. Overexpression of RCN1 and RCN2, rice TERMINALFLOWER 1/ CENTRORADIALIS homologs, confers delay of phase transition and altered panicle morphology in rice. *The Plant Journal*. 29(6):743-750.

- Ohyanagi, H., Tanaka, T., Sakai, H., Shigemoto, Y., Yamaguchi, K., Habara, T., Fujii, Y., Antonio, B.A., Nagamura, Y., Imanishi, T., Ikeo, K., Itoh, T., Gojobori, T and Sasaki, T. 2006. The Rice Annotation Project Database (RAP-DB): hub for *Oryza sativa* ssp. japonica genome.
- Oikawa, T and Kyozuka, J. 2009. Two-step regulation of LAX PANICLE1 protein accumulation in axillary meristem formation in rice. *The Plant Cell*. 21:1095–1108.
- Qiao, Y., Piao, R., Shi, J., Lee, S., Jiang, W., Kim, B., Lee, J., Han, L., Ma, W and Koh, H. 2011. Fine mapping and candidate gene analysis of dense and erect panicle 3, DEP3, which confers high grain yield in rice (*Oryza sativa* L.). *Theoretical and Applied Genetics*. 122:1439-1449.
- Sato, Y., Takehisa, H., Kamatsuki, K., Minami, H., Namiki, N., Ikawa, H., Ohyanagi, H., Sugimoto, K., Antonio, B.A and Nagamura, Y. 2013. RiceXPro Version 3.0: expanding the informatics resource for rice transcriptome. *Nucleic Acids Research*. 41: D1206–D1213.
- Suzaki, T., Sato, M., Ashikari, M., Miyoshi, M., Nagato, Y and Hirano, H. 2004. The gene FLORAL ORGAN NUMBER1 regulates floral meristem size in rice and encodes a leucine-rich repeat receptor kinase orthologous to Arabidopsis CLAVATA1. *Development*. 131(22):5649-5657.
- Tegedera, M and Rentsch, D. 2010. Uptake and Partitioning of Amino Acids and Peptides. *Molecular Plant*. 3(6): 997–1011.
- Tello-Ruiz, M.K., Naithani, S., Stein, J.C., Gupta, P., Campbell, M., Olson, A., Wei, S., Preece, J., Geniza, M.J., Jiao, Y., Lee, Y.K., Wang, B., Mulvaney, J., Chougule, K., Elser, J., Al-Bader, N., Kumari, S., Thomason, J., Kumar, V., Bolser, D.M., Naamati, G., Tapanari, E., Fonseca, N., Huerta, L., Iqbal, H., Keays, M., Fuentes, A.M.P., Tang, A., Fabregat, A., D'Eustachio, P., Weiser, J., Stein, L.D., Petryszak, R., Papatheodorou, I., Kersey, P.J., Lockhart, P., Taylor, C., Jaiswal, P and Ware, D. 2017. Gramene 2018: unifying comparative genomics and pathway resources for plant research. *Nucleic Acids Research*. 46:1181-1189.
- Tian, F., Yang, D., Meng, Y., Jin, J and Gao, G. 2020. PlantRegMap: charting functional regulatory maps in plants. *Nucleic Acids Research*. 48(D1):D1104–D1113.
- Wei, X., Xu, J., Guo, H., Jiang, L., Chen, S., Yu, C., Zhou, Z., Hu, P., Zhai, H and Wan, J. 2010. DTH8 Suppresses Flowering in Rice, Influencing Plant Height and Yield Potential Simultaneously. *Plant Physiology*. 153:1747-1758.
- Wu, Y., Wang, Y., Mi, X., Shan, J., Li, X., Xu, J and Lin, H. 2016. The QTL GNP1 encodes GA20ox1, which increases grain number and yield by increasing cytokinin activity in rice panicle meristems. *Genetics*. pp. 1-21.
- Xia, L., Zou, D., Sang, J., Xu, X., Yin, H., Li, M., Wu S., Hu, S., Hao, L and Zhang, Z. 2017. Rice Expression Database (RED): an integrated RNA-Seq-derived gene expression database for rice. *Journal of Genetics and Genomics*. pp. 1-19.

- Xue, W., Xing, Y., Weng, X., Zhao, Y., Tang, W., Wang, L., Zhou, H., Yu, S., Xu, C., Li, X and Zhang, Q. 2008. Natural variation in Ghd7 is an important regulator of heading date and yield potential in rice. *Nature Genetics*. 40(6):761-767.
- Yan, W., Liu, H., Zhou, X., Li, Q., Zhang, J., Lu, L., Liu, T., Liu, H., Zhang, C., Zhang, Z., Shen, G., Yao, W., Chen, H., Yu, S., Xie, W and Xing, Y. 2013. Natural variation in Ghd7.1 plays an important role in grain yield and adaptation in rice. *Cell Research*. 23:969-971.
- Ye, J., Niu, X., Yang, Y., Wang, S., Xu, Q., Yuan, X., Yu, H., Wang, Y., Wang, S., Feng, Y and Wei, X. 2018. Divergent Hd1, Ghd7, and DTH7 alleles control heading date and yield potential of japonica rice in Northeast China. *Frontiers in Plant Science*. 9:1-12.
- Yonemaru, J., Yamamoto, T., Fukuoka, S., Uga, Y., Hori, K and Yano, M. 2010. Q-TARO: QTL Annotation Rice Online Database. *Rice*. 3: (194–203).
- Zhao, H., Yao, W., Ouyang, Y., Yang, W., Wang, G., Lian, X., Xing, Y., Chen, L and Xie, W. 2015. RiceVarMap: a comprehensive database of rice genomic variations. *Nucleic Acids Research*. 43: D1018–D1022.

PREDATORY SPIDERS (ARACHINIDA: ARANEAE) ABUNDANCE AND DIVERSITY IN TRANSGENIC AND NON-TRANSGENIC COTTON FIELDS

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ABSTRACT

The study conducted during *kharif* season of 2020-21 to assess the 'seasonal diversity and abundance of Spiders in Transgenic (Bt) and non-transgenic (non-Bt) cotton fields of Nalgonda district, Telangana state, during *kharif* 2020-21'. Hand-picking method was used for the collection of spiders. A total of 580 spiders from Bt cotton, 776 spiders from non-Bt cotton were collected. Out of those, a total of eight species of spiders on Bt cotton and 10 species of spiders on non-Bt cotton were observed, which belonged to five families of order Araneae. Seasonal diversity and abundance were lower in the month of July and progressively raised from August to November, there after decreased from December to January in both Bt and non-Bt cotton fields. The decreased abundance of spiders in Bt cotton compared to non-Bt cotton might be due to absence of host insect pests that serve as food for spiders. Ecological indices were calculated for analysis of community structure of spiders. The habitat structure of Araneae in both Bt and non-Bt cotton fields is stable and suitable as the H-Values are above 1.5 with equal distribution of spiders (J-values are closer to 1.0) and both had high richness (D-values are closer or above 1.0).

Keywords: Bt cotton, Ecological indices, Hand-picking method, Non-Bt cotton and Spiders

INTRODUCTION

Cotton, *Gossypium hirsutum* L (Malvaceae: Malvales) is one of the most important cash crops of many warm climatic countries of the world i.e., USA, Brazil, China, India and Pakistan etc. and playing a key role in economic, political and social affairs of the world. Indian farmers were named it as 'white gold' and 'king of fibres'. It is useful in producing five basic products i.e., lint, oil, seed

meal, hulls and linters. India ranks first in the world having 11.8 million hectares area under Bt cotton, followed by China and USA (James, 2011). In India, the cotton is grown on 129.57 lakh hectares area with a production of 371 lakh bales and productivity of 486.76 kg/ha⁻¹ (National Cotton Scenario, 2021). It also provides 65% raw material to textile industry and contributed 1/3rd of total foreign exchange

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earning of India (Mayee and Rao, 2002). The climate of India is very suitable for transgenic (Bt) and non-transgenic (non Bt) cotton cultivation. But unfortunately, insect pests cause serious damage to cotton crops. The production of cotton in India is severely hampered by 162 species of insect-pests accounting for 10-30 percent losses (National Centre for Integrated Pest Management, Anonymous, 2014). Major pests of cotton are American bollworm, spotted bollworm, pink bollworm and sucking pests like Leafhoppers, whiteflies, thrips, aphids and mealybug and these insect-pests cause damage to crop throughout the growing season (Shera *et al.*, 2013). However, bollworms have been tackled by introducing Bt cotton. One might expect decreased abundance of susceptible Lepidopteran bollworms and their natural enemies in Bt cotton fields. The number of insecticide applications to control sucking pests is another important factor that can affect arthropod communities and the associated beneficial fauna in Bt cotton fields.

Spiders are essential biological control agents (Laxman *et al.*, 2016). Spiders such as *Neoscona theisi*, *Peucetia viridans* and *Rhene* sp suppress the population of various cotton insect pests. Spiders are abundant invertebrate fauna in any environment (Laxman *et al.*, 2016) and most species are highly beneficial as they feed on insects and small arthropods. Spiders play a key role in integrated pest management of agro-ecosystem. Ecological parameters and taxonomic importance of different species of spiders from cotton fields were investigated by many researchers (Platnick, 2004; Alvi, 2007; Maqsood, 2011). More than 35000 species of spiders have been identified in the world

(Ghavami *et al.*, 2007). Spiders are more common predators of the harmful insects (Nemade *et al.*, 2015). Spiders are one of the most abundant predatory groups, in the terrestrial ecosystems and play important role in pest control (Nemade *et al.*, 2015).

Keeping this in view, the study was conducted to assess the 'Seasonal diversity and abundance of Spiders in Transgenic (Bt) and non-transgenic (non-Bt) cotton fields of Nalgonda district, Telangana state, India'.

MATERIALS AND METHODS

The study was conducted at farmer's fields of transgenic (Bt) cotton (SRCH-639 BG II) and non-transgenic (non-Bt) cotton in semi-arid tropical region of Palem village, Nakrekal Mandal, Nalgonda District, Telangana State, India during *kharif* season of 2020-21. It is located between 17° 13' 49" N and 79° 28' 04" E. Sample was collected every month from July 2020 to January 2021 in the morning hours. Hand-picking method was used for the collection of spiders. For spider population count, five plots each having area of 5m x 5m was selected in both Bt and non-Bt cotton fields. Whole plants were observed visually for spiders. The whole plant was observed from bottom to top and both sides (Upper and lower side) of the plant leaves. The spider population was carefully counted. Spiders were preserved in 70 percent ethyl alcohol in glass vials of size 10 cm x 2.5 cm and labeled. Spiders were identified with the help of keys by comparing the morphological and taxonomical features (Samiayyan, 2014), guide on cotton pests and predators (Dileepkumar *et al.*, 2008) by Regional Agricultural research station Warangal, PJTSAU and also published literature.

Ecological indices of spider species i.e., Species diversity (Shannon-Wiener Index), Species richness (Margalef's Index) and Species evenness (Pielou Evenness Index) were calculated.

1. Species diversity [Shannon-Wiener index (H)]

$$H = -\sum P_i \log P_i$$

Where,

H = Shannon-Weiner index,

\sum = Sum,

$P_i = n_i / N$,

n_i = Number of individuals of each species in the sample,

N = Total number of individuals of all species in the sample.

2. Species evenness [Pielou Evenness Index (J)]

$$J = H/H_{\max}$$

Where,

J = Evenness index,

H = Shannon -Weiner index,

$H_{\max} = \log S$,

S = number of species.

3. Species richness [Margalef's Index(D)]

$$D = \frac{S-1}{\log N}$$

Where,

D = Species richness,

S = total number of species,

N = total number of individuals.

RESULTS AND DISCUSSION

A total of 580 spiders from Bt cotton and 776 spiders from non-Bt cotton were collected by hand-picking during *kharif* season of 2020-

21. Out of those, a total of eight species of spiders on Bt cotton and ten species of spiders on non-Bt cotton were observed, which belonged to five families (Araneidae, Lycosidae, Oxyopidae, Pisauridae and Salticidae) of order Araneae in both Bt and non-Bt cotton fields.

The family Araneidae was the richest with three species followed by Oxyopidae with two species, Lycosidae, Pisauridae and salticidae with one species each on Bt cotton while Araneidae was the richest with three species followed by Oxyopidae, Salticidae and Lycosidae with two species each, Pisauridae with one species each on non-Bt cotton. Similar number of families were recorded in both Bt and non-Bt cotton fields (Fig. 1).

The species *Argiope anasuja* (Writing spider), *Argiopepulchella* (Signature spider) and *Neoscona theisi* (Spotted orb-weaver/Barn spider) of family Araneidae were recorded in both Bt and non-Bt cotton fields. The species *Draposa atropalpis* (Indian wolf spider) belongs to family Lycosidae was recorded in both Bt and non-Bt cotton fields, whereas the species *Hippas agreenalliae* (Wolf spider) of family Lycosidae was recorded in non-Bt cotton fields only. The species *Oxyopessunsndae* (lynx spider) and *Peucetiavidans* (Green lynx spider) of family Oxyopidae were recorded in both Bt and non-Bt cotton fields. The species *Perenethis sindica* (Nursery web spider) of family Pisauridae was recorded in both Bt and non-Bt cotton fields. The species *Hyllus semicupreus* (heavy-bodied jumper spider) of family Salticidae was observed in both Bt and non-Bt cotton fields, whereas the species *Rhene* sp (Jumping spider) of family Salticidae was observed in non-Bt cotton fields only (Table1).

Species			
Order	Family	Bt cotton	Non-bt cotton
Araneae	Araneidae	<i>Argiope anasuja</i> (Thorell)	<i>Argiope anasuja</i> (Thorell)
		<i>Argiope pulchella</i> (Thorell)	<i>Argiope pulchella</i> (Thorell)
		<i>Neoscona theisi</i> (Walckenaer)	<i>Neoscona theisi</i> (Walckenaer)
Lycosidae		<i>Draposa atropalpis</i> (Gravely)	<i>Draposa atropalpis</i> (Gravely)
		<i>Hippasa greenalliae</i> (Black wall)	<i>Hippasa greenalliae</i> (Black wall)
Oxyopidae		<i>Oxyopes sunsндае</i> (Tikader)	<i>Oxyopes sunsндае</i> (Tikader))
		<i>Peucetia viridans</i> (Hentz)	<i>Peucetia viridans</i> (Hentz)
Pisauridae		<i>Perenethis sindica</i> (Simon)	<i>Perenethis sindica</i> (Simon)
		<i>Hyllus semicupreus</i> (Simon)	<i>Hyllus semicupreus</i> (Simon)
Salticidae		-	<i>Rhenesp</i>

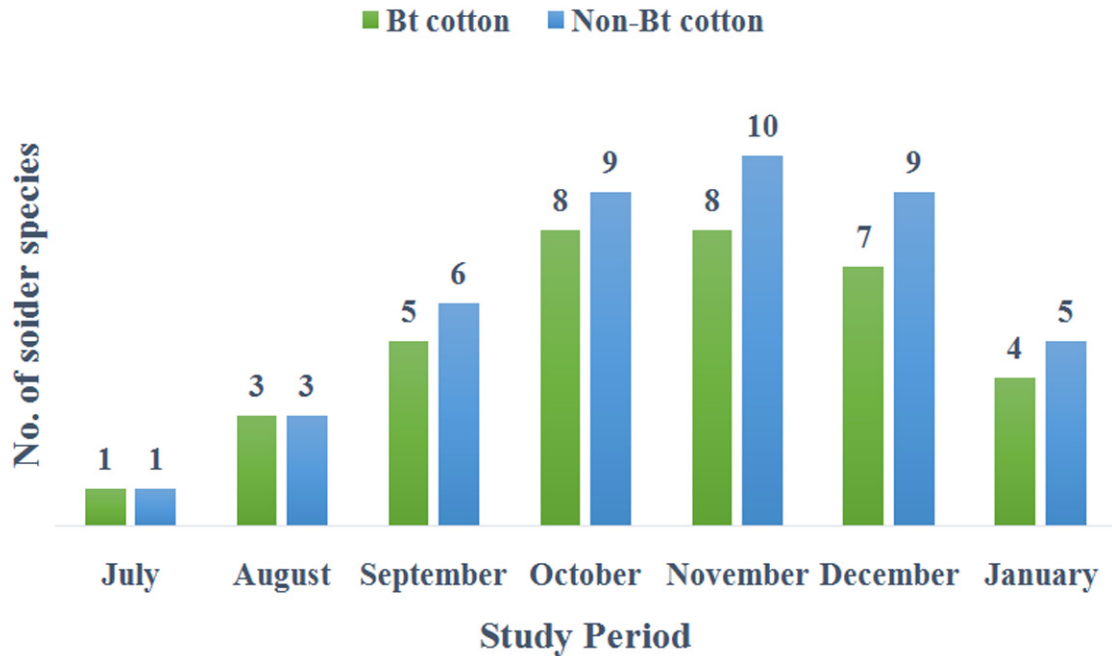


Fig. 1. Number of spider species of different families of order Araneae in both Bt and non-Bt cotton fields during 2020-21

Seasonal diversity and Abundance:

The species *A. anasuja* (Writing spider) was recorded from August to December and peak (4.4 ± 0.244 on Bt and 4.8 ± 0.2 on non-Bt) was recorded in November in both Bt and non-Bt cotton fields. The species *A. pulchella* (Signature spider) was noticed from September to November with peak population of 3 ± 0.547 in Bt and 4.2 ± 0.916 in non-Bt fields was noticed. The species *N. theisi* (Spotted orb-weaver/Barn spider) was initiated from July to January and peak was noticed in September in both Bt (8 ± 0.547) and non-Bt (9.2 ± 1.067) cotton fields. The species *D. atropalpis* (Indian wolf spider) was observed from September to January and peak population was noticed in September in both Bt (4.2 ± 0.489) and non-Bt (5 ± 0.447) cotton fields. The population of *H. greenalliae* (Wolf spider) was noticed from September to January and peak (3.2 ± 1.019) was noticed in November in non-

Bt cotton fields only. The species *O. sunsnda* (lynx spider) was recorded from October to January in both Bt and non-Bt cotton fields with a peak population count of 3 ± 0.707 on Bt in November and 3.6 ± 0.509 on non-Bt in October. The species *P. viridans* (Green lynx spider) was observed from October to December on Bt cotton, whereas the incidence was continued upto January in non-Bt cotton fields and a peak of 5 ± 0.0 on Bt and 5.6 ± 0.4 on non-Bt was noticed in October. The species *P. sindica* (Nursery web spider) was recorded from August to January on Bt, while its incidence was appeared upto December and starting from August on non-Bt cotton with peak population of 3.4 ± 0.927 on Bt and 4 ± 0.316 on non-Bt in November. The species *H. semicupreus* (heavy-bodied jumper spider) was noticed from October to December with a peak of 2.8 ± 0.374 on Bt and 3.4 ± 0.244 on non-Bt in November. The

Table 2. Seasonal diversity and mean abundance (Mean \pm SE) of Spiders in Bt and non-Bt cotton fields

Species		July	August	September	October	November	December	January
<i>Argiope anasuja</i>	Bt	0.0 \pm 0.0	3 \pm 0.70	3.6 \pm 0.50	4.2 \pm 0.37	4.4 \pm 0.24	2.8 \pm 0.2	0.0 \pm 0.0
	non-Bt	0.0 \pm 0.0	3.2 \pm 0.48	3.4 \pm 0.24	4.4 \pm 0.24	4.8 \pm 0.2	2.8 \pm 0.37	0.0 \pm 0.0
<i>Argiope pulchella</i>	Bt	0.0 \pm 0.0	0.0 \pm 0.0	2 \pm 0.54	2.6 \pm 0.50	3 \pm 0.54	0.0 \pm 0.0	0.0 \pm 0.0
	non-Bt	0.0 \pm 0.0	0.0 \pm 0.0	2.4 \pm 0.24	3.8 \pm 0.2	4.2 \pm 0.91	0.0 \pm 0.0	0.0 \pm 0.0
<i>Neoscona theisi</i>	Bt	2 \pm 0.31	5.6 \pm 1.3	8 \pm 0.54	7.8 \pm 0.2	1.4 \pm 0.50	4 \pm 1.04	3.4 \pm 0.92
	non-Bt	2.4 \pm 0.24	6.4 \pm 0.24	9.2 \pm 1.06	8.4 \pm 1.74	1.8 \pm 0.37	5.2 \pm 0.37	4.6 \pm 0.50
<i>Draposa atropalpis</i>	Bt	0.0 \pm 0.0	0.0 \pm 0.0	4.2 \pm 0.48	3.2 \pm 0.37	3.6 \pm 0.67	3 \pm 0.54	2.2 \pm 0.37
	non-Bt	0.0 \pm 0.0	0.0 \pm 0.0	5 \pm 0.44	3.6 \pm 0.92	4 \pm 0.31	3.4 \pm 0.50	2.4 \pm 0.24
<i>Hippasa greenalliae</i>	Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0
	non-Bt	0.0 \pm 0.0	0.0 \pm 0.0	2.4 \pm 0.24	2.8 \pm 0.37	3.2 \pm 1.01	2.4 \pm 0.24	2 \pm 0.44
<i>Oxyopes sunsnda</i>	Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	2.8 \pm 0.58	3 \pm 0.70	2.8 \pm 0.58	1.8 \pm 0.48
	non-Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	3.6 \pm 0.50	3.4 \pm 0.24	3.2 \pm 0.66	2.2 \pm 0.37
<i>Peucetia viridans</i>	Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	5 \pm 0.0	1 \pm 0.54	3.4 \pm 0.81	0.0 \pm 0.0
	non-Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	5.6 \pm 0.4	1.6 \pm 0.4	4.2 \pm 0.2	5.4 \pm 0.4
<i>Perenethis sindica</i>	Bt	0.0 \pm 0.0	2 \pm 0.31	0.2 \pm 0.2	3.4 \pm 0.24	3.4 \pm 0.92	3 \pm 0.31	3 \pm 0.70
	non-Bt	0.0 \pm 0.0	2 \pm 0	0.8 \pm 0.37	3.8 \pm 0.58	4 \pm 0.31	3.2 \pm 0.66	0.0 \pm 0.0
<i>Hyllus semicupreus</i>	Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	2.4 \pm 0.24	2.8 \pm 0.37	2 \pm 0.31	0.0 \pm 0.0
	non-Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	3 \pm 0.31	3.4 \pm 0.24	2.4 \pm 0.24	0.0 \pm 0.0
<i>Rhena</i>	Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0
	non-Bt	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	0.0 \pm 0.0	3.6 \pm 0.24	4.2 \pm 0.2	0.0 \pm 0.0

species *Rhena* (Jumping spider) was initiated from November to December and peak of 4.2 \pm 0.2 was noticed in non-Bt cotton fields only (Table. 2). The number of species are increased as spider abundance increased during 2020-21 cotton cropping season suggesting that the differences in diversity between Bt and non-Bt cotton fields were caused by differences in abundance.

The species *N. theisi* in the month of July, *A. anasuja*, *N. theisi* and *P. sindica* in August, *A. anasuja*, *A. pulchella*, *N. theisi*, *D. atropalpis* and *P. sindica* in September, *A. anasuja*, *A. pulchella*, *N. theisi*, *D. atropalpis*, *O. sunsnda*, *P. viridans*, *P. sindica* and *H. semicupreus* in October, *A. anasuja*, *A. pulchella*, *N. theisi*, *D. atropalpis*, *O. sunsnda*, *P. viridans*, *P. sindica* and *H. semicupreus* in November, *A. anasuja*, *N. theisi*,

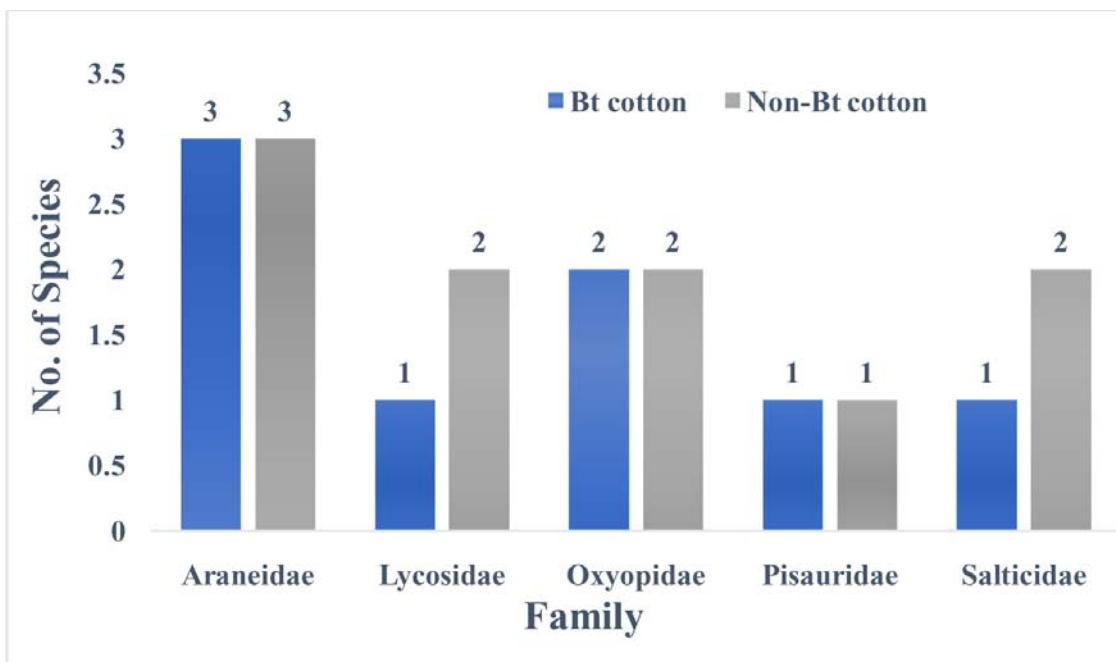


Fig. 2. Seasonal diversity of spider species in Bt and non-Bt cotton fields during 2020-21 cotton season

D.atropalpis, *O.sunsndae*, *P.viridans*, *P.sindica* and *H.semicupreus* in December, *N.theisi*, *D.atropalpis*, *O.sunsndae*, and *P.viridans* in January on Bt cotton and *N. theisi* in the month of July, *A.anasuja*, *N.theisi* and *P.sindica* in August, *A.anasuja*, *A.pulchella*, *N.theisi*, *D.atropalpis*, *H.greenalliae* and *P.sindica* in September, *A. anasuja*, *A. pulchella*, *N. theisi*, *D. atropalpis*, *H.greenalliae*, *O.sunsndae*, *P. viridans*, *P.sindica* and *H.semicupreus* in October, *A.anasuja*, *A.pulchella*, *N. theisi*, *D.atropalpis*, *H. greenalliae*, *O. sunsndae*, *P.viridans*, *P.sindica*, *H.semicupreus* and *Rhene* sp in November, *A.anasuja*, *N.theisi*, *D.atropalpis*, *H.greenalliae*, *O.sunsndae*, *P.viridans*, *P.sindica*, *H.semicupreus* and *Rhene* sp in December, *N.theisi*, *D.atropalpis*, *H.greenalliae*, *O.sunsndae*, and *P.viridans* in January were observed on non-Bt cotton fields (Table. 2).

Ecological Indices: Three characteristics were calculated for analysis of community structure of spiders. i.e., Species diversity (Shannon –Wiener Index), Species evenness (Pielou Evenness Index) and Species richness (Margalef's Index).

Species diversity (Shannon-Weiner Index) values (H-Values) of Araneae ranged between 0 and 2.0 in Bt, 0 and 2.2 in non-Bt cotton during 2020-21 cropping season. Species richness (Margalef's Index) values (D-Values) of Araneae ranged between 0 and 1.48 in Bt, 0 and 1.75 in non-Bt during 2020-21 cotton season. Species evenness (Pielou Evenness Index) values (J-Values) of Araneae ranged between 0.82 and 0.98 in Bt, 0.86 to 0.99 in non-Bt during 2020-21 cotton season (Table 3).

The H-values of Araneae under 1.0 indicated that the habitat structure is not suitable.

Table 3. Ecological Indices for Araneae (spiders) in Bt& Non-Bt cotton fields during 2020-21 cotton season

	H-Values (Diversity)		J-Values (Evenness)		D-Values (Richness)	
	Bt	non-Bt	Bt	non-Bt	Bt	non-Bt
July	0	0	-	-	0	0
August	1.00	0.98	0.91	0.89	0.50	0.49
September	1.31	1.54	0.81	0.86	0.88	1.05
October	1.99	2.13	0.96	0.97	1.38	1.51
November	2.00	2.25	0.96	0.98	1.48	1.75
December	1.92	2.16	0.99	0.98	1.28	1.58
January	1.35	1.52	0.97	0.94	0.75	0.90

While, H-values of above 1.0 indicate that Bt and non-Bt cotton fields are stable for their habitat. In case H-values are between 1.5 and 2.0, it indicated the structure of habitat is stable and suitable balanced for them, from September onwards the habitat structure of Araneae in both Bt and non-Bt cotton fields is stable and suitable as the H-values are above 1.5. Evenness values in Bt and non-Bt cotton are closer to 1.0 indicate that the spiders are distributed equally. Richness values in Bt and non-Bt cotton are under 0.5 which indicates that the spiders are low and closer to 1.0 indicate that the spiders are more.

Our results indicated that minor differences in the spider community occurred between Bt and non-Bt cotton fields. However, non-Bt cotton often had higher spider abundance than Bt cotton fields. The present findings are in line with Sun *et al.* (2003) who recorded that the population in density of spiders was significantly lesser in transgenic cotton than normal cotton. The seasonal mean abundance of spiders indicated that no much variation in the mean population of spiders between Bt-cotton and non Bt cotton

fields. Seasonal diversity and abundance were lower in the month of July progressively raised from August to November, there after decreased from December to January in both Bt and non-Bt cotton fields. Present investigation results are in support with the findings of Laxman *et al.*, 2016 where in it was reported that the spiders were mostly found in middle of the cotton cropping seasons in Warangal district of Telangana state. Xu Wen Hua *et al.*, (2004) reported a significant variation in population dynamics of a spiders in cotton fields in China during 2002. In general, the seasonal mean abundance of predators indicates that there was little difference with respect to green lynx spider, brown lynx spider, garden spider, writing spider and signature spider in Bt and non Bt-cotton fields. Present findings are in near agreement with Kengegowda (2003), who reported that spiders appeared more or less same in Bt and non Bt-cotton. Rajanikanth (2004) also reported that there was no difference in predatory population in Bt and non Bt-cotton. However, the present findings are in contrary to the Hagerty *et al.*, (2005) who reported that the

activity of spiders was consistently higher in Bt cotton than non Bt-cotton. In the present investigation it was observed that spider numbers varied between months within a year in Bt and non Bt-cotton fields, which is similar to the finding of Silberbaur (2001). In September, October and November months there were a large number of spiders in Bt-cotton and non Bt-cotton fields, which coincides with high incidence of herbivore activity during the active cotton growing period. If the natural enemy is a specialist on herbivore that was highly susceptible to Bt toxin, the normal enemy's number may likely to decline in the Bt field due to the absence of host. As spiders are generalists predatory, their activity and abundance will depend on presence of host on the crop. According no impact is expected for spiders found higher numbers during these months.

CONCLUSION

Overall spider population was lower in Bt-cotton compared to non-Bt-cotton. Seasonal diversity and abundance were lower in the month of July progressively raised from August to November, after that decreased from December to January in both Bt and non-Bt cotton fields. From these results it can be concluded that Bt cotton may have no marked negative effects on the spider community in cotton fields. The richness and evenness of spiders was similar in both Bt and non-Bt cotton fields.

REFERENCES

- Alvi, Z. H. 2007. Taxonomical and ecological studies of spiders from some fruit gardens of district Jhang, M. Phil. Thesis submitted to Department of Zoology, Govt College University of Faisalabad, Punjab, Pakistan.
- Dileep Kumar B., Malathi S, and Har Prasad Rao, N. 2008. Guide on cotton pests and predators Regional Agriculture Research Station PJTSAU, Warangal. pp. 1-498.
- Ghavami S., Taghizadeh, M., Amin, G and Karimian, Z, 2007. Spider (Order Araneae) Fauna of cotton Fields in Iran. Journal of Applied Biological Sciences. 1 (2): 07-11.
- Hagerty, A. M., Kilpatrick, A. L., Turnipseed, S. G., Sullivan, M. J, and Bridges, W. C. 2005. Predaceous Arthropods and lepidopteran pests on conventional Bollgard and Bollgard II cotton under untreated and disrupted conditions. Journal of Economic Entomology. 34(1): 105-114.
- James, C. 2011. Global Status of Commercialized Biotech/ GM crops ISAAA Brief No. 43. ISAAA, Ithaca, NY. pp. 1-324.
- Kengegowda, N. 2003. Studies on the population dynamics and screening of Bt cotton hybrids against insect pests. M. Sc. Thesis submitted to University of Agricultural Sciences. pp. 49-82.
- Laxman P., Kiranmai K., Thiruthathi U., and Sammaiah Ch. 2016. Impact of weather factors on predatory spiders in Bt and non Bt-cotton fields of Warangal, Telangana. Bio life. 4(2):386-391.
- Maqsood, I. 2011. Taxonomical and ecological studies of spiders from the citrus and guava fruit gardens of district Faisalabad, Pakistan, M. Phil. Thesis submitted to (Unpublished), Department of Zoology, Govt College University of Faisalabad, Punjab, Pakistan.

- Mayee C. D., and Rao MRK. 2002. Current cotton production and protection scenario including GM cotton, Crop report Cotton Agro look.pp. 14-16.
- National Centre for Integrated Pest Management, 2014. Integrated Pest Management Package for Cotton. Director, National Centre for Integrated Pest Management, LBS Building, IARI Campus, New Delhi. pp.1-8.
- National Cotton Scenario.2021. National cotton Scenario. Retrieved from the website (https://cotcorp.org.in/national_cotton.aspx).
- Nemade P.W., Budhvat K.P., Wadaskar P.S., Patil B.R., 2015. Status of leafhopper (*Amrasca biguttula biguttula* Ishida) in Bt cotton and impact of weather parameters and natural enemies on its population. Journal of Cotton Research and Development. 29(2):287-292.
- Platnick, N. I. 2004. The World Spider Catalog, Version 5.0. American Museum of Natural History, New York City.
- Rajanikanth, R. 2004. Performance of Bt cotton against major insect pests and their natural enemies under irrigated ecosystem, M. Sc.Thesis submitted to University of Agricultural Science, Dharwad, Karnataka, India.
- Samiayyan, K. 2014. Spiders - The generalist super predators in agro-ecosystems. pp. 283-310. <https://doi.org/10.1016/B978-0-12-398529-3.00016-6>.
- Shera, P., Kumar,V and Aneja A. 2013. Seasonal abundance of sucking insect pests on transgenic Bt cotton *vis-à-vis* weather parameters in Punjab, India. Act a Phytopathologica et Entomologica Hungarica. 48(1):63-74.
- Silberbauer, L. 2001. Sources of beneficial insects colonising cotton fields' CRC Final report, Cotton CRC Project Number: 2.2.16. pp. 1-4.
- Sun, C.G., Zhang, Q.W., Xu, J., Wang, Y.X and Liu, J.L.2003. Effect of transgenic Bt cotton pests and transgenic Bt+CpTI cotton on the population dynamics of main cotton pests and their natural enemies. Acta Entomologica Sinica. 46: 705-712.
- Xu Wen Hua., Wu Chun, Wang Ruiming, Shan Xiaoling and Wu. Jinlong. 2004. Dynamic distribution of spider predominant species on Bt transgenic cotton in Jiangsu coastal cotton area. Jiangsu Journal of Agricultural Sciences. 20(1): 23-27.

INFLUENCE OF LONG TERM FERTILIZATION ON YIELD AND ACTIVE POOLS OF SOIL ORGANIC CARBON IN RICE - RICE CROPPING SEQUENCE OF ONATTUKARA

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ABSTRACT

The effect of long term fertilization on yield and active pools of soil organic carbon under rice-rice cropping sequence was studied during 2020-21 in a long term fertilization experiment conducted since 1964 at Onattukara Regional Agricultural Research Station, Kayamkulam, Kerala. The results indicated that the application of FYM along with NPK fertilizers (80 kg N ha⁻¹, 20 kg as FYM and 60 kg as A.S. + 40 kg P₂O₅ ha⁻¹ as Rajphos + 40 kg K₂O ha⁻¹) as MOP resulted in significant increase in rice yield. Soil organic carbon, soil microbial biomass carbon, nitrogen, and phosphorus, water soluble carbon, water soluble carbohydrates and dehydrogenase activity were the highest under treatment receiving combined application of FYM and NPK fertilizers. These fractions contribute to the active pool of soil organic carbon and can be identified as an indicator of soil quality. Present study thus provided an insight on how management practices affect crop yield and active pools of carbon.

Keywords: Integrated Nutrient Management, Soil Organic Carbon

INTRODUCTION

The sandy plains of Kerala constitute a unique agro ecological unit designated as Onattukara sandy plain (AEU 3). Rice based cropping system is the predominant cropping system in the low lands of Onattukara region where two crops of paddy are raised during Virippu (April to August) and Mundakan (August-September to December-January), followed by sesame/pulses/vegetables in the summer rice fallows. Onattukara soils are generally coarse textured with immature profiles, low nutrient and

water retention capacity. Critical low soil organic matter status is the predominant cause for the decline in soil health and consequent fall in crop productivity of this region. Soil organic carbon is an important index of soil fertility because of its relationship to crop productivity (Vintheret *al.*, 2004). Declining soil organic carbon level often leads to decreased crop productivity (Lal, 2006). Hence, maintaining soil organic carbon level is essential for agricultural sustainability. To better understand the mechanism by which carbon is stabilized or lost from the soil, the total soil organic

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carbon can be divided into labile or active carbon pool and a non-labile or stable or recalcitrant carbon pool. The labile or active carbon pool is that fraction of total soil organic carbon having rapid turnover rates and is most vital in terms of crop production as it greatly influences nutrient cycling for maintaining soil quality and productivity (Chan *et al.*, 2001). Non labile carbon pool is the most stable pool or recalcitrant pool and gets slowly decomposed by microbial activity (Wiesenberg *et al.*, 2010). A judicious mix of organic manures along with inorganic fertilizers is always ideal to improve soil physical properties and also to sustain agronomic productivity. It is difficult to detect soil organic carbon changes in a short term due to its slow rate of formation (Malhi *et al.*, 2011). Therefore, long term fertilization experiments are always ideal to detect changes in soil organic carbon.

MATERIALS AND METHODS

Study site

Onattukara sandy plain, extending from the coast line to the midlands forms a special agro-ecological unit of Kerala (AEU 3). The soils of the region are sandy, deep, well drained, strongly acidic, have low cation exchange capacity with shallow water table and single grain structure. A 57 year on-going Permanent Manurial Trial (PMT), on rice at Onattukara Regional Agricultural Research Station, Kayamkulam, since 1964 was selected for the study. The study was conducted from April 2020 to September 2020.

The experiment was laid out in Randomized Block Design (RBD) with eight treatments each replicated thrice with rice variety 'Jaya'. The N, P and K are supplied in the form of Ammonium sulphate (A.S), Rajphos and Muriate of Potash

(MOP), respectively. The eight treatments were T_1 -80 kg N ha⁻¹ as FYM, T_2 -80 kg N ha⁻¹ as A.S, T_3 -80 kg N ha⁻¹ as A.S + 40 kg P₂O₅ ha⁻¹ as Rajphos, T_4 - 80 kg N ha⁻¹ as A.S + 40 kg K₂O ha⁻¹ as MOP, T_5 -40 kg P₂O₅ ha⁻¹ as Rajphos + 40 kg K₂O ha⁻¹ as MOP, T_6 - 80 kg N ha⁻¹ as A.S + 40 kg P₂O₅ ha⁻¹ as Rajphos + 40 kg K₂O ha⁻¹ as MOP, T_7 - 80 kg N ha⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P₂O₅ ha⁻¹ as Rajphos + 40 kg K₂O ha⁻¹ as MOP, T_8 - Absolute control.

Soil sampling and analysis

Soil samples collected from each plot passed through 2mm sieve and stored in polythene bags. These were further subjected to various analysis. Organic carbon was determined using Walkley and Black method (Walkley and Black, 1934). Soil microbial biomass carbon was determined using Chloroform fumigation extraction method (Jenkinson and Powlson, 1976). Soil microbial biomass nitrogen was determined using Chloroform fumigation extraction method (Brookes *et al.*, 1985). Soil microbial biomass phosphorous was determined using Chloroform fumigation incubation method (Brookes *et al.*, 1982). Water soluble carbon was determined using acid extraction method (Nelson and Sommer's, 1996). Water soluble carbohydrates was determined using anthrone method (Brink *et al.*, 1960). Dehydrogenase activity was determined using Colorimetric estimation of TPF hydrolysed g⁻¹ of soil 24⁻¹h (Casida, 1977).

RESULTS AND DISCUSSION

Grain and straw yield

Grain yield was highest (2.69 t ha⁻¹) in treatment receiving 80 kg N ha⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P₂O₅ ha⁻¹ as Rajphos

+ 40 kg K_2O ha⁻¹ as MOP (Table 1). The lowest (1.71 t ha⁻¹) was recorded in absolute control (T_8) during both the seasons. There was no significant variation among treatments for straw yield. Treatment receiving 80 kg N ha⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P_2O_5 ha⁻¹ as Rajphos + 40 kg K_2O ha⁻¹ as MOP (T_7) recorded the highest straw yield. The lowest was recorded by absolute control (T_8). The mean grain and straw yield for the past 57 years has been given in table 2 and the treatment receiving 80 kg N ha⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P_2O_5 ha⁻¹ as Rajphos + 40 kg K_2O ha⁻¹ as MOP i.e., T_7 (2.13 t ha⁻¹ and 5.33 t ha⁻¹) recorded the highest mean grain and straw yield. Urkurkaret *et al.* (2010) reported that integrated use of chemical fertilizers along with organic manures like FYM, green manure or wheat straw adds huge amount of organic matter in soil there by increased grain and straw yield. The increased yield might be due to the increased availability of secondary and micronutrients through FYM (Bhattacharya *et al.*, 2004).

Soil Organic Carbon

Soil organic carbon (SOC) was significantly influenced by treatments. During both the season, treatment receiving FYM+Ammonium Sulphate+Rajphos+M.O.P(T_7) recorded the highest value of soil organic carbon (0.66%). The absolute control (T_8) recorded the lowest value of soil organic carbon (0.30%) (Table 2). The initial soil organic carbon was shown in Table 4. The treatment T_7 [80 kg N ha⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P_2O_5 ha⁻¹ as Rajphos + 40 kg K_2O ha⁻¹ as MOP] (0.59%) recorded the highest initial soil organic carbon content. The increase in soil organic carbon in FYM+NPK treated plot can be ascribed to increase in total

nitrogen and soil organic matter contents compared to sole application of fertilizers (Chakraborty *et al.*, 2011).

Soil Microbial Biomass Carbon

Different treatments had significantly influenced soil microbial biomass carbon (SMBC) (Table 3). The treatment T_7 [80 kg N ha⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P_2O_5 ha⁻¹ as Rajphos + 40 kg K_2O ha⁻¹ as MOP] recorded the highest value (309.65 mg kg⁻¹) during both the seasons followed by T_1 (80 kg N ha⁻¹ as FYM) (266.54 mg kg⁻¹) and the lowest was recorded by absolute control, T_8 (88.23 mg kg⁻¹). The results obtained are in conformity with the observation of Patel *et al.* (2018) under soybean-wheat cropping system. This might be due to application of FYM which resulted in increased root biomass which enhanced the growth and development of microorganisms.

Soil Microbial Biomass Nitrogen

Treatments had significant influence on soil microbial biomass nitrogen (SMBN) (Table 3). Treatment receiving FYM+Ammonium Sulphate +Rajphos+M.O.P(T_7) recorded the highest value of soil microbial biomass nitrogen (56.24 mg kg⁻¹). The lowest SMBN content was recorded in absolute control (T_8) (18.02 mg kg⁻¹). The results are in agreement with the observation of Patel *et al.* (2018) who reported a 14.6% increase in SMBN in plot treated with NPK+FYM compared to NPK alone. High soil organic matter, better root proliferation and additional supply of N in the form of FYM may be responsible for the increased SMBN (Verma and Mathur, 2009).

Soil microbial biomass phosphorous

Data (Table 3) revealed that treatments had significant influence on soil microbial biomass

Table 1. Effect of long term fertilization on grain and straw yield of rice

S.No.	Treatments	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
1	T ₁ - 80 kg N ha ⁻¹ as FYM	2.15	4.87
2	T ₂ -80 kg N ha ⁻¹ as A.S, T ₃ -80 kg N ha ⁻¹ as A.S	1.72	2.76
3	T ₃ - 80 kg N ha ⁻¹ as A.S + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos	2.03	3.58
4	T ₄ -80 kg N ha ⁻¹ as A.S + 40 kg K ₂ O ha ⁻¹ as MOP	2.09	4.42
5	T ₅ -40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	1.90	3.11
6	T ₆ - 80 kg N ha ⁻¹ as A.S + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	2.13	4.43
7	T ₇ - 80 kg N ha ⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	2.69	5.63
8	T ₈ - Absolute control	1.71	2.74
C.D @ 5%		0.528	NS
SE(m)		0.172	0.805
C.V. %		14.443	35.367

phosphorous (SMBP) content of soil. The treatment receiving FYM+AmmoniumSulphate +Rajphos+M.O.P(T₇)recorded the highest value of soil microbial biomass phosphorous (39.89 mg kg⁻¹) andthe lowest (11.22 mg kg⁻¹) was recorded by absolute control (T₈). High soil organic matter and better root proliferation may be responsible for the increased SMBP (Verma and Mathur, 2009).

Water Soluble Carbon

The highest water soluble carbon (97.92 mg kg⁻¹) was recorded in treatment receiving FYM+AmmoniumSulphate +Rajphos+M.O.P (Table 3)and the lowest by control plot (27.92 mg kg⁻¹). Yagi *et al.* (2003) reported that the increase in water soluble carbon under integrated nutrient management may be due to the priming effect with the application of

Table 2. Effect of long term fertilization on mean grain and straw yield over 57 years in rice

S.No.	Treatments	Mean grain yield (t ha ⁻¹)	Mean straw yield (t ha ⁻¹)
1	T ₁ - 80 kg N ha ⁻¹ as FYM	1.71	4.102
2	T ₂ -80 kg N ha ⁻¹ as A.S, T ₃ -80 kg N ha ⁻¹ as A.S	1.39	2.42
3	T ₃ - 80 kg N ha ⁻¹ as A.S + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos	1.64	3.18
4	T ₄ -80 kg N ha ⁻¹ as A.S + 40 kg K ₂ O ha ⁻¹ as MOP	1.65	3.92
5	T ₅ -40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	1.52	2.81
6	T ₆ - 80 kg N ha ⁻¹ as A.S + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	1.76	3.93
7	T ₇ - 80 kg N ha ⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	2.13	5.33
8	T ₈ - Absolute control	1.404	1.34

inorganic nitrogen and fresh organic manure that stimulated the microbial activity thus enhanced the mineralization of nitrogen in soil organic carbon by decomposition of soil organic carbon and releasing the water soluble carbon fractions.

Water Soluble Carbohydrates

Table 3 represents the influence of various treatments on water soluble carbohydrate content in soil. Treatment receiving FYM+Ammonium Sulphate +Rajphos+M.O.P(T₇) recorded the highest content (110.12 mg kg⁻¹) whereas the lowest content of water soluble carbohydrates (40.97 mg kg⁻¹) was recorded by T₈ (control). The results were in conformity with the findings of Tripura *et al.* (2018) who reported

the highest water soluble carbohydrates in treatment receiving 50% NPK of recommended dose +FYM at 10t ha⁻¹ in groundnut-wheat sequence under long term fertilization.

Dehydrogenase Activity

Dehydrogenase activity was significantly influenced by different treatments. Treatment receiving FYM+ Ammonium Sulphate+ Rajphos+ M.O.P recorded the highest value of dehydrogenase activity (19.46 µg TPF hydrolysed g⁻¹ soil 24 hr⁻¹) and the lowest by T₈ (15.45 µg TPF hydrolysed g⁻¹ soil 24 hr⁻¹) (Table 3). Geet *al.* (2009) reported that in Entisols, integrated nutrient management supplied

Table3. Effect of long term fertilization on active pools of carbon in rice-rice cropping sequence

Treatments	Soil organic carbon(%)	Soil microbial biomass carbon (mg kg ⁻¹)	Soil microbial biomass nitrogen (mg kg ⁻¹)	Soil microbial biomass phosphorus (mg kg ⁻¹)	Water soluble carbon (mg kg ⁻¹)	Water soluble carbohydrates (mg kg ⁻¹)	Dehydrogenase activity (µg TPF hydrolysed g ⁻¹ soil 24 hr ⁻¹)
T ₁ - 80 kg N ha ⁻¹ as FYM	0.64	266.54	55.13	35.67	96.21	105.12	19.42
T ₂ -80 kg N ha ⁻¹ as A.S, T ₃ - 80 kg N ha ⁻¹ as A.S	0.50	132.99	36.12	16.55	37.91	62.82	15.78
T ₃ - 80 kg N ha ⁻¹ as A.S + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos	0.55	152.32	43.87	31.50	84.67	72.56	16.50
T ₄ -80 kg N ha ⁻¹ as A.S + 40 kg K ₂ O ha ⁻¹ as MOP	0.57	177.34	52.56	32.25	51.56	58.89	17.45
T ₅ -40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	0.54	133.11	36.93	22.02	50.78	65.98	16.34
T ₆ - 80 kg N ha ⁻¹ as A.S + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	0.60	221.98	55.01	33.10	38.34	78.32	18.50
T ₇ - 80 kg N ha ⁻¹ (20 kg as FYM and 60 kg as A.S.) + 40 kg P ₂ O ₅ ha ⁻¹ as Rajphos + 40 kg K ₂ O ha ⁻¹ as MOP	0.66	309.65	56.24	39.89	97.92	110.12	19.46
T ₈ - Absolute control	0.30	88.23	18.02	11.22	27.92	40.97	15.45
C.D @ 5%	0.042	5.372	3.504	2.967	5.058	5.912	1.700
SE(m)	0.015	1.881	1.227	1.039	1.771	2.07	0.595
C.V.%	29.395	3.302	14.134	20.811	9.026	13.285	6.185

Table 4. Initial soil organic carbon of long term fertilization in rice-rice cropping sequence

Treatments	Initial soil organic carbon (%)
T ₁ - FYM	0.55
T ₂ -Ammonium Sulphate(A.S)	0.43
T ₃ - A.S+Rajphos	0.47
T ₄ -A.S+MOP	0.50
T ₅ -Rajphos+MOP	0.46
T ₆ - A.S+Rajphos+MOP	0.52
T ₇ - FYM+A.S+Rajphos+MOP	0.59
T ₈ - Control	0.22

organic substrate and thus triggered the microbial population and dehydrogenase activity.

CONCLUSION

The highest grain yield was recorded under combined application of NPK and FYM. Active carbon pools viz., SOC, SMBC, SMBN, SMBP, WSC, water soluble carbohydrates and dehydrogenase activity were recorded the highest under integrated nutrient management. The study hence revealed that inclusion of organics along with inorganic fertilizer as in the case of T₇ (FYM+A.S+Rajphos+MOP) played an important role in influencing active carbon pools under rice based cropping system and it is an ideal management practice for maintaining soil health. Development of appropriate agricultural practices to increase soil organic carbon sequestration as a means there by to reduce greenhouse gas emission in rice-rice cropping sequence has to be adopted. Soil quality under different treatments should be done periodically.

REFERENCES

- Bhattacharyya, R., Prakash, V., Kundu, S., Rivastava, A.K. and Gupta, H.S. 2004. Effect of long-term manuring on soil organic carbon, bulk density and water retention characteristics under soybean-wheat cropping sequence in north-western Himalayas. *Journal of Indian Society of Soil Science* 52: 238-242.
- Brink, R.H., Dubach, P and Lynch, D.L. 1960. Measurement of carbohydrates in soil hydrolyzates with anthrone. *Soil Science*. 89: 157-166.
- Brookes, P.C., Landman, A., Pruden, G and Jenkinson, D.S. 1985. Chloroform fumigation and the release of soil nitrogen: a rapid direct extraction method to measure microbial biomass nitrogen in soil. *Soil Biology and Biochemistry*. 17:837-842.

- Brookes, P.C., Powlson, D.S and Jenkinson, D.S. 1982. Measurement of microbial biomass phosphorus in soil. *Soil Biology and Biochemistry*. 14:319–329.
- Casida, L.E. 1977. Microbial metabolic activity in soil as measured by dehydrogenase determinations. *Applied and Environmental Microbiology*. 34: 630-636.
- Chakraborty, A., Chakrabarti, K., Chakraborty, A and Ghosh, S. 2011. Effect of long-term fertilizers and manure application on microbial biomass and microbial activity of a tropical agricultural soil. *Biology and Fertility of Soils*. 47: 227-233.
- Chan, K.Y., Bowman, A and Oates, A. 2001. Oxidizable organic carbon fractions and soil quality changes in an OxicPaleustaff under different pasture lays. *Soil Science*. 166: 61–67.
- Ge, G. F., Li, Z.J., Zhang, J., Wang, L.G., Xu, M.G., Zhang, J.B., Wang, J.K., Xie, X.L and Liang, Y.C. 2009. Geographical and climatic differences in long-term effect of organic and inorganic amendments on soil enzymatic activities and respiration in field experimental stations of China. *Ecological Complexity*. 6: 421–431.
- Jenkinson, D.S and Powlson, D.S. 1976. The effects of biocidal treatments on metabolism in soil fumigation with chloroform. *Soil Biology and Biochemistry*. 8: 167-177.
- Lal, R. 2006. Enhancing crop yields in the developing countries through restoration of the soil organic carbon pool in agricultural lands. *Land Degradation and Development*. 17: 197-209.
- Malhi, S., Nyborg, M., Goddard, T and Puurveen, D. 2011. Long-term tillage, straw management and N fertilization effects on quantity and quality of organic C and N in a black chernozem soil. *Nutrient Cycling in Agroecosystem*. 90: 227–241.
- Nelson, D.W and Sommers, L.E. 1996. Total carbon, organic carbon and organic matter. In: *Methods of soil analysis* (Sparks, D.L., Editor). Madison Press, Wisconsin, USA. pp. 961–1010.
- Patel, G., Dwivedi, B.S., Dwivedi, A.K., Thakur, R and Singh, M. 2018. Long-term effect of nutrient management on soil biochemical properties in a vertisol under soybean–wheat cropping sequence. *Journal of Indian Society of Soil Science*. 66(2): 215-221.
- Tripura, P., Polara, K.B and Shitab, M. 2018. Influence of long term fertilization on yield and active pools of soil organic carbon in anTypicHaplustepts under groundnut–wheat cropping sequence. *International Journal of Current Microbiology and Applied Science*. 7(9): 781-794.
- Urkurkar, J.S., Tiwari, A., Chitale, S and Bajpai, R.K. 2010. Influence of long term use of inorganic and organic manures on soil fertility and sustainable productivity of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Inceptisols. *Indian Journal of Agricultural Science* 80(3): 208-212.
- Verma, G and Mathur, A.K. 2009. Effect of integrated nutrient management on active pools of soil organic matter under maize–wheat system of a TypicHaplustept. *Journal of Indian Society of Soil Science*. 57: 317–322.

- Vinther, F.P., Hansen, E.M and Olsen, J.E. 2004. Effects of plant residues on crop performance, N mineralisation and microbial activity including field CO₂ and N₂O fluxes in unfertilized crop rotations. *Nutrient Cycling in Agroecosystem*. 70: 189-199.
- Walkley, A and Black, I. A. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*. 37(1): 29-38.
- Wiesenberg, G.L.B., Dorodnikov, M and Kuzyakov, Y. 2010. Source determination of lipids in bulk soil and soil density fractions after four years of wheat cropping. *Geoderma*. 156: 267–277.
- Yagi, R., Ferreeira, M. F., Cruz, M.C.P and Barbosa, J.C. 2003. Organic matter fraction and soil fertility under the influence of timing, vermicompost. *Scientia Agricola*. 60: 549-557.

EFFECT OF SPACING AND SODIUM NITRO PRUSSIDE ON GROWTH AND YIELD OF AFRICAN MARIGOLD DURING SUMMER IN ANDHRA PRADESH

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ABSTRACT

A two-year study from 2018 to 2019 conducted at Horticultural Research Station, Venkataramannagudem, Dr YSR Horticultural University, Andhra Pradesh, India on effect of spacing and sodium nitro prusside (SNP) concentration on plant growth and flower yield of African marigold cv. Bidhan Marigold-2 by inducing heat stress tolerance during summer revealed that closer spacing of 45 x 30 cm, higher SNP concentration of 200 μ M and their interaction effect recorded highest flower yield ha^{-1} (165.959, 178.267, 209.953 respectively) and BCR (1.65, 1.95, 2.76 respectively) whereas for rest of the vegetative, flower and yield parameters, maximum values were recorded at wider spacing of 60 x 30 cm, higher SNP concentration of 200 μ M and interaction effect of 60 x 30 cm + 200 μ M SNP indicating heat stress tolerance during plant growth in summer.

Key words : Marigold summer cultivation; Sodium nitro-prusside; Spacing

INTRODUCTION

Marigold is a hardy crop which grows throughout the year under tropical and subtropical conditions but flowering depends upon variety, day length and temperature. In many parts of Andhra Pradesh, plant growth is ceased with a reduction in flower size and yield during summer months due to prevailing high temperatures. Though, seasonal flowers like jasmine and crossandra are available during summer months, their shelf life is very low when compared to marigold. Hence, the production of marigold during summer season fetches

premium price in market as it coincides with various customary celebrations and functions.

Productivity and quality of any crop under abiotic stress can be improved by adopting certain special horticultural practices. Plant geometry plays an important role in growth and yield of crop especially during summer season. Spacing influences the creation of micro climate in the canopy. Sodium nitro prusside (SNP), a nitric oxide (NO) donor, alleviates the adverse effects of heat stress in plants. by playing a vital role in several physiological processes like secondary root initiation, plant height, stomatal

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closure, photosynthesis, and floral regulation etc. Yang *et al.* (2011) reported an increase in activity of superoxide dismutase (SOD), peroxidase (POX), catalase (CAT) and ascorbate peroxidase (APX) enzymes by application of sodium nitro prusside (SNP) a nitric oxide donor on heat-stressed chrysanthemum plants. In this study, investigation on the role of spacing and SNP on plant growth and yield of marigold cultivar Bidhan marigold – 2 by inducing heat stress was done.

MATERIALS AND METHODS

The research site was located at Horticultural Research Station, Venkataramannagudem West Godavari, Andhra Pradesh geographically situated at 16°83'N latitude and 81°5' E longitude with an altitude of 34 m (112 feet) above the mean sea level. This zone experiences hot and humid summer, mild winter and average annual rainfall of 900 mm. The experiment was carried out in the year 2017 and 2018. The marigold variety selected is orange coloured Bidhan Marigold-2. The experiment was laid out in a Randomized Block Design with factorial concept and replicated twice. The experiment consists of fifteen treatment combinations comprising of three spacing's (45 x 30 cm, 45 x 40 cm and 60 x 30 cm), three doses of sodium nitroprusside (0 µM, 100 µM and 200 µM) and nine interaction effects (45 x 30 cm + 0 µM SNP, 45 x 30 cm + 100 µM SNP, 45 x 30 cm + 200 µM SNP, 45 x 40 cm + 0 µM SNP, 45 x 40 cm + 100 µM SNP, 45 x 40 cm + 200 µM SNP, 60 x 30 cm + 0 µM SNP, 60 x 30 cm + 100 µM SNP and 60 x 30 cm + 200 µM SNP) with a plot size of 3.2 m x 3.0 m.

Sodium nitroprusside (SNP) solutions of 100 µM and 200 µM were prepared in 1000 ml

volumetric flask by dissolving 0.1 mg and 0.2 mg of SNP respectively in one litre of distilled water. As per the treatment, SNP solution of desired concentration was prepared freshly by using double distilled water just before application and spraying was done at 20 and 40 days after transplantation into main field. Spraying was done during early morning, until the spray solution was run off on all the plants by using a manual sprayer.

Observations on vegetative growth, flowering and yield parameters were recorded at 150 days after transplantation for ten plants randomly tagged with a label in each treatment and replication. Ten plants were pulled-off carefully from the ground and washed thoroughly with clean water to remove the soil particles adhered and dried in shade for recording the observations on different growth parameters in destructive method of sampling.

RESULTS AND DISCUSSION

Effect of spacing on vegetative parameters of Bidhan Marigold - 2

In this investigation, wider spacing of 60 x 30 cm recorded maximum number of primary branches (12.28), secondary branches (40.77), plant spread (27.17 cm in E-W and 45.45 cm in N-S directions), maximum leaf area (49.10 dm²), stem diameter at base (1.01 cm), specific leaf weight (11.99 mg cm⁻²), total fresh biomass (1668.08 g) and highest total dry matter (314.85 g) whereas highest plant height of 88.24 cm and internodal length of 44.7 mm was recorded with a closer spacing of 45 x 30 cm.

Wider spacing provided greater availability of plant nutrients, water and better sunlight exposure among plants which resulted in

maximum number of primary and secondary branch production that in turn favoured more lateral growth of plant. The results are in conformity with the findings of Yadav *et al.* (2004) in marigold. The decrease in internodal length with increase in spacing could be attributed to the lesser competition among plants for nutrients, water, and light at low plant densities and also due to production of more number of lateral branches. Similar results were earlier reported by Himabindu (2010) in marigold cv. Pusa Narangi Gaiinda. Plant spread is maximum due to the reason that wider spacing provides congenial growth conditions for root and shoot growth. Similar result of increase in plant spread was reported by Yadav *et al.* (2004). Variation in plant spread might be due to higher ground area provided per plant resulting in production of more lateral branches that in turn recorded shorter plant height and more plant spread. The wider plant spread at wider spacing in marigold was attributed to congenial growing conditions such as more space available for growth of roots and shoots (Dongre, 1984). More number of leaves at wider spacing might be due to more number of branches and it was earlier reported by Chaturvedi *et al.* (2010) in marigold. The increased thickness of stem could be ascribed to a better availability of nutrients per unit area due to sufficient space resulting in less competition among the plants. Significant variation in specific leaf weight depending on spacing might be attributed to production of more number of leaves and dry matter at wider spacing due to less competition among the plants for water, nutrients, air and sunlight. Similar results of increased leaf area at wider spacing were earlier reported by Chaturvedi *et al.* (2010) in African marigold.

The highest fresh weight and dry weight of plants with wider spacing is due to maximum plant spread, more number of primary and secondary branches, leaf area and increased girth of the stem. The maximum plant height and internodal length with closer spacing is due to increased competition among plants for space, nutrients, water and especially sun light. The production of taller plants with closer spacing and dense population were also reported earlier by Yadav *et al.* (2004). (Table 1)

Effect of sodium nitro prusside on vegetative parameters of Bidhan Marigold - 2

Maximum plant height (88.09 cm), primary (14.05) and secondary branches (44.72), plant spread (28.34 cm in E-W and 43.78 cm in N-S), leaf area (51.70 dm²), stem diameter at base (1.14 cm), specific leaf weight (14.65 mg cm⁻²), total fresh biomass (2072.11 g) and total dry matter (391.16 g) was recorded with 200 µMSNP spray while maximum internodal length of 42.6 mm was observed with 0 µMSNP spray. SNP being a potential donor of NO that is required for cell elongation, cell division, and tissue differentiation (Fernández-Marcos *et al.*, 2012) might have lead to optimal plant growth recording highest plant height. Nitric oxide is closely linked to auxin and cytokinin activities and SNP influenced the reduction of high temperature induced lipid peroxidation, H₂O₂ content thereby increasing chlorophyll content, ascorbate (AsA), glutathione (GSH) and GSH/ glutathione disulfide (GSSG) ratio which increased the photosynthesis rate and protected plants from heat stress. This also resulted in the production of highest number of primary and secondary branches, maximum leaf area, fresh and dry

weight of plants. The decrease in internodal length with increase in SNP concentration might be attributed to the overall growth of the plant in terms of height, spread and lateral branches production as they alleviated heat stress. High photosynthetic rate might be the reason for increased plant spread and leaf area through production of more number of lateral branches. Similar results with application of SNP during heat stress were reported by Meng-Wang *et al.* (2015) in oriental Lilly 'Siberia' and Sheena Nain *et al.* (2017) in marigold.

Increase in endogenous nitric oxide via application of SNP improved the photosynthetic performance in plants and improvement was associated with an increase in photosynthetic pigments. Photosynthesis increased due to increase in all gas exchange parameters positively associated with higher photosynthetic rate and hence higher biomass production and dry weight. (Table – 1)

Interaction effect of spacing and SNP on vegetative parameters of Bidhan Marigold - 2

Among the interaction effects, primary branches (14.66), secondary branches (46.78), plant spread (30.09 cm in E-W and 51.13 cm in N-S directions), leaf area (53.78 dm²), stem diameter at base (1.31 cm), specific leaf weight (16.04 mg cm⁻²), total fresh biomass (2291.58 g) and total dry matter (432.57 g) was recorded in 60 cm x 30 cm + 200 µMSNP whereas highest plant height (93.60) was recorded with 45 cm x 30 cm + 200 µM SNP and highest internodal length of 47.9 mm was observed with 45 cm x 30 cm + 0 µM SNP concentration. (Table – 1)

These results indicate that the impact of spacing is more compared to SNP concentration on increasing the plant height because of space limitation. But when it comes to similar spacing, the impact of SNP concentration plays a major role in increasing the plant height. Less number of primary branches in lesser spacing is recorded even under favourable conditions provided by SNP during heat stress. The production of more number of primary branches at wider spacing and heat alleviation through NO released from SNP by increasing the rate of photosynthesis and photosynthates production lead to more number of secondary branches. The decreased plant spread at lower spacing and urea application might be attributed to the lack of space, water and nutrients for lateral plant spread apart from reduced chlorophyll damage and photosynthetic rate due to lack of NO to alleviate heat stress. The impact of SNP concentration is more in increasing the total dry matter plant¹ at similar spacing due to the heat alleviation effects of NO by delaying senescence and increasing photosynthetic rate.

Effect of spacing on flower parameters of Bidhan Marigold - 2

Wider spacing of 60 cm x 30 cm delayed flowering, taken more days for first flower bud appearance (42.43) and 50 % flowering (55.63) (Table – 2). Wider spacing also recorded prolonged flowering duration of 77.06 days with longer flower receptacle (2.10 cm) and highest flower diameter (4.88 cm) which might be due to less competition for resources leading to prolonged vegetative phase thereby accumulating more photosynthates in plants which was earlier reported by Sheena Nain *et al.* (2017) in African marigold. Early flowering in

closer spacing might be due to early physiological maturity of the shoots. Similar results were reported by Himabindu (2010) in marigold.

Effect of SNP on flower parameters of Bidhan Marigold - 2

Data depicted in Table – 2 showed that increased SNP concentration delayed flowering, days taken for first flower bud appearance and 50% flowering with 200 μ M SNP spray recording highest number of days to first flower bud appearance (46.58) and 50 % flowering (60.54). This might be due to promotional activity of NO on vegetative growth especially under abiotic stresses (Song *et al.*, 2009). Nitric oxide suppresses the transition to flowering not by disrupting the circadian clock but by affecting the expression of regulatory genes in flowering pathways (Nigel and Fang-Qing., 2005). Spraying 200 μ M SNP also recorded maximum values for flower duration (87.49), flower diameter (4.92 cm) and length of flower receptacle (2.22 cm). Exogenous NO released from SNP enhanced the leaf chlorophyll content to increase photosynthesis during senescence which might in turn delayed plant senescence and increased flowering duration. The increase in flower diameter and length of flower receptacle with increase in SNP concentration might be due to the role NO has in elongation and growth of plants by influencing cell division and cell enlargement processes (Gabaldon *et al.*, 2005) along with modifications at the hormonal levels as NO acts as a secondary messenger in various metabolic processes (Unsal and Arisan 2009). Similar results were reported by Meng-Wang *et al.* (2015) in oriental lily.

Interaction effect of spacing and SNP on flower parameters of Bidhan Marigold - 2

Interaction effect of 60 cm x 30 cm with 200 μ M SNP recorded delayed flowering with 47.01 days for first flower bud appearance and 61.21 days for 50 % flowering. It also recorded increase in duration of flowering (88.18 days), flower diameter (5.20 cm) and length of receptacle (2.27 cm) followed by 45 cm x 40 cm with 200 μ M SNP. (Table – 2)

Higher SNP concentration spray might have increased the availability of water and nutrients in abundance at wider spacing coupled with delayed senescence through reduced chlorophyll damage and increased production of photosynthates due to increased rate of photosynthesis under heat stress which could have been effectively translocated from source to sink portion resulting in continuous flowering.

Effect of spacing on yield parameters of Bidhan Marigold - 2

Wider spacing of 60 cm x 30 cm reported maximum number of flowers per plant (46.19), ten flower weight (53.22 g) and yield per plant (0.251 kg) whereas maximum flower yield ha^{-1} (165.959 q) was reported in closer spacing of 45 cm x 30 cm. Wider spacing provided favourable conditions like availability of nutrients, sunlight and soil moisture to individual plants which in turn increased the flower number, flower weight and yield per plant. Similar results of increased flower diameter with increase in spacing were earlier reported by Sheena Nain *et al.* (2017) in marigold. Higher flower yield ha^{-1} recorded at closer spacing could be due to the presence of more number of plants per ha^{-1} . (Table – 2)

Table : 1Effect of spacing, SNP and their interaction on vegetative parameters of African marigold cv. Bidhan Marigold-2

Treatment	Plant height (cm)	Number of branches		Internodal Length (mm)	Plant Spread (cm)		Leaf area (dm ²)	Stem diameter at base (cm)	Specific leaf weight (mg cm ⁻²)	Total fresh biomass plant ⁻¹ (g)	Total dry matter plant ⁻¹ (g)
		Primary	Secondary		E-W	N-S					
Spacing (cm)											
T ₁ : 45 x 30	88.24	11.21	37.03	44.7	24.83	30.50	45.30	0.78	9.81	1306.50	246.74
T ₂ : 45 x 40	77.20	11.73	39.21	40.7	25.77	34.98	46.99	0.89	10.81	1491.31	281.53
T ₃ : 60 x 30	82.95	12.28	40.77	36.0	27.17	45.45	49.10	1.01	11.99	1668.08	314.85
S Em±	0.08	0.01	0.02	0.02	0.05	0.04	0.02	0.001	0.005	7.98	1.51
CD	0.24	0.01	0.07	0.06	0.14	0.11	0.05	0.002	0.015	23.20	4.39
Sodium Nitro Prusside Concentration											
T ₄ : 0 μ M	76.83	9.44	34.00	42.6	23.34	30.44	41.47	0.72	7.37	914.70	172.74
T ₅ : 100 μ M	83.48	11.74	38.29	40.4	26.09	36.72	48.22	0.84	10.58	1479.08	279.23
T ₆ : 200 μ M	88.09	14.05	44.72	38.5	28.34	43.78	51.70	1.14	14.65	2072.11	391.16
S Em±	0.08	0.01	0.02	0.02	0.05	0.04	0.02	0.001	0.005	7.98	1.51
CD	0.24	0.01	0.07	0.06	0.14	0.11	0.05	0.002	0.015	23.20	4.39
Interaction effect of Spacing (cm) xSodium Nitro Prusside Concentration											
T ₇ : 45 x 30 + 0 μ M	82.61	9.04	31.91	47.9	22.56	23.15	39.63	0.65	6.82	837.08	158.09
T ₈ : 45 x 30 + 100 μ M	88.53	11.16	36.50	43.6	24.46	30.58	46.13	0.74	9.32	1231.58	232.73
T ₉ : 45 x 30 + 200 μ M	93.60	13.43	42.67	42.6	27.48	37.77	50.14	0.95	13.28	1850.83	349.41
T ₁₀ : 45 x 40+ 0 μ M	71.11	9.44	34.43	41.7	23.54	27.82	41.62	0.71	7.31	911.25	172.08
T ₁₁ : 45 x 40+ 100 μ M	78.07	11.70	38.49	40.9	26.32	34.68	48.17	0.83	10.48	1488.75	281.03
T ₁₂ : 45 x 40+ 200 μ M	82.43	14.04	44.72	39.6	27.45	42.44	51.18	1.14	14.63	2073.92	391.49
T ₁₃ : 60 x 30 + 0 μ M	76.78	9.82	35.67	38.3	23.91	40.35	43.15	0.78	7.98	995.75	188.05
T ₁₄ : 60 x 30 + 100 μ M	83.83	12.36	39.88	36.5	27.50	44.88	50.36	0.95	11.94	1716.92	323.94
T ₁₅ : 60 x 30 + 200 μ M	88.23	14.66	46.78	33.3	30.09	51.13	53.78	1.31	16.04	2291.58	432.57
S Em±	0.14	0.01	0.04	0.04	0.08	0.06	0.03	0.001	0.009	13.82	2.62
CD	0.42	0.02	0.12	0.11	0.24	0.18	0.08	0.004	0.027	40.18	7.61

Table : 2 Effect of spacing, SNP and their interaction on flower and yield parameters of African marigold cv. Bidhan Marigold-2

Treatment	Days taken to first flower bud appearance	Days taken to 50% flowering	Duration of flowering (days)	Flower diameter (cm)	Length of flower receptacle (cm)	Ten flower weight (g)	Number of flowers plant ⁻¹	Flower yield plant ⁻¹ (kg)	Flower yield ha ⁻¹ (q)	BCR
Spacing (cm)										
T ₁ : 45 x 30	41.51	54.46	75.78	4.26	2.01	50.32	44.00	0.228	165.959	1.65
T ₂ : 45 x 40	41.97	55.04	76.45	4.57	2.06	52.03	45.27	0.242	123.341	1.34
T ₃ : 60 x 30	42.43	55.63	77.06	4.88	2.10	53.22	46.19	0.251	137.075	1.52
S Em±	0.01	0.01	0.01	0.003	0.001	0.02	0.02	0.0002	0.45	
CD	0.03	0.02	0.04	0.008	0.003	0.06	0.05	0.0005	1.30	
Sodium Nitro Prusside Concentration										
T ₄ : 0 µ M	37.15	48.46	64.48	4.29	1.88	45.81	37.60	0.178	103.848	1.04
T ₅ : 100 µ M	42.18	56.11	77.33	4.51	2.07	52.35	46.29	0.243	144.262	1.52
T ₆ : 200 µ M	46.58	60.54	87.49	4.92	2.22	57.42	51.58	0.299	178.267	1.95
S Em±	0.01	0.01	0.01	0.003	0.001	0.02	0.02	0.0002	0.45	
CD	0.03	0.02	0.04	0.008	0.003	0.06	0.05	0.0005	1.30	
Interaction effect of Spacing (cm) x Sodium Nitro Prusside Concentration										
T ₇ : 45 x 30 + 0 µ M	36.66	48.03	63.99	3.93	1.86	43.16	36.46	0.162	118.289	1.89
T ₈ : 45 x 30 + 100 µ M	41.73	55.46	76.53	4.22	2.03	51.35	45.18	0.233	169.636	0.29
T ₉ : 45 x 30 + 200 µ M	46.14	59.88	86.83	4.62	2.15	56.47	50.35	0.288	209.953	2.76
T ₁₀ : 45 x 40+ 0 µ M	37.22	48.43	64.53	4.29	1.89	46.23	37.74	0.181	92.482	1.61
T ₁₁ : 45 x 40+ 100 µ M	42.12	56.14	77.38	4.47	2.07	52.48	46.29	0.244	124.401	0.22
T ₁₂ : 45 x 40+ 200 µ M	46.58	60.55	87.46	4.93	2.23	57.38	51.78	0.300	153.139	2.18
T ₁₃ : 60 x 30 + 0 µ M	37.58	48.93	64.92	4.62	1.91	48.04	38.58	0.190	100.771	1.80
T ₁₄ : 60 x 30 + 100 µ M	42.70	56.74	78.09	4.83	2.11	53.22	47.40	0.253	138.747	0.26
T ₁₅ : 60 x 30 + 200 µ M	47.01	61.21	88.18	5.20	2.27	58.41	52.61	0.310	171.707	2.51
S Em±	0.02	0.01	0.02	0.005	0.002	0.04	0.03	0.0003	0.78	
CD	0.05	0.04	0.07	0.013	0.005	0.10	0.08	0.0009	2.26	

Effect of SNP on yield parameters of Bidhan Marigold - 2

Yield data from Table – 2 revealed that 200 μ M SSNP spray recorded maximum ten flower weight (57.42 g), number of flowers per plant (51.58), flower yield per plant (0.299 kg) and flower yield ha^{-1} (178.267 q). This may be due to the fact that NO involves in increasing rate of photosynthesis, antioxidant enzymes activation, membrane protection, osmolyte accumulation, post translational modification, gene expression mediated through MAPK, stomatal closure and activation of heat shock protein mediated through CDPK under heat stress conditions resulting in delayed senescence and higher yields per hectare. This result of present study is in conformity with the work of Himabindu (2010) in African marigold.

Interaction effect of spacing and SNP on yield parameters of Bidhan Marigold - 2

Wider spacing of 60 cm x 30 cm coupled with 200 μ M SNP spray effectively alleviated the adverse effects of heat stress on flower yield of marigold during summer by recording maximum ten flower weight (58.41 g), number of flowers per plant (52.61) and yield per plant (0.31 kg). Better uptake of nutrients, water and sunlight resulting in improved production of photosynthates by plants at wider spacing coupled with significant increase in rate of photosynthesis by decreasing the chlorophyll damage during heat stress and delaying senescence by NO might be the reason for improved flower weight, number of flowers and flower yield plant^{-1} (kg). Flower yield ha^{-1} (209.95 q) was reported higher in closer spacing of 45 cm x 30 cm with 200 μ M SNP spray due to presence of more number of plants per unit area

and positive effects of SNP to combat heat stress thereby increasing the flower yield plant^{-1} . The higher BCR at closer spacing of 45 cm x 30 cm (1.65), at 200 μ M SNP spray (1.95) and their interaction effect (2.76) might be attributed to the increased flower yield ha^{-1} (Table – 2).

CONCLUSION

Finally it can be concluded that, closer spacing of 45 cm x 30 cm with 200 μ M SNP spray twice at 20 and 40 days after transplanting was found to be beneficial in terms of flower yield and BCR followed by wider spacing of 60 cm x 30 cm with 200 μ M SNP spray which was found to be the best in terms of flower quality parameters.

REFERENCE

- Chaturvedi, S.K, Meena, M.L, Divya, M. and Tiwari, R.K. 2010. Effect of spacing and nitrogen level on growth, flowering and yield of marigold (*Tagetes erecta* L.) cv. Pusa narangi gainda. *Environment and Ecology*. 28(3): 1567-70.
- Dongre, G.N. 1984, Standardisation of horticultural practices for commercial production of marigold (*Tagetes erecta* L.). *M.Sc.(Hort) Thesis*, University of Agricultural Sciences, Bangalore, India.
- Fernández-Marcos, M, Sanz, L, Lorenzo, Ó. 2012. Nitric oxide: An emerging regulator of cell elongation during primary root growth. *Plant Signaling and Behavior*. 7: 196-00.
- Gabaldon, C, Gomez, R.L.V, Pedreno, M.A. and Ros Barcelo, A.R. 2005. Nitric oxide production by differentiating xylem of *Zinnia elegans*. *NewPhytology*. 163: 121-30.

- Hima Bindu, R. 2010. Effect of plant growth regulators and spacing on growth, flower yield and carotenoids content of African marigold (*Tagetes erecta* L.) cv. Pusa narangi gainda. *MSc. Thesis*. Andhra Pradesh Horticultural University, Venkatramannagudem, India.
- Meng Wang, Bin Li, Yong-Chao Zhu, Li-Juan Niu, Xin Jin, Qing-Qing Xu and Wei-Biao Liao. 2015. Effect of exogenous nitric oxide on vegetative and reproductive growth of oriental lily 'Siberia'. *Horticulture, Environment, and Biotechnology*. 56(5): 677-86.
- Nigel, M.C. and Fang-Qing Guo. 2005. New insights into nitric oxide metabolism and regulatory functions. *Trends in Plant Science*. 10(4): 195-00.
- Sheena Nain, Beniwal, B.S, Dalal R.P.S. and Sonu Sheoran. 2017. Effect of pinching and spacing on growth, flowering and yield of African marigold (*Tagetes erecta* L.) under semi-arid conditions of Haryana. *Journal of Applied and Natural Science*. 9(4): 2073-78.
- Song, J, Shi, G.W, Xing, S, Chen, M. and Wang, B.S. 2009. Effects of nitric oxide and nitrogen on seedling emergence, ion accumulation, and seedling growth under salinity in the euhalophyte *Suaeda salsa*. *Journal of Plant Nutrition and Soil Science*. 172: 544-49.
- Unsal, N.P. and Arisan, D. 2009. Nitric oxide signaling in plants. *Botanical Review*. 75: 203-29.
- Yadav, R.M, Dubey, P. and Asati, B.S. 2004. Effect of spacing and nitrogen levels on growth, flowering and flower yield of marigold (*Tagetes erecta* L.). *The Orissa Journal of Horticulture*. 32(1): 41-45.
- Yang, W, Sun, Y, Chen, S, Jiang, J, Chen, F, Fang, W. and Liu, Z. 2011. The effect of exogenously applied nitric oxide on photosynthesis and antioxidant activity in heat stressed chrysanthemum. *Biologia Plantarum*. 55(4): 737-40.

KNOWLEDGE AND ATTITUDE OF RURAL WOMEN WEAVERS TOWARDS SOCIAL MEDIA MARKETING

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ABSTRACT

The objective of this research is to find out the level of knowledge of 50 women weavers on social media marketing and their attitude towards the same. The study was conducted in the state of Assam between August and September, 2021 and the district Lakhimpur was selected as the study area. Two villages were selected randomly and a sample of 25 weavers were selected from each village, thus, the making total sample size of 50. The main findings of the study revealed that more than half (60%) of the respondents has medium level knowledge on social media marketing and its sites and 40% have unfavourable attitude towards it. However, it is also worth mentioning that nearly equal number of respondents (38%) have favourable attitude. The women weaved different types of fabrics like cotton and silk and some of the noteworthy garments are the traditional mekhe lachadar of Assam and Gamusa.

Keywords: Attitude, Handloom weavers, Knowledge, Rural women, Social media marketing

INTRODUCTION

Enterprises have been expected to play a crucial role in the overall development of the country. Empirics suggest that the vast majority of entrepreneurs in developing countries are involved in micro and small enterprises (Naude, 2010).

Micro, Small and Medium Enterprises (MSME) sector, which is often termed as the 'engine of growth' is considered as the most dynamic and vibrant sector of Indian economy as it provides large number of employment to rural as well as urban segment. The MSME

sector, which is growing exponentially, contributes 37.54 percent to National GDP, 45 percent to total industrial production and 40 percent to total exports. Manufacturing segment within the MSME contributes to 7.09 percent of GDP (MSME Report, 2012).

Assam is a house of natural and precious mineral resources. At present, unfortunately the state is amongst the industrially underdeveloped states in the country. However, the state is not lagging behind the rest of the country in respect of women entrepreneurs. This is evident from the fact that Assam accounts for 18 percent

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Table 1. Categorization of enterprises

Types of Enterprises		Investment limit in plant and machinery / equipment
Manufacturing Enterprises	Micro Enterprises	Up to Rs. 25 lakhs
	Small Enterprises	Above Rs. 25 lakhs and up to Rs 5 crores
Service Enterprises	Micro Enterprises	Up to Rs. 10 lakhs
	Small Enterprises	Above Rs. 10 lakhs and up to Rs.2 crores

Source: Economic Survey of Assam, 2020-21

women entrepreneurs of the total number of entrepreneurs as against 10.11% percent in the country. In the state, very few women entrepreneurs are in big enterprises and most of them are mainly concerned in the Small Scale Insudtries (SSI) sector (Economic Survey of Assam, 2013-14).

Presently the Small Scale Industries have been sub divided into Micro, Small and Medium Enterprises under the Micro Small and Medium Enterprises Act, 2006. The categorization of enterprises is made based on their investment in plant and machineries in case of manufacturing sector or in equipments in case of service sector as shown in the Table 1.

Unfortunately, constraints arise when it comes to marketing of their products. In spite of their hard work, the rural entrepreneurs do not get ample scope and exposure and therefore their enterprises remain confined to their own locality. People outside the town or the district are not even aware about the existence of the enterprises. However, this can be overcome in a quite easy manner by a very recent technique i.e. online marketing. In this case, online marketing with special reference to social media marketing, being on trend in the present

scenario, can be expected to greatly help the small entrepreneurs in marketing of their products in a broader dimension, providing greater exposure to the entrepreneurs.

Therefore, keeping in view the importance of small scale entrepreneurship in economic development of a country, the researcher has decided to undertake this study with the following objectives:

To study the demographic profile of the respondents; to assess the level of knowledge of the respondents on social media marketing and, to analyze the level of attitude of the respondents towards social media marketing.

MATERIALS AND METHODS

The study was conducted in the state of Assam during August and September, 2021 and the district Lakhimpur was selected as the study area, since data showed that rural women handloom weavers are predominantly found in larger number in this district.

North Lakhimpur Sub division was selected from Lakhimpur district, followed by the Boginadi block using purposive random sampling method, with the criteria that they should have at least one smart phone in the family. The

Table 2. Statistical analysis and scoring to measure knowledge of the respondents

S. No.	Category	Score Range	Score
1	Highly	Mean + SD(28.23+1.69)	3
2	Medium	Mean- SD to mean + SD(29.92 to 26.54)	2
3	Low	Mean – SD(28.23-1.69)	1

investigator has randomly selected two villages from the Boginadi block viz., SarianiGaon and MaazGaon and a sample of 25 weavers were selected from each village randomly. Thus, the total sample size for the study is 50. Data were collected through a structured interview schedule. Analysis of data included descriptive statistics such as frequency, percentage analysis, mean and standard deviation.

In order to elicit information regarding level of knowledge of the respondents, a list of 20 positive and negative statements on various marketing strategies through social media was prepared after reviewing different related journals, books, research papers etc. All the statements were in objective form with dichotomous (Correct or Incorrect) statements giving '1' score for correct statements and '0' for incorrect statements.

To measure the attitude of the respondents towards social media marketing, a scale consisting of twenty positive and negative statements was designed relating to social media

marketing. The responses were recorded on a 5-point continuum following Likert Scale as 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree'. The responses were scored as 5, 4, 3, 2 and 1, respectively according to their weightage for the positive statements and 1, 2, 3, 4, 5, for the negative statements.

Regarding demographic profile of the respondents, the findings of the study reveal that majority of the respondents (40%) included in the study were of 21-30years. This is an encouraging finding in context to the present research of social media marketing, because this is the age where the individuals are generally full of energy and enthusiasm to achieve more in life, having capacity of giving maximum mental and physical input in the process.

Also, it was reported that majority of the respondents belonged to OBC/MOBC caste (54%) and here the findings showed that the respondents of sample villages were from different castes of which OBC caste dominated the entire group.

Table 3. Statistical analysis and scoring to measure attitude of the respondents

S. No.	Category	Score Range	Score
1	Highly favourable	Mean + SD(39.88+5.04)	3
2	Favourable	Mean- SD to mean + SD(34.84 to 44.92)	2
3	Unfavourable	Mean – SD(39.88-5.04)	1

RESULTS AND DISCUSSION**Demographic Profile of the respondents****Table 4. Demographic Profile of the respondents**

S. No.	Category	Frequency(N=50)	Percentage(%)
	Age (in years)		
1	Below 20	2	4
	21-30	28	56
	31-40	12	24
	41-50	8	16
	Religion		
2	Hindu	46	92
	Muslim	4	8
	Caste		
3	General	15	30
	OBC/MOBC	27	54
	ST	5	10
	SC	3	6
	Others	-	-
	Marital status		
4	Unmarried	5	10
	Married	42	84
	Widow	3	6
	Type of family		
5	Nuclear family	36	72
	Joint family	9	18
	Extended family	5	10
	Size of family		
6	Small (2-4)	30	60
	Medium (5-7)	13	26
	Large (8 and above)	2	4
	Education		
7	Primary school	3	6
	Middle school	7	14
	High school	13	26
	Higher secondary	23	46
	Graduate	3	6
	Diploma	1	2
	Others	-	-

S. No.	Category	Frequency(N=50)	Percentage(%)
8	Main occupation of the family		
	Farming	44	88
	Service	3	6
	Business	2	4
	Daily wage earner	1	2
9	Monthly income (in Rs.)		
	10000-20000	7	14
	20001-30000	10	20
	30001-40000	28	56
	40001-50000	3	6
	>50000	2	4

Majority were from Hindu community (92%) and married (84%) because unlike urban areas, rural girls get married at young age. Respondents belonged to nuclear families (72%) with small family sizes (60%). This finding is a clear indication of the present trend in the rural areas. This situation may be attributed to the fact that due to the disintegration of the family system in the rural areas, the majority of the families were found nuclear. These findings are in accordance with the findings of Chetia (2002). Also, the small family size might be due to increase awareness on family planning through communication media as well as family planning measures adopted by the rural families helps to reduce the family size. This finding is in line with the finding of Borkakoty (2013) who observed that majority of rural women belonged to smaller size family.

A total of 46% of the respondents were higher secondary pass in regard to educational qualification. This is a good picture for the respondents as higher secondary education, although not a high level of education, is

expected to be enough to help them understand and learn new ways of marketing.

Table 4 also highlights that a large majority of the respondents' families (88%) had farming as their main occupation; since the study is in rural area, therefore it is an obvious picture that a large majority of people will have farming as an occupation.

About half of the respondents (51%) had monthly income of Rs. 30001-Rs. 40000, followed by 20% with income of Rs. 20001-Rs.30000. In this study, it is found that half of the whole respondents (51%) have very moderate income considering the hike in prices of almost all good and commodities in the present days, for which adopting social media for marketing would be of great help to these people to raise their level of income.

As per the research findings of Sivaraman (2017), changes in social and economic frameworks contribute to invigorate the role and status of women. Socio economic characteristics nourish the intention of entrepreneurship budding among women.

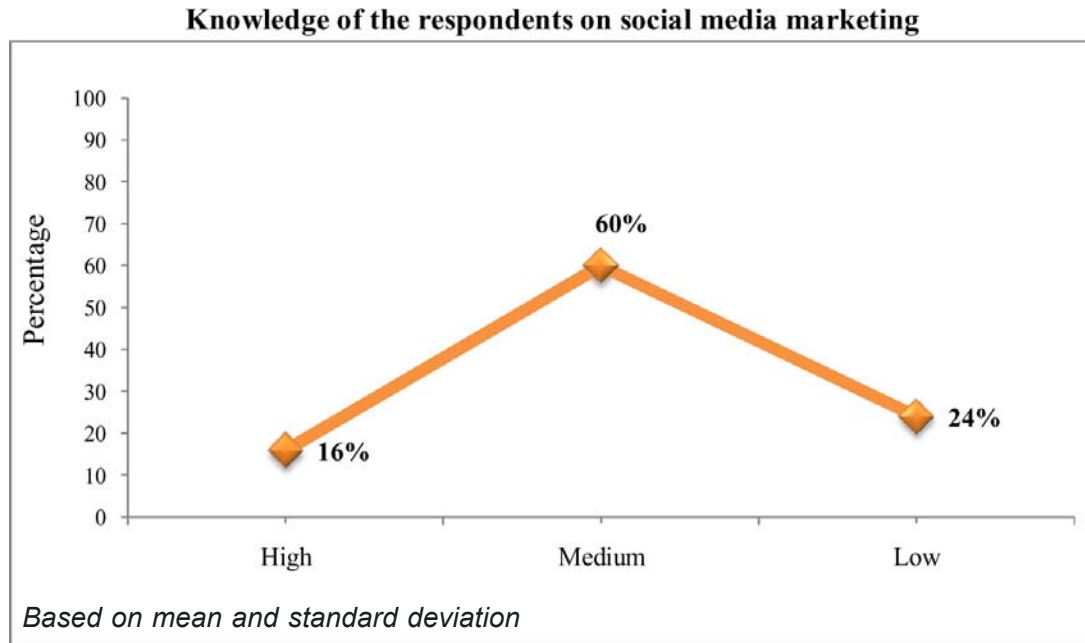


Fig. 1. Knowledge level of respondents on social media marketing (n=50)

Items produced by the women entrepreneurs in their enterprises

The respondents were mainly found to produce gamusa and Mekhela Chadar in both cotton and silk, which are the main traditional representation of Assam. The selected respondents were also found to produce various other garments both for men and women like shirt, kurta, jackets, scarf, shawls, bed and pillow covers, handkerchiefs etc. They produce the garments in traditional motifs and patterns mostly. It was found that all the selected respondents were highly skilled in their work. They have been running their enterprises in a simple unorganized manner since last 10-15 years. They never had any definite advertisements or promotions of products.

Fig.1. clearly indicates that out of total respondents, only 16% of the were found to have high level of knowledge on social media marketing and more than half of the respondents (60%)

had medium level of knowledge on social media marketing. It might be due to the fact that education and family status of an individual can greatly affect his or her knowledge level. According to Wanjiku (1994), where resources are limited within the family, education of males comes first. Females have been socialized to accept this, and then they usually drop out of school for the benefit of their brothers. It is because of this situation, even today girls in some rural places are asked to quit studying once they pass 10th or 12th grade. So, majority of the respondents have been found to be higher secondary pass in the present study. Due to lack of time because of household chores, the women do not get free time to use phones or think of any other new strategies for their enterprise. Moreover, being a rural area, the network connectivity is not that stable because of which majority of the women do not get much exposure to social media site even for their personal purpose. However, Devi and Mozhi (1999)

Ranking of first ten knowledge statements based on their mean score

Table 5. Ranking of first ten knowledge statements based on their mean score

S. No.	Statements	Mean Score	Rank
1	Social media is on high trend in the present days.	1	I
2	Facebook marketing has become one of the best marketing channels in the world of entrepreneurship	0.92	II
3	Social media is one of the tools of online marketing	0.88	III
4	Products can be accessed by the customers throughout the day (24×7) through social media.	0.74	IV
5	There are different social media sites that can be used for business purpose also.	0.72	V
6	Instagram gives information needed to make informative decisions on how to receive better results.	0.70	VI
7	High-level skills or computer equipment are not needed to participate in social media.	0.68	VII
8	Facebook, WhatsApp, YouTube and Instagram are effective marketing channels.	0.64	VIII
9	Sometimes the accounts may get hacked or have technical issues if not handled carefully.	0.32	IX
10	Major portion of entrepreneurs are using social media for marketing.	0.29	X

revealed that the knowledge level of 76% of farm women of Tamil Nadu was medium followed by high knowledge level and low knowledge with 14% and 10% respectively.

Table 5 shows that the highest mean score for the respondents was found in the statement “Social media is on high trend in the present days” and the mean score is 1. The respondents scored second and third highest mean score in the knowledge statements “Facebook marketing has become one of the best marketing channels

in the world of entrepreneurship” and “Social media is one of the tools of online marketing”, respectively.

Fig.2. clearly depicts that out of total 50 respondents, only 22% of the respondents were found to have highly favourable attitude towards social media marketing. 38% of the respondents had favourable attitude towards on social media marketing techniques. However, it was heartbreaking to find out that 40% of the respondents had unfavourable attitude towards

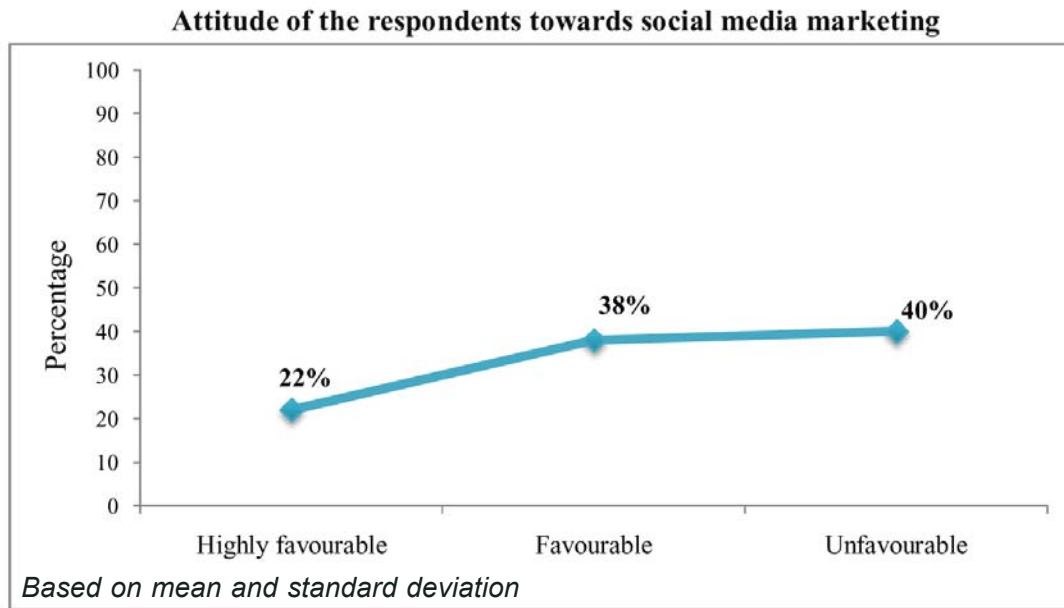


Fig. 2. Attitude level of respondents towards social media marketing (n=50)

social media marketing. This finding gives a clear indication of the result that although the respondents had been hearing about social media and had medium knowledge regarding social media marketing, they were quite skeptical when it comes to their own use. And that is because they were very cautious or concerned of the fact that their product designs might be imitated or their accounts may get hacked and are therefore, not fully ready to take a risk by adopting social media marketing. However, there were also some respondents who were found to have quite favourable attitude towards social media marketing. They have been using Facebook, Instagram pages and are getting greater profit than traditional way of marketing. They said that being women, it is not that easy for them to move around across the state for marketing of their products, in that case, social media is helping them a lot to make their products reach out to people not only in the state, but

across the country. However, a few respondents opined that seeing the advantages of social media nowadays, they are planning to open an account in Facebook, YouTube and create WhatsApp group of their own for marketing purpose. Moreover, the current Pandemic situation has also put a great impact on the pattern of marketing and sales of products of the respondents. Many of them admitted that they had faced severe loss because of lockdown and thus, now they are planning to cover up those losses through social media marketing.

Table 6 shows that the highest mean score for the respondents was found in the statement "Traditional way of marketing is better than social media marketing", and the score is 1.23. The respondents scored second and third highest mean score in the attitude statements "It is difficult to use social media sites for marketing" and "Social media marketing is more interesting than traditional way of marketing", respectively.

Ranking of first ten attitude statements based on their mean score:

Table 6. Ranking of first ten attitude statements based on their mean score

S. No.	Statements	Mean Score	Rank
1	I feel that traditional way of marketing is better than social media marketing	1.23	I
2	I find social media sites difficult to use for marketing	1.01	II
3	I find social media marketing more interesting than traditional way of marketing	1	III
4	Social media advertising is more informative for me than any other form of advertising	0.98	IV
5	Social media is not helping me in getting recognition	0.93	V
6	Use of social media sites is enhancing my online communication skills and performance	0.90	VI
7	It is quite easy for me to upload products in the Facebook and WhatsApp	0.88	VII
8	Social media has helped me earn greater profit than before.	0.86	VIII
9	Social media has helped me to strengthen relationships with customers	0.81	IX
10	I do not feel safe for my products in Facebook and Instagram	0.77	X

CONCLUSION

Nearly half of the respondents (40%) included in the study were of 21-30 years, belonged to OBC/MOBC caste (54%), majority were from Hindu community (92%) and married (84%) had nuclear families (72%) with small family sizes (60%). 46% of the respondents were higher secondary pass in regard to educational qualification. 88% of the respondents had farming as their main occupation and had monthly income of Rs.30001- Rs.40000. A total of 60% of the respondents have medium level knowledge on

social media marketing and its sites, and 40% have unfavourable attitude towards it. However, it is also worth mentioning that almost equal number of respondents (of about 38%) have favourable attitude. It is unfortunate that a large number of weavers are still not in favour of modern way of marketing.

REFERENCES

Borkakoty, J. 2013. Involvement of women in Agricultural and allied operations: A case study in Golaghat District, Assam, India. Indian J. Basic Sci. Soc. Sci. 2(2).

- Chetia, M. 2002. Involvement of rural women in poultry farming. Unpublished M.Sc. thesis, Assam Agricultural University, Jorhat.
- Devi, M.C. and Mozhi, A. 1999. Participation of farm women in rice farming. Unpublished M.Sc. Thesis, Tamil Nadu, GD, Naidu Agricultural University, Coimbatore.
- Economic Survey. 2014. Directorate of Economics and Statistics, Govt. of Assam. Retrieved from website([https://des.assam.gov.in/sites/default/files/swfutilityfolder/departments/ecost at medh as suinoid3 / menu/document/economic survey2013-14pdf](https://des.assam.gov.in/sites/default/files/swfutilityfolder/departments/ecost%20at%20medha%20suinoid3%20menu/document/economic%20survey2013-14pdf)) on 19.11.2021.
- Economic Survey. 2021. Directorate of Economics and Statistics, Govt. of Assam. Retrieved from website ([https://des.assam.gov.in/sites/default/files/swfutilityfolder/departments/eco statmed](https://des.assam.gov.in/sites/default/files/swfutilityfolder/departments/eco%20statmed) has suinoid3 / menu/document/economic survey2013-14pdf) on 19.11.2021.
- MSME Report.2012. MSME Policy. Government of Assam. Retrieved from website ([http://msme.gov.in/ Write Read Data/Document File/ANNUALREPORT-MSME-2013-14P.pdf](http://msme.gov.in/WriteReadData/DocumentFile/ANNUALREPORT-MSME-2013-14P.pdf)) on19.11.2021.
- Naude, W. 2010. Promoting entrepreneurship in developing countries: Policy challenges. UNU-WIDER Policy Brief. World Institute for Development Economics Research. United Nations University, Finland. pp. 1-7.
- Sivaraman, A. 2017. Women in the Kerala Model of Development. Jindal Journal of Public Policy. 3(1). pp. 97-104.
- Wanjiku, A. O. 1994. Academic background of students and achievement in a computer science programme in a Nigerian University. European Journal of Social Sciences. 9(4):564-572.

CONSUMPTION PATTERN OF FOODS HIGH IN FAT, SALT, AND SUGAR IN THE ADULT POPULATION OF URBAN VADODARA

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ABSTRACT

Conventionally known for malnutrition, Indians now frequently report obesity and its consequences. Diets have varied from a traditional pattern to foods high in fat, salt, and sugar (HFSS). This cross-sectional study was carried out on adults of urban Vadodara during 2017. Data concerning the socio-economic status, medical history, anthropometry, physical activity, dietary pattern, food purchasing pattern, quantitative food frequency, and three days 24-hour dietary recall were obtained. Anthropometric measurements indicated that 18% of subjects were overweight, 40% obese and 90% were abdominally obese. The majority of the respondents were physically inactive. Respondents reported strong family history of diabetes, hypertension, and hyperlipidemia. Meal skipping was persistent among the overweight and obese people. Almost all the respondents consumed high in fat, salt and sugar (HFSS) foods with wavering frequency with the predominant impetus being taste. Most frequently consumed HFSS foods were wafers, puffs, samosa, ice cream, papad, and soft drink. The 3 days 24-hour dietary recall conceded that energy intake escalated by 203 kcal during weekends compared to weekdays. The mean per capita intake of oil, salt, and sugar was 56.15g, 12.69g, and 32.05g, respectively. Consumption of HFSS foods was particularly exorbitant among overweight and obese subjects.

INTRODUCTION

On a global level, non-communicable diseases (NCDs) cause more deaths than all other causes combined (WHO, 2014). In India, 63% of all deaths in 2016 were credited to NCDs (WHO, 2018). A plethora of studies has cited the growing prevalence of NCDs in India (Vennu *et al.*, 2019; Ahirwar and Mondal 2019; Yadav and Shekhar 2019; Arokiasamy, 2018). The

prevalence of diabetes has risen from 5.9% to 9.1%, hypertension from 17.2% to 29.2%, and obesity from 4% to 15% (Arora *et al.*, 2014). The prevalence of diabetes in India is 77 million and in South East Asia 11.3% (IDF, 2019). The Indian Council of Medical Research (ICMR) conveyed that the prevalence of diabetes is 9.8% (7.6-12.0) in urban and 5.1% (4.2-6.0) in rural Gujarat (Anjana *et al.*, 2017). The prevalence of

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hypertension in Gujarat is 17.9% and overweight/obesity is 18.9% (Arora *et al.*, 2014). The South-East Asia region is addressing an expeditious increase in the prevalence of NCDs, owing to major alterations in dietary patterns and physical inactivity. These modifications have majorly resulted from globalization and urbanization leading to nutrition transition (Mohan *et al.*, 2016). Diet is a crucial determinant of NCDs. Foods particularly high in fats, salt, and sugars (HFSS) are major contributory factors (GoI, 2015). Consumption of HFSS foods has become entrenched in the diet and may present a health risk if consumed regularly. The global shift towards diets high in sugar and energy-dense ultra-processed foods is linked to a higher prevalence of NCDs (Caro *et al.*, 2017).

There is a dearth of data particularly from low and middle-income countries vis-à-vis the major trends in prevalence, awareness, and control of hypertension on grounds of substandard surveillance and follow-up mechanisms (Lohiya *et al.*, 2019). There is an urgent need to address this modern food consumption pattern. Hence, the study was conducted to elicit information regarding HFSS foods consumption and purchasing pattern of adults (25-50 years) in urban Vadodara, who are at extraordinary risk of developing NCDs.

MATERIALS AND METHODS

The study was conducted in 2017 on 400 adults (25-50 years) of urban Vadodara, Gujarat. It was a cross-sectional study conducted in a single phase. The formula applied for sample size calculation in a cross-sectional study is $4pq/L^2$, in which, p is the prevalence, $q = (100-p)$ and L is the allowable error of prevalence. Taking the prevalence of consumption of high salt as 20%

in Gujarat based on the literature, the sample size is estimated to be 400 respondents. Using the Vadodara Municipal Corporation map, four wards were purposely selected from each of the four administrative zones, and enumeration of households was performed. A total of 50 households were randomly selected from each ward. Based on the inclusion-exclusion criteria and consent for participating, subjects were interviewed from the selected households until the desired sample size was achieved. Data was collected concerning the background information and socioeconomic status using a semi-structured questionnaire. A pre-tested questionnaire was used to assess the medical history. The dietary pattern was assessed using structured questionnaires regarding food habits, food purchasing patterns, quantitative food frequency, and three days of 24-hour dietary recall. Evidence of physical activity was based on International Physical Activity Questionnaire (IPAQ). Anthropometric parameters such as weight, height, Body Mass Index (Asia-Pacific Criteria, 2004), waist and hip circumference were recorded. Blood pressure was measured using a sphygmomanometer. A subset of 50 households was provided with oil, sugar, and salt samples, and per capita consumption of the same was noted. Pre and post-weight of oil, sugar, and salt were taken to arrive at the exact amount of consumption. The data were analysed using SPSS (Version 24). The nutritive value calculation for 24-hour dietary recall was performed using Diet Soft Software. Frequency distribution and percentages were calculated for all parameters that were expressed in rank order. Means and standard errors were calculated for all parameters that were exposed numerically. Correlation and regression were calculated for

the trends observed. The study was approved by the Institutional Ethics Committee for Human Research. Written informed consent was also acquired from the respondents.

RESULTS AND DISCUSSION

Socio-personal profile of the respondents

The mean age of the subjects was 34 ± 7 years. A greater percentage (70.8%) of the respondents lived in a nuclear family setup. 42.3% were graduates while 37.5% pursued professional studies. 69% of the respondents had a monthly income in the range of 80,000 to 2 lacs while for 15% income exceeded 2.5 lacs. The self-reported medical history of the subjects affirmed the prevalence of hypertension as 6% followed by 5.5% for diabetes. The prevalence of overweight/obesity is determined to be a pivotal modifiable factor in Type- 2 diabetes incidences. Older age and a family history of diabetes have been positively associated with predicting the development of diabetes (Dhruvet *et al.*, 2011 and Ghorpadeet *et al.*, 2013).

Anthropometric and Bio-Physical Characteristics

The mean weight was 65.13 ± 10.99 kg. The Body Mass Index (BMI) was found to be on the higher side with a mean value of 24.61 ± 3.83 kg/m². The overall prevalence of overweight was 18% and obesity was 40% (Table 1).

The prevalence of overweight was found to be higher among males (20.4% vs. 15.9%) whereas obesity was higher among females (41.6%). The abdominal obesity as assessed by WC, WHR, and WSR revealed that 90% of the subjects had higher measurements, increasing the risk for CVDs. Comparable results were obtained from a study with a reported prevalence of overweight and obesity as 21.7% and 48.3%, respectively. Higher than reasonable values for waist circumference and waist-hip ratio were also documented (Dhruvet *et al.*, 2011). However, in another study, an alarming 70% prevalence of obesity with a mean BMI of 26.5 ± 4.7 was communicated (Muley and Iyer, 2014). The prevalence of obesity was slightly higher among

Table 1. Anthropometric and biophysical profile of the subjects (Mean \pm SD)

Variable	Male	Female	Total	t value
1. Weight(kg)	68.68 ± 10.35	62.05 ± 10.63	65.13 ± 10.99	6.33***
2. Height (cm)	167.1 ± 6.4	158.8 ± 6.1	162.7 ± 7.5	13.19***
3. Body Mass Index (kg/m ²)	24.59 ± 3.40	24.62 ± 4.17	24.61 ± 3.83	0.06
4. Waist Circumference (cm)	94.75 ± 9.89	91.83 ± 10.27	93.19 ± 10.19	2.88**
5. Hip Circumference (cm)	96.49 ± 9.87	101.34 ± 10.25	99.08 ± 10.35	4.80***
6. Waist Hip Ratio	0.98 ± 0.07	0.91 ± 0.04	0.94 ± 0.09	13.60***
7. Waist Stature Ratio	0.57 ± 0.07	0.57 ± 0.07	0.57 ± 0.07	1.67
8. Systolic Blood Pressure (mmHg)	125.38 ± 8.65	122.55 ± 9.53	123.86 ± 9.23	3.09**
9. Diastolic Blood Pressure (mmHg)	84.09 ± 7.87	82.05 ± 7.99	82.99 ± 7.99	2.56*

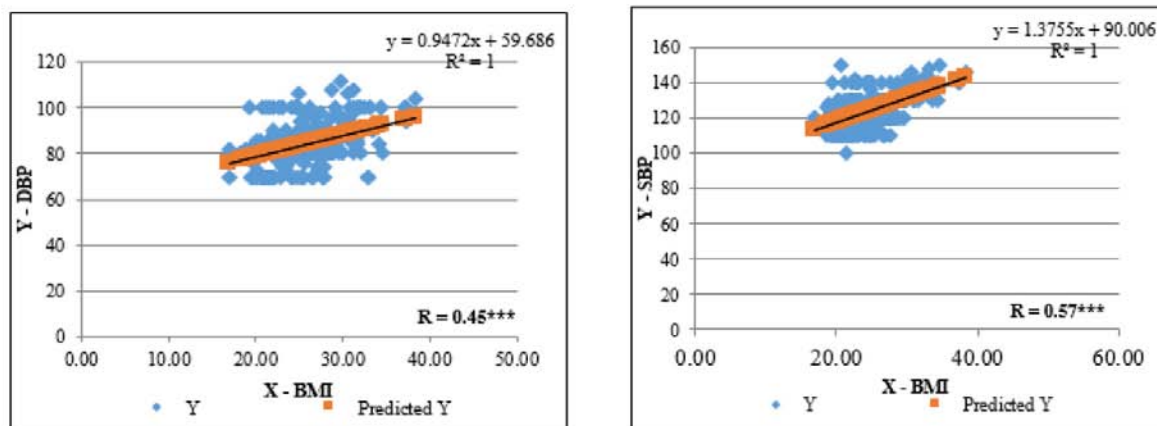


Fig.1(a) and 1 (b). Correlation between BMI and SBP, DBP

female participants. The overall prevalence of obesity was found to be much higher (45.4%) in the younger age group (25-35 years) as compared to the older (29.7%). This is similar to the statistics of the National Family Health Survey which affirmed the higher preponderance of NCDs among adults in the age group 35-49 years, specifically among women residing in urban areas (Vennu et al., 2019). Obesity has been implied as a crucial risk factor in the development of essential hypertension, diabetes, and co-morbidities (Jiang et al., 2016).

Prevalence of pre-hypertension and hypertension

The mean systolic blood pressure (SBP) was 123.86 ± 9.23 mmHg while the mean diastolic blood pressure (DBP) was 82.99 ± 7.99 mmHg. The prevalence of prehypertension was 73.8% and that of hypertension was 19%. Fig. 1(a) and 1(b) indicate that a rise in BMI was significantly correlated with elevated blood pressure, intensifying the risk of CVDs. The prevalence of hypertension was higher among males. This resonates with the results of a study reporting significantly higher levels of DBP in males of Vadodara than females and a positive link

between hypertension and obesity (Muley and Iyer, 2014).

Physical Activity Profile of the Subjects

The mean Metabolic Equivalent of Task (MET) minutes/week was 359.3, which implies a sedentary lifestyle reflecting little physical activity. A greater number (78%) were sedentary while 22% were moderately active. None of the subjects qualified for heavy physical activity. A negative correlation was detected between physical activity and Body Mass Index.

Dietary habits and purchasing practices

Table 2 demonstrates the dietary habits of the subjects across the Body Mass Index. Around 70% of the subjects were vegetarian. Few subjects reported allergies to certain foods. Dietary supplements in one form or the other were being taken by 3.3% of subjects. Notably, almost half (44.1%) of the study participants reported adding 3 teaspoons of sugar in a single cup of tea/coffee. 11% of the subjects reported eating out 3-4 times a week which infers a minimum of 12 days in a month. 50.6% of obese subjects were consuming 4 meals a day with more persistent skipping of meals.

Taste (82.3%) was considered the most prominent factor in purchasing food followed by shelf life (54.3%), price (52.3%), and nutritive content (54.5%). Half of the subjects professed being exposed to High fat, salt, and sugar food advertisements quite often with the most substantial sources being television and newspapers. These endorsements were able to influence the purchasing practices of 34.3%. Merely 9% of subjects perceived their diet as 'very healthy'.

Consumption of high fat, salt, and sugar (HFSS) foods

Nearly all the subjects (99.0%) reported consuming foods high in fat, salt, and sugar,

however with varying frequencies, and the major reasons furnished were taste (70.5%), ease of availability (24.7%), and convenience (21.5%). Occasional consumption of foods rich in fat was reported. The frequency of consumption of puff and samosa was found to be once a week by 11.8% and 14%, respectively. *Panipuri* was being consumed daily by 6.5%. 15.6% of the subjects consumed wafers thrice a week. Salt-laden foods such as *Papad* were devoured every day as accompaniments by 35% and ketchup was consumed by 21% once a week. However, a majority reported only occasional consumption of foods rich in sugar. 19.8% were consuming cola once a week. Results commensurate with studies assessing the snacking pattern of urban

Table 2. Dietary Habits of the Subjects across BMI (n, %)

Variable	Response	Normal		Overweight		Obese	
		Male n = 77	Female n = 88	Male n = 38	Female n = 34	Male n = 71	Female n = 89
Number of meals consumed in a day	2 meals	1 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)	2 (2.2)
	4 meals	38 (49.4)	37 (42)	13 (34.2)	17 (50.0)	32 (45.1)	45 (50.6)
	>4 meals	5 (6.5)	4 (4.5)	0 (0.0)	0 (0.0)	2 (2.8)	2 (2.2)
Amount of sugar added in one cup of tea/coffee/milk	1 tsp.	0 (0.0)	2 (2.3)	0 (0)	1 (2.9)	1 (1.4)	0 (0.0)
	2 tsp.	26 (33.8)	24 (27.3)	12 (31.6)	13 (38.2)	15 (21.1)	23 (25.8)
	3 tsp.	29 (37.7)	39 (44.3)	14 (36.8)	13 (38.3)	37 (52.1)	44 (49.4)
Skipping of meals	2 tbsp.	4 (5.2)	7 (8.0)	5 (13.2)	2 (5.9)	3 (4.2)	5 (5.6)
	No sugar	11 (14.3)	5 (5.7)	2 (5.2)	2 (5.9)	2 (2.8)	2 (2.2)
Skipping of meals	Yes	10 (13.0)	8 (9.1)	3 (7.9)	6 (17.6)	15 (21.1)	17 (19.1)
	No	67 (87)	80 (90.9)	35 (92.1)	28 (82.4)	56 (78.9)	72 (80.9)

Note: Values in parentheses denote the percentages

residents of Vadodara, delineating that bakery products and shallow fried snacks, followed by deep-fried items are the major snacking components (Dhruvet *et al.*, 2011). Snack items are usually brimmed with fats and salt and are deep-fried proliferating their trans-fat content, and this elucidates their potential effects and relationship with numerous health outcomes (Green *et al.*, 2016). The consumption of foods high in fat was significantly higher among overweight and obese subjects. High sugar food consumption was positively correlated with BMI. A systematic review outlined that a high-fat dietary pattern predisposed subjects to a higher BMI and one high in sweets and snacks was associated with a greater risk of diabetes compared to a traditional diet based on rice and pulses. However, other relationships with NCD risk factors were less clear (Green *et al.*, 2016).

Per capita consumption of fat, salt, and sugar

The reported mean per capita consumption of oil and ghee was 56.15g and 15.12g, respectively indicating a higher than recommended consumption of visible fat. The

mean per capita consumption of sugar and salt was 32.05g and 12.69g, respectively which are considerably beyond the recommendation. The stratification of per capita consumption across BMI (Fig. 2) divulges that the intake of oil among overweight and obese subjects was higher, while ghee and salt intake were virtually the same, and a slight downturn in sugar intake was observed in obese individuals. The salt intake was greater than 10g, with a trivial difference among hypertensives and normotensives. However, a positive correlation was found between salt intake and blood pressure. Quantification study on a sub-sample demonstrated that the mean oil intake was 41.67 ± 8.64 g, sugar 29.63 ± 7.99 g, and salt intake was 9.78 ± 1.97 g per day which is lesser (15g for fat and 3-4 g for salt and sugar) than reported consumption.

Nutrient Intake of the subjects

The mean intake of macronutrients and micronutrients are provided in Tables 3 and 4. The mean energy intake was found to be significantly higher on weekends with an average addition of 203 calories, while no significant

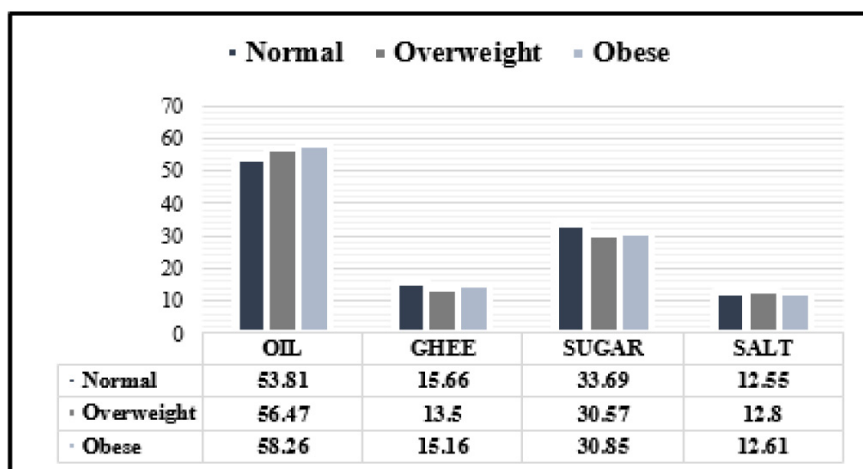


Fig. 2. Per capita consumption of fat, salt, and sugar (g) across BMI

Table 3. Mean macronutrient intake of subjects (mean \pm SD)

		Male n = 186	Female n = 214	Total n = 400
Average of 3 days	Energy (kcal)	2414 \pm 379	2391 \pm 397	2403 \pm 388
	Protein (g)	54.7 \pm 8.6	54.0 \pm 8.8	54.3 \pm 8.7
	Visible Fat (g)	37.5 \pm 6.2	37.4 \pm 6.2	37.4 \pm 6.2
	Total Fat (g)	93.7 \pm 13.5	92.2 \pm 13.8	92.8 \pm 13.7

Table 4. Mean micronutrient intake of subjects (mean \pm SD)

		Male n = 186	Female n = 214	Total n = 400	F Value
Average of 3 days	Iron (mg)	10.14 \pm 1.13	10.11 \pm 1.28	10.13 \pm 1.21	0.058
	Calcium (mg)	482.15 \pm 74.74	474.11 \pm 76.63	477.84 \pm 75.77	1.120
	Vitamin C (μ g)	49.91 \pm 13.55	48.8 \pm 15.4	49.32 \pm 14.54	0.565
	Carotene (μ g)	2546.55 \pm 1328.51	2464.5 \pm 1473.13	2502.65 \pm 1406	0.328
	Sodium (mg)	441.68 \pm 86.6	432.1 \pm 72.56	436.56 \pm 79.45	1.445
	Potassium (mg)	1129.45 \pm 135.3	1133.58 \pm 149.88	1131.65 \pm 143.14	0.083

Table 5. Post Hoc test for nutrient intake across BMI

Parameter	F value	Normal vs. Overweight	Normal vs. Obese	Overweight vs. Obese
Energy	142.16***	10.273***	19.479***	5.628***
Protein	110.94***	11.166***	17.928***	1.854***
Visible Fat	24.98***	5.320***	8.738***	1.116
Total Fat	132.19***	9.566***	18.936***	5.465***
Cholesterol	18.36***	5.72***	5.606***	1.409***
Sugar	30.75***	6.663***	8.224***	0.343
Free Sugars	24.31***	5.56***	6.874***	0.800
Sodium	15.19***	4.697***	6.141***	0.930

*** $P < 0.001$

difference was observed between two weekdays. There was no significant difference across gender in macronutrient intake.

The consumption of all the macronutrients was higher in overweight and obese people. Fat consumption was approximately 20g higher among obese subjects. An inflating trend was

observed in visible fat intake from normal to obese. There was a steep surge observed in free sugar intake among overweight and obese. Percent protein intake decreased from 9.13% (normal) to 8.91% in obese, while percent fat intake was nearly the same.

Post Hoc test for nutrient intake across BMI (Table 5) indicates that the mean intake of energy, protein, visible fat, total fat, cholesterol, sugar, and free sugar was significantly high in overweight and obese. It is crucial to note that the sodium intake was significantly higher among overweight and obese subjects while no significant difference in mean intake of visible fat, sugar, and free sugar is observed between overweight and obese subjects.

CONCLUSION

The findings indicated a higher prevalence of obesity and prehypertension. The prevalence of obesity was found to be rampant in the younger age group evidencing that these individuals would be at a higher risk to suffer from its co-morbidities with advancing age. Information regarding per capita consumption of edible oil, fats, salt, and sugar was found to be on the higher side suggesting a need to create awareness to curtail the consumption of the same. Furthermore, the findings demonstrated a higher frequency of consumption of some of the HFSS foods at home as well as outside, with significantly higher values reported for overweight and obese subjects in comparison to subjects having a normal BMI.

The data generated through this study would help in planning and implementing advocacy for the control of NCDs. Along with health policies at the population level, there has

also been increasing support towards risk detection and management approaches for NCDs at the individual level. Complications of NCDs can be curbed by timely detection and subsequent remedial measures in individuals who are at high risk of NCDs. There is a dire need for generating more data on dietary intakes for assessing fat, salt, and sugar intake. Such data generated at the national level will warrant a strong basis for establishing regulatory limits for manufacturers. If a nutrition database of locally consumed HFSS foods is made available, then it would help in identifying the foods contributing to high fat, salt, and sugar consumption, which in turn would contribute to setting up cut-off limits in processed foods.

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REFERENCES

- Ahirwar, R and Mondal, P.R. 2019. Prevalence of obesity in India: A systematic review. *Diabetes and Metabolic Syndrome*.13(1):318-321.
- Anjana, R.M., Deepa, M., Pradeepa, R., Mahanta, J., Narain, K., Das, H.K., Adhikari, P., Rao, P., Saboo, B., Kumar, A and Bhansali, A. 2017. Prevalence of diabetes and prediabetes in 15 states of India: results from the ICMR–INDIAB population-based cross-sectional study. *Lancet Diabetes and Endocrinology*. 5(8):585-96.
- Arokiasamy, P. 2018. India's escalating burden of non-communicable diseases. *Lancet Global Health*. 6(12):1262-1263.

- Arora, N.K., Pillai, R., Dasgupta, Rand Garg, P.R. 2014. Whole-of-society monitoring framework for sugar, salt, and fat consumption and non-communicable diseases in India. *Annals of the New York Academy of Sciences*. 1331(1):157-173.
- Caro, J.C., Smith-Taillie, L., Ng, S.W and Popkin, B. 2017. Designing a food tax to impact food-related non-communicable diseases: The case of Chile. *Food Policy*. 71:86.
- Dhruv, S., Patel, S and Uma, S. 2011. Snacking pattern of residents of Vadodara: A pilot study. *International Journal of Applied Biology and Pharmaceutical Technology*. 2(2): 81-87.
- Ghorpade, A.G., Majgi, S.M., Sarkar, S., Kar, S.S., Roy, G., Ananthanarayanan, P. Hand Das, A.K. 2013. Diabetes in rural Pondicherry, India: A population-based study of the incidence and risk factors. *WHO South-East Asia Journal of Public Health*. 2(3-4):149–155.
- Green. R., Milner, J., Joy, E.J., Agrawal, S and Dangour, A.D. 2016. Dietary patterns in India: A systematic review. *British Journal of Nutrition*. 116(1):142-8.
- IDF. 2019. IDF Diabetes Atlas. International Diabetes Federation. pp. 39-40.
- Jiang, S.Z., Lu, W., Zong, X.F., Ruan, H.Y and Liu, Y. 2016. Obesity and hypertension (Review). *Experimental and Therapeutic Medicine*. 12(4): 2395-2399.
- Lohiya, A., Daniel, R.A., Kar, S.S., Sahu, S.K., Nongkynrih, B and Varghese, C. 2019. Measuring outcomes of hypertension treatment in primary care in resource-limited settings. *WHO South-East Asia Journal of Public Health*. 8(2):112–114.
- GoI. 2015. Report of working group on addressing consumption of foods high in fat, salt and sugar (HFSS) and promotion of healthy snacks in schools of India. Ministry of Women and Child Development, Government of India, New Delhi. pp.7-8.
- Muley, A and Iyer, U. 2014. A pilot study on vitamin D status and metabolic syndrome in adult Indian population. *International Journal of Applied Sciences and Biotechnology*. 2(2): 126-131.
- Vennu, V., Abdulrahman, T.A and Bindawas, S.M. 2019. The Prevalence of overweight, obesity, hypertension, and diabetes in India: Analysis of the 2015–2016 national family health survey. *International Journal of Environmental Research and Public Health*. 16(20):3987.
- Mohan, V., Ruchi, V., Gayathri, R., Bai, M.R., Sudha, V., Anjana, R.M and Pradeepa, R. 2016. Slowing the diabetes epidemic in the World Health Organization South-East Asia Region: The role of diet and physical activity. *WHO South-East Asia Journal of Public Health*. 5(1):5–16.
- WHO. 2014. Global status report on non-communicable diseases 2014. World Health Organization. Geneva, Switzerland. pp. 1.
- WHO. 2018. Non-communicable diseases country profiles 2018. World Health Organization. Geneva, Switzerland. pp. 1.
- Yadav, R and Shekhar, C. 2019. Trend and Regional Variations in Communicable and Non-communicable Diseases in India: 1996-2014. *Child Health and Mortality*. 65.

OPTIMISATION OF PROTEIN ENRICHED JACKFRUIT SEED FLOUR BASED NUTRI SPREADS

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ABSTRACT

The jackfruit seed flour based nutri spreads were enriched by skimmed milk powder (SMP) in the study conducted from 2016 to 2018. These protein sources were incorporated to the jackfruit seed flour based nutri spread in varying percentage levels (10%, 20%, 30%, 40% and 50%). Organoleptic and nutritional quality evaluation of prepared enriched jackfruit seed flour based nutri spreads were done. All nutri spreads obtained high scores for organoleptic qualities. The best treatment was selected through sensory evaluation using a score card with a nine point hedonic scale. Based on organoleptic evaluation, nutri spread prepared with 70 per cent jack fruit seed flour and 30 percent skimmed milk powder had a maximum mean score of 8.66 for overall acceptability. The selected enriched nutri spread was subjected to physico-chemical analysis and was observed to have moisture (3.64%), energy (421 Kcal), carbohydrate (18.56 g 100 g⁻¹), protein (14.34 g 100 g⁻¹), fat (30.42 g 100 g⁻¹), calcium (136 mg 100 g⁻¹), iron (0.97 mg 100 g⁻¹), sodium (5.97 mg 100 g⁻¹) and potassium (27.45 mg 100 g⁻¹). Highly acceptable, nutritionally superior and shelf stable nutri spreads could be developed successfully based on jackfruit seed flour without adding any preservatives.

Key words: Jackfruit seed flour, nutri spreads, protein source, skimmed milk powder

INTRODUCTION

Spreads are concentrated foods with high nutritive value and have significant role in the nutrition of children, sports persons and adults. Nut spread, a type of nutri spread is popular and is widely accepted by consumers due to its good flavour, nutritional value and suitability for consumption either alone or in combination with a variety of other foods. Nut spreads provide

energy, protein, essential fatty acids, vitamins and minerals in the diet.

Spread is a confectionary product based on powdered sugar, vegetable fat, cocoa powder, milk powder and other ingredients. Its physical and sensory properties are strongly influenced by the behaviour of the fat phase (Loncarevic *et al.*, 2014). Spreads are concentrated foods with high nutritive value and are favourite in the

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nutrition of children, sports persons and also of adults (Raljic *et al.*, 2013). Nut spreads are products made with nuts such as almond, cashew, hazelnut, macadamia nut, peanut, pecan, pistachio and walnut (Shakerardekani *et al.*, 2013).

Chocolates preads are very popular among children. Most of the commercially available spreads contain more than 30 percent fat and 40 percent sugar, which may lead to several health problems. Moreover, the cost of these spreads is also very high.

Jackfruit seed flour is a nutritious ingredient which is having favourable properties for extensive food applications. Jackfruit seed flour was found to be rich in proteins, carbohydrates and minerals. The fat content of the seed flour was negligible, making it a good constituent in functional foods which can be consumed safely. It showed better results for water absorption, oil absorption, swelling power and can be utilised in various food for mulations (Abraham and Jayamuthunagai, 2014). Islam *et al.* (2015) reported that jackfruit seeds contain 15.88 percent moisture, 2.49 percent crude fiber, 5.78 percent protein and a low fat of 1.77 percent.

Fat content of different types of spreads is between 20% to 60%. Fats are an important raw material that affect the behaviour of spreads during processing, and a number of quality characteristics of the final product like taste, melting, mouth feel, texture, other physical characteristics, as well as their nutritive value. With increasing health awareness among people, much consumer attention has focused on low fat, low sugar and nutrient enriched

spreads which provide certain functional properties. Ready-to-eat foods such as bread, sandwiches, etc. are commonly used now a days and hence the demand has come up for cost effective, nutritious spreads based on locally available resources. With increasing health awareness among people, much consumer attention has focused on low fat, low sugar and nutrient enriched spreads which provide certain functional properties. Nutri spreads can be considered as a healthy alternative to commercial high fats preads. Hence, the study was conducted to identify the suitability of jackfruit seed flour as an ingredient for the standardization of nutri spreads which is nutritionally superior and cost effective.

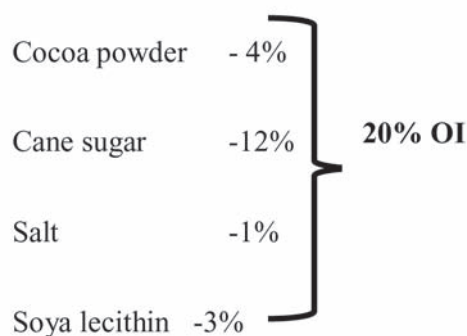
MATERIALS AND METHODS

Selection and collection of jackfruit seed flour

The experiment was conducted during 2016-18 at the Research cum Department of Community Science of College of Agriculture, Kerala Agricultural University, Thrissur. Jackfruit seeds were used as the major ingredient. Jackfruit seeds were collected from homesteads. Cocoa powder and cocoa butter were procured from Cocoa Research Centre of Kerala Agricultural University. All other raw ingredients needed for the study were purchased from the local market.

Standardization of nutri spreads

Jackfruit seed flour was prepared based on standard procedure. Cocoa powder, cane sugar, salt and soya lecithin were the other ingredients used in nutri spreads. The amount of other ingredients (OI) were kept in a fixed proportion of 20 percent as detailed below,



Jackfruit seed flour based nutri spreads

Jackfruit seed flour was prepared using standard procedure (Pandey, 2004).

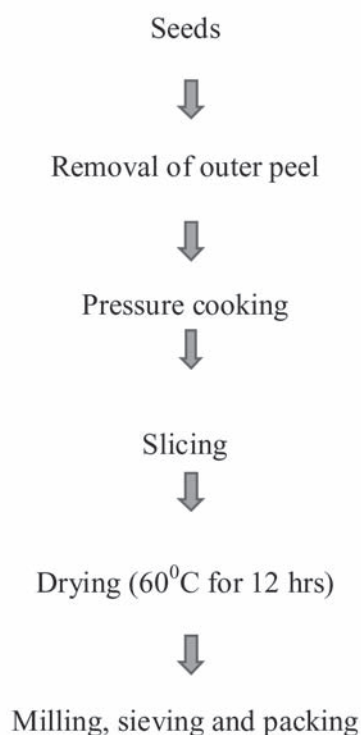


Fig.1. Preparation of jackfruit seed flour

The best combination of jackfruit seed flour based nutri spread was selected for the protein enrichment. The combination contains 35 percent of jackfruit seed flour (JSF), 45 percent of hydrogenated palm oil (HPO) and 20

per cent of other ingredients (OI) was selected as the best JSF based nutri spread combination. Jackfruit seed flour nutri spreads were enriched using skimmed milk powder (SMP). The protein source was incorporated to the base material in selected spread in varying percentage levels (10%, 20%, 30%, 40% and 50%).

The jackfruit seed flour nutri spreads and skimmed milk powder (SMP) was incorporated in varying percentages from 10 percent to 50 percent (JT₁ - JT₅). Jackfruit seed flour nutri spread without enrichment served as the control (JT₀). The experiment was conducted in a Completely Randomised Design (CRD) with 6 treatment combinations with three replications. The details of treatments and combination are detailed below (Table 1.).

Table 1. Combinations of protein enriched nutri spreads

Treatments	Combinations
JT ₀	Control (35% JSF + 45% HPO + 20% OI)
JT ₁	90% JSF + 10% SMP
JT ₂	80% JSF + 20% SMP
JT ₃	70% JSF + 30% SMP
JT ₄	60% JSF + 40% SMP
JT ₅	50% JSF + 50% SMP

*JSF-Jackfruit seed flour based nutri spreads, HPO- Hydrogenated palm oil, SMP- skimmed milk powder, OI- Other ingredient

Organoleptic evaluation

A series of acceptability trials were carried out using simple triangle test at the laboratory level by a selected panel of fifteen judges between the age group of 18- 35 years as

suggested by Jellineck (1985). The organoleptic evaluation of the nutri spreads were carried out. The reconstituted nutri spreads were evaluated organoleptically by the judges using a 9 point hedonic scale.

Nutrient analysis of the nutri spreads

The nutritive qualities like moisture, carbohydrate, protein, fat, fibre, calcium, iron, sodium and potassium of best enriched jackfruit seed flour based nutri spreads were determined initially. Analyses were carried out in triplicate.

Statistical analysis

The scores obtained for organoleptic evaluation were evaluated by Kendall's Coefficient of Concordance (W).

Cost of Production of enriched Jackfruit seed flour based nutri spreads

The cost of production of the most acceptable combination of jackfruit seed flour based nutri spreads was computed based on the market price of procured ingredients used for preparation of products along with labour charge, fuel charge, electricity charge and packaging cost. The cost was calculated for 100 g of the product and compared with similar products available in the market.

RESULTS AND DISCUSSION

Organoleptic evaluation

Organoleptic evaluation of enriched nutri spreads were carried out separately. In the study, jackfruit seed flour (JSF) nutri spread enriched with skimmed milk powder (SMP), treatment JT₃(70% JSF+30% SMP) had a highest mean score in all the sensory attributes like appearance (8.88), colour (8.44), flavour

(8.22), texture (9.00), taste (8.66) and overall acceptability (8.66). In enriched JSF, 30 percent in corporation of skimmed milk powder was found to be the most acceptable. When the percentage of skimmed milk powder increased, the appearance, colour, flavour and texture decreased significantly (Table 2).

Values in parentheses is mean rank score based on Kendall's W and significant at 1% level

Wilson and David (2017) reported that nine percent soya protein along with 0.6 percent lecithin and four percent dietary fibre has the high scores for texture and overall acceptability in soy spread.

Nutrient analysis of the nutri spreads

Based on the sensory evaluation, in case of nutri spreads based on jackfruit seed flour, the treatment JT₃(70%JSF+30% SMP) was found to be the best. The nutritive value of selected jackfruit seed flour based nutri spread enriched with skimmed milk powder observed to have moisture (3.64%), energy (421 Kcal), carbohydrate (18.56 g 100 g⁻¹), protein (14.34 g 100 g⁻¹), fat (30.42 g 100 g⁻¹), calcium (136 mg 100 g⁻¹), iron (0.97 mg 100 g⁻¹), sodium (5.97 mg 100 g⁻¹) and potassium (27.45 mg 100 g⁻¹) and shown in Table 3. Wilson and David (2017) reported that soya spread in corporation with soy prote in isolate had a prote in content in the range of 11.66 to 14.04 percent.

Cost of Jackfruit seed flour based nutri spreads

The cost of nutri spread enriched with skimmed milk powder was Rs. 55.25/ 100 g. The market price of nut spread was observed as Rs.135/100 g. The cost of prepared nutri spread

Table 2. Mean scores for organoleptic evaluation of jackfruit seed flour based nutri spreads enriched with skimmed milk powder

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
JT ₀ (35% JSF+45%HPO+20% OI)	7.66 (1.83)	8.33 (4.00)	7.56 (2.33)	8.00 (3.17)	8.00 (3.83)	7.88 (2.17)
JT ₁ (31.5%JSF +3.5% SMP)	7.55 (2.67)	8.11 (3.33)	8.00 (3.00)	8.00 (3.00)	7.11 (1.1)	7.66 (2.83)
JT ₂ (28% JSF+7% SMP)	8.88 (4.50)	8.44 (4.33)	8.20 (3.90)	9.00 (4.50)	8.22 (4.1)	8.55 (4.33)
JT ₃ (24.5 JSF+10.5% SMP)	8.88 (4.50)	8.44 (4.33)	8.22 (4.00)	9.00 (4.50)	8.66 (4.8)	8.66 (4.67)
JT ₄ (21% JSF+14% SMP)	7.48 (2.33)	7.44 (1.67)	7.87 (2.33)	7.33 (1.83)	7.55 (2.8)	7.11 (1.17)
JT ₅ (17.5% JSF+17.5% SMP)	7.44 (1.00)	7.33 (1.33)	7.77 (2.00)	6.88 (1.17)	7.33 (2.0)	7.44 (2.00)
Kendalls W	.953	.949	.667	.988	.959	.925

*JSF-Jackfruit seed flour based nutri spreads,HPO- Hydrogenated palm oil,SMP- skimmed

Table 3. Nutritional qualities of enriched and unenriched nutri spreads

Treatments	Energy (Kcal)	Protein (g/100 g)	Fat (g/100 g)	CHO (g/100 g)	Calcium (mg/100 g)	Iron (mg/100 g)	Sodium (mg/100 g)	Potassium (mg/100 g)
Control JT ₀ (JSF+HPO)	520.02	6.60	46.02	19.86	16.50	1.86	8.29	27.60
Enriched JT ₃ (JSF+SMP)	421	14.34	30.42	18.56	136	0.97	5.97	27.45

*JSF-Jackfruit seed flour based nutri spreads,HPO- Hydrogenated palm oil,SMP- skimmed milk powder

was lower compared to the market price of nut spread.

CONCLUSION

Jack fruit seed flour was proven as a potential source of nutrients and can be utilised effectively for developing functional foods. Jackfruit seed flour based nutri spreads had high organoleptic qualities with remarkably smooth texture and had good amount of essential nutrients. From the study, it is evident that highly acceptable nutri spreads could be prepared from jackfruit seed flour cost effectively. In enriched nutri spreads, incorporation of 70% jack seed flour and 30% skimmed milk powder (JT₃) was found to be high in protein content with maximum acceptability. Incorporation of underutilized fruits such as jackfruit for the development of convenient foods increased the nutritive value and reduced the cost.

REFERENCES

- Abraham, A and Jayamuthunagai, J. 2014. An analytical study on jackfruit seed flour and its incorporation in pasta. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*. 5 (2): 1597-1610.
- Islam, M. S., Begum, R., Khatun, M and Deyl, K. C. 2015. A study on nutritional and functional properties analysis of jackfruit seed flour and value addition to biscuits. *International Journal of Engineering Research and Technology*. 4(12): 139-147.
- Jellinek, G. 1985. *Sensory Evaluation of Food: Theory and Practice*. Ellis Horwood, Chichester, England. pp. 590-596.
- Loncarevic, I., Pajin, B., Dokic, L., Seres, Z., Fister, A., Simovic, D. S and Krstonosic, V. 2014. Rheological and textural properties of cocoa spread cream with sunflower lecithin. *Acta Tehnica Corviniensis – Bulletin of Engineering*. 7: 47-50.
- Pandeay, S. 2004. Value added products and byproducts from jackfruit. Ph. D. thesis submitted to Kerala Agricultural University, Vellayani, Kerala. pp.120-122.
- Raljic, J. V. P., Petronijevic, J. G. L., Dimic, E. B., Popov, V. S., Vujasinovic, V. B., Blesic, I. V and Portic, M. J. 2013. Quality parameters of mixed milk and cocoa spreads. *HemijskalIndustrija*. 67 (5): 781-793.
- Shakerardekani, A., Karim, R., Ghazali, H. M and Chin, N.L. 2013. Textural, rheological and sensory properties and oxidative stability of nut spreads. *International Journal of Molecular Science*. 14: 4223-4241.
- Wilson, land David, J. 2017. Studies on quality parameters of soya spread incorporated with soy protein isolate. *International Journal of Chemical Studies*. 5 (3): 319-322.

NUTRITIONAL AND HEALTH STATUS OF LODHA TRIBAL WOMEN OF MAYURBHANJ DISTRICT IN COMPARISON TO THEIR MALE COUNTERPARTS

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ABSTRACT

Lodha is a primitive tribe living in a dense forest area of West Bengal, Odisha, and Jharkhand. This study was conducted to determine the nutritional status of both male and female Lodha tribes. A total of 400 Lodha tribal people including 200 males along with 200 tribal females were selected randomly in the age range for all groups was 18-45 years and belonged to the non-pregnant and non-lactating category. A total of 400 subjects were randomly selected from 10 villages of Morada, Baripada, Shamakhunta from the Suliapada block of Mayurbhanj district. The prevalence of Chronic Energy Deficiency (CED) among female Lodha tribe (82.5%) was significantly higher ($\chi^2=15.635$, $p=0.0015$) than their male counterparts (57%). This study also reported that the male Lodha tribal were more affected by the overweight and obese category of Chronic Energy Deficiency CED. These also warned the tribal families about the arrival of the burden of overweight and obesity, the opposite side of malnourishment. All the physiological parameters like pulse rate, systolic pressure, and a diastolic pressure of female tribal had lower than the male tribal. However, the difference between them was not significant ($\chi^2=0.2002$, $p=0.1014$). Similarly, this study also stated there was no significant difference ($\chi^2=2.441$, $p=0.4887$) of morbidity patterns like skin infection, intestinal infections, respiratory infections, and vitamin deficiencies of male and female Lodha tribal people.

Keywords- Female, Male, Lodha tribe, Nutritional status

INTRODUCTION

India is a very primordial country having a very distinct place in the world for its diversity, wealth, and people of verified ethnic groups requiring special attention from education, social, economic, health, and nutritional security point of view. Instead of remarkable progress worldwide in the area of science, technology, in

the field of preventive and curative health, still, some people live in the lap of nature and far away from civilized society and lead a very piteous life with inclining to their customs, traditions, beliefs, and myths. These people are known as tribal. They are considered autochthonous people. Near about 75 primitive tribes live in this holy country. These primitive tribal communities are identified

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in 15 states/ union territories. As per the census of India 2011, 84 million of the tribal constitute 8.2% of the total population of our country. Taking the credit of largest tribal communities in the world (Topal and Samal, 2001, and Pal *et al.*, 2015).

Lodha is a primitive tribe living in a dense forest area of districts Mednapure (West Bengal), Mayurbhanj (Odisha), and Singhbhum (Jharkhand). Lodha has its specific language, customs, tradition, and living styles. Lodhas are different from other people in respect of food habits and living styles (Pal *et al.*, 2015). They solely depend upon the forest for their earning. They collect minor forest produce from the nearby forest, are employed as manual labor, and don't have enough income. Some of them don't have adequate knowledge about cultivation practices and earned money by robbery and theft and they were named as "Criminal tribe" by the British government till the revocation of the Criminal Tribes Act of 1952 (Pal *et al.*, 2015). The practice of that criminality has very much deep-rooted in this community that they were boycotted by the rest of the community. Till today they are considered as a degenerated human group and require special attention for improving their economic, social, educational, nutritional status.

Women play an important role in shaping the health and nutritional status of the family members, whereas they have very poor health and nutritional status. The health and nutritional status of the women who belong to Particularly vulnerable tribal group (PVTG) are not different from these women rather they have a very miserable status due to poverty, ignorance, illiteracy, lack of awareness, customs, tradition, and blind beliefs. Proper understanding of

different health aspects of tribal women is required so that proper health measures can be chalked out and implemented. More necessarily there is an emergency need for the region-specific study of the health and nutritional status of the tribal women, as the national level study may not quite be applicable for the regional diversities of the tribal population. Panda and Guha (2009) reported the scenario development among Lodha tribal people and pointed out shortcomings of the governmental approach towards the development of the marginal community. However, studied the nutritional and health status of the tribal people. There is chronic energy deficiency noticed among the men of the Lodha community revealed by Goswami (2014). Lodha community is socially and economically backward and the total literacy rate of the Lodha tribe is 43.1%, whereas, the female literacy rate is 35.1% as per the census 2011. Assessment of nutritional status is considered as a measure of health and is essential for planners to understand the food and nutritional condition among the tribal population for the betterment of these vulnerable groups.

There is a scarcity of studies conducted on Lodha tribal women of the Mayurbhanj district. Along with this, there is very little information regarding the dietary intake and nutritional status of the Lodha tribes. Hence, for getting some required information regarding health and nutritional status the present study was carried out to study the health and nutritional status of the Lodha tribal groups including both males and females. This information will be helpful for the formulation of required development programs for the food and nutritional security of the Lodha tribal people in the Mayurbhanj district of Odisha.

MATERIALS AND METHODS

Selection of site and subject of the study

The study was carried out in 10 villages of Morada, Baripada, Shamakhunta, and the Suliapada block of Mayurbhanj district, as Lodha tribal people are concentrated in these villages. The research was conducted on 2019 and 2020. A total of 400 Lodha tribal people including 200 males along with 200 tribal females were selected randomly, the age range for all groups was 18-45 years and females have belonged to non-pregnant and non-lactating categories. Both Lodha tribal men and women were measured for their anthropometric measurements and questioned for their socio-economic and other related information.

DATA COLLECTION

In the selected villages the data collection started from one end of the village to another side. The information on the socio-demographic profile was collected from each of the households through the pre-designed and pre-tested questionnaire. The medical officer had diagnosed all the individuals coupled with clinical examination with the cooperation of Asha and Anganwadi worker of nearby Integrated Child Development Service (ICDS) project office. Anthropometric measurements such as weight, height, waist circumference, hip circumference, and mid-arm circumference were measured by using standard equipment and procedures. Lever accurate weighing scales were used and calibrated before and after each session. Weight should be taken with only minimum clothing and was measured to the nearest 0.01 kg. Height was taken on the height board and all the measures should be taken to ensure that the respondents were standing upright with feet flat and firm

against the wall and was measured to the nearest 0.1cm. Waist circumference, hip circumference, and mid-arm circumference were measured by the non-stretchable fiber tape. BMI was calculated using the following standard equation of Asian Indian- specific guidelines for defining and managing overweight and obesity (2009).

The Chi-square test was used for assessing the association between age, income, type of family, and education with BMI. The data were analyzed using the statistical software package SPSS 21.0 version and MS Excel 2019. The mean and standard deviation of the anthropometric data was calculated for each age group. Data analysis using the Chi-square test was applied to evaluate statistical significance.

$$\text{BMI} = \text{weight (kg)} / \text{height (m}^2\text{)}$$

The following cut-off points were used

Table shows that 44.5% and 75.5% of male and female Lodha tribal people belonged to nuclear family, whereas, 22.5% and 7.5% of male and female Lodha tribal people live in a joint family. The results indicated that 82% and 4% of the tribal female had more than 3 no.s and one child, respectively. However, only 62.5% and 1.5% tribal males had more than 3 no.s and one child respectively. A majority of 73% and 74% of the tribal males and females had 4-7 total family members, whereas only a minimum of 8% and 12% of the tribal males and females had 4-7 total family members. In respect of educational status, majority of 62% males and 73% females were illiterate. Only 1% of tribal male and 2.5% of tribal females had completed secondary level education (10 + 2). This showed the female tribal women had higher educational qualifications than tribal men. Only 1% of Lodha female had

RESULTS AND DISCUSSION**Table 2. Socio-economic status of the respondents (n= 200)**

S. No.	Personal variables	Male (n= 200)	Percentage (%)	Female (n= 200)	Percentage (%)
1	Type of family				
	Joint	45	22.5	15	7.5
	Nuclear	89	44.5	151	75.5
	Extended	66	33	34	17
2	Number of children				
	1	3	1.5	8	4
	2	18	9	16	7.7
	3	54	27	19	63
	>3	125	62.5	157	82
2	Total family members				
	1-4	38	19	28	14
	4-7	146	73	148	74
	>7	16	8	24	12
3	Educational status				
	Illiterate	124	62	158	79
	Primary (up-to class V)	46	23	22	11
	Secondary (VI - X)	24	12	6	3
	10 th class	4	2	7	3.5
	10+2	2	1	5	2.5
	Graduate	-	-	2	1
	Postgraduate	-	-	-	-
4	Self-occupation				
	Agriculture	86	43	23	11.5
	Agriculture labor	56	28	82	41
	Mahatma Gandhi National MGNREGS	30	15	32	16
	Anganwadi Worker	-	-	1	0.5
	Anganwadi Helper	-	-	12	6
	Agriculture labour+ Leaf	28	14	22	11
	Housewife	-	-	28	14

NUTRITIONAL AND HEALTH STATUS OF LODHA TRIBAL WOMEN IN COMPARISON TO THEIR MALE COUNTERPARTS

S. No.	Personal variables	Male (n= 200)	Percentage (%)	Female (n= 200)	Percentage (%)
5	Continuous earnings for the family throughout the year				
	Continuous earnings present	82	41	68	34
	Continuous earnings Absent	118	59	132	66
6	Activity pattern of subjects				
	Sedentary	76	38	10	5
	Moderate	64	32	23	11.5
	Heavy	60	30	167	88.5
7	Source of Income				
	Agriculture	86	43	64	32
	Agriculture and others	114	57	136	68
8	Monthly Income (Rs.)				
	< 2000/-	65	32.5	122	61
	2000/- -3000/-	123	59.5	66	33
	3000/- - 5000/-	8	4	4	2
	5000/- -10,000/-	3	1.5	5	2.5
	10,000/- 15,000/-	1	0.5	3	1.5
9	Earning members				
	1	108	54	132	66
	2	88	44	62	31
	>2	4	2	6	3
10	Debts condition				
	Present	68	34	42	21
	Absent	132	66	158	79
11	Economics status of the families				
	Above poverty line	6	3	14	7
	Below poverty line	194	97	186	93

completed graduation, whereas, none of the Lodha male had such qualification. Goswami, (2015) deviated from the study and stated that majority of the Mankidia males (94.9%) and females (98.1%) were illiterate, 4.5% Mankidia males were completed primary while Mankidia females of only 1.3% completed primary education. Kanrar and Goswami (2020) also stated the varied results from the present study that majority of both Juang males (81.15%) and females (86.41%) were illiterate.

Agriculture is the main occupation of male tribal (43%), whereas, 41% of the female tribes were engaged as agricultural labourers. Both Lodha males of 16% and females of 5% were engaged in Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). A total of only 14% of the tribal females were housewives and did not support any additional income to families. However, few of the Lodha females (6.5%) due to their higher education were coming forward and working as Anganwadi workers and helpers in the Anganwadi center. Goswami (2015) stated that 73.7% of Mankidia males depended upon minor forest collection and women (37.8%) were unemployed and few of them (14.7%) were engaged in rope making. Mankidia male (15.4%) were daily labour, whereas, females (30.8%) were daily labour. Kanrar and Goswami (2020) also revealed maximum Juang females were unemployed and working as homemakers and collected forest products (58%).

A total of 41% of the males and 34% of the female tribes were able to get continuous jobs throughout the year, whereas, more than half of the tribes (59% of the male and 66%) of the females were unable to get the continuous job.

By concerning the activity pattern of the respondents, 38% of the male Lodha tribal had sedentary activity and 30% had heavy activity patterns. But in the case of females, 88.5% were having a heavy pattern of activity and only 5% had sedentary activity. This study showed that Lodha females were more laborious than male Lodha. Agriculture was the source of income of 43% of male Lodha and 32% of female Lodha tribal people. Whereas Agriculture and others were the sources of income of 57% and 68% of male and female Lodha respectively.

Table 2 shows that the monthly income of the tribal male and female respondents. 59.5% Lodha male tribal had a monthly income of Rs. 2000-3000 whereas 61% Lodha female tribal had less than Rs. 2000 per month. 0.5% of male and 1.5% of female Lodha tribal had a monthly income of maximum range i.e. Rs. 10,000-15,000. This table showed the male Lodha tribal people had better economic status than female Lodha tribal women.

Table 2 indicates that the maximum participants of Lodha male (54%) and Lodha female (66%) had one earning member in the family. Lodha male of 44% and female (31%) had 2 numbers of earning members and least participants of 2% and 3% had more than 2 numbers of earning members in the family. This resulted both male and female Lodha tribe had nearly same numbers of earning members in the family.

Table 2 reveals that the debt condition of the respondents. The debt condition of both male (66%) and female (79%) respondents had absent whereas the debt condition in case of 34% of male and 21% of the female had present. This showed more numbers of debt condition is

absent in female Lodha people than male Lodha people.

Also, Table 2 depicts the economic status of the families. Male Lodha tribal 97% and female Lodha tribal 93% were below the poverty line, whereas, 3% and 7% of the male Lodha and female Lodha tribal were above the poverty line. This indicated that till today both male and female Lodha respondents had miserable economic standards.

Table 3 shows that the body mass index of both male and female Lodha tribal respondents. BMI calculation is an easy and precise assessment of the degree of thinness or obesity, according to the recommendations of WHO. The results of the present study pointed out that the prevalence of undernutrition among female Lodha tribal was significantly higher ($\chi^2=15.635$, $p=0.0015$) (82.5%) than that of males (57%) Lodha tribal people. A similar study was also reported by Kshatriya and Acharay (2016) that the overall undernutrition among the tribal females of nine tribes observed was 47.4% as

against 32.1% for the tribal males. Again they also stated that three tribes like Kora, Oraon, and Bathudi tribes showed a 60% prevalence in the overall undernutrition category (BMI<18.5Kg/m²) as compared to their male counterparts who showed less than 42% prevalence of overall undernutrition. Mukhopadhyay (2009) studied on Santal tribal and also stated similar findings that there was a notable disparity in the prevalence of undernutrition between males (30.5%) and females (38.5%) but the difference was not significant ($\chi^2 = 2.832$, $P = 0.092$). But Mittal and Srivastav (2006) found differentiated findings that the prevalence of undernutrition among female Oraon was less (30.7%) than that of male Oraon (47%).

More numbers of Lodha male respondents (35.5%) was coming under the normal category of BMI than that of Lodha female tribal (14%). But the study of Mittal and Srivastav (2006) varied from the present study and resulted in higher numbers of female Oraon (38.7%) were belonging to the normal category of BMI than

Table 3. Body Mass Index of Tribal male (n=200) and female (n=200) according to the standard of Asian Indian- specific guidelines, 2009

S. No.	Grading of BMI	of BMI (Kg/m ²)	Male		Female	
			Frequency (n=200)	Percentage (%)	Frequency (n=200)	Percentage (%)
1	Underweight	<18.5	114	57	165	82.5
2	Normal Range	18.5-22.9	71	35.5	28	14
3	Over Weight	23-24.9	11	5.5	6	3
4	Obese	≥ 25	4	2	1	0.5

($\chi^2=15.635$, $p=0.0015$, Association is significant)

Source: Asian Indian- specific guidelines for defining and managing overweight and obesity, 2009.

Table 4. Physiological parameters of Lodha tribal male and females

SI No.	Parameters	Lodha tribal Male	Lodha tribal Female
1	Pulse Rate (Beats/min)	76.87	69.78
2	Systolic blood pressure (mmHg)	109.76	104.43
3	Diastolic blood pressure (mmHg)	78.78	68.12

($\chi^2 = 0.2002$, $p = 0.1014$, Association is not significant)

that of male Oraon (22.5%). However, considering overweight and obese categories of Chronic Energy Deficiency (CED), male tribal were significantly ($\chi^2 = 15.635$, $p = 0.0015$) affected more (overweight 5.5% and obese 2%) than that of female tribal (overweight 3% and obese 0.5%). This study pointed that the male Lodha tribal were more affected by the overweight and obese category of Chronic Energy Deficiency (CED) and these also warned the tribal families about the arrival of the burden of overweight and obesity, the opposite side of malnourishment.

Table 4 showed the physiological parameters of Lodha male and female respondents. The Lodha female tribal had a

lower pulse rate (69.78 beats/min) than the Lodha male i.e of 76.87 beats/min. Both the Lodha female and male had low blood pressure i.e 104.43/68.12 beats/min and 109.76/ 78.78 beats/min but the blood pressure of Lodha male was near to normal level. All the physiological parameters of female tribal had lower than the male tribal but the difference between them was not significant ($\chi^2 = 0.2002$, $p = 0.1014$).

Table 5 reveals that the morbidity pattern between Lodha tribal male and female respondents. Overall all the infections like skin infection (21.35%), respiratory infection (45%), and vitamin deficiencies (35%) of Lodha male respondents had lower than the Lodha female

Table 5. Morbidity pattern between Lodha tribal male and female

SI No.	Parameters	Lodha tribal Male (n=200)	Lodha tribal Female (n=200)
1	Skin infections	22	35
2	Intestinal infections	49	47
3	Respiratory infections	45	48
4	Vitamin deficiencies	35	43

($\chi^2 = 2.441$, $p = 0.4887$, Association is not significant)

respondents of skin infection (34.5%), intestinal infection (45.5%), respiratory infection (48%) and vitamin deficiencies (43%). But intestinal infection (48.5%) of Lodha male tribal had more than female (45.5%). This indicated that the morbidity pattern among Lodha male respondents had lower than Lodha female respondents but variation was seen concerning intestinal infection, i.e it was more among males than females. The study stated that there was no significant difference ($\chi^2=2.441$, $p=0.4887$) of morbidity pattern between male and female Lodha tribal.

CONCLUSION

The study reveals that the Lodha tribal male is enjoying better nutritional status in comparison to their female counterparts. Chronic Energy Deficiency (CED) malnutrition is high among females along with this the female has all the physiological parameters higher than their male counterparts. But this study also pointed that the male Lodha tribal were more affected by the overweight and obese category of Chronic Energy Deficiency (CED) than female tribal and these also warned the tribal families about the arrival of the burden of overweight and obesity, the opposite side of malnourishment.

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REFERENCES

Goswami, M. 2014. Body mass index and chronic energy deficiency among adult male Lodhas and Khariasof Mayurbhanj, Odisha. Anthrocon: Online Journal of

Anthropology, Physical Anthropology. 10(2): 359-364.

Goswami, M. 2015. Anthropometric characteristics and chronic energy deficiency of the Mankidias - APTG of Northern Odisha, India Studies of Tribes and Tribals. 0(1): 1-6.

Government of India. 2011. Census of India 2011. Scheduled castes and scheduled tribes. www.censusindia.gov.in

Kshatriya, G.K and Acharya, S.K. 2016. Gender Disparities in the Prevalence of Under-nutrition and the Higher Risk among the Young Women of Indian Tribes. PLoS ONE 11(7): 1-22.

Kanrar, P and Goswami, M. (2020). Sociodemographic Profile, Reproductive Health and Nutritional Status Among the Juangs- A Particularly Vulnerable Tribal Groups of Odisha, India. The Oriental Anthropologist 20(1): 135-149.

Mittal, P.C and Srivastava, S. 2006. Diet, nutritional status and food-related traditions of Oraon tribes of New Mal (West Bengal), India: The International Electronic Journal of Rural and Remote Health Research, Education, Practice and Policy: 6: 385 1-11.

Mukhopadhyay, A. 2009. Anthropometric characteristics and undernutrition among adult Santal tribe of Birbhumi district, West Bengal, India. Anthropological Science. 1-4.

Pal, A., Bepari, M., Maity, P and Choudhury, S.M. 2015. Nutritional and Health status of adult women of the Lodha tribal population of

- PaschimMidnapore, West Bengal, India: Compared with nontribal women. *East African Journal of Public Health*. 12(1): 988-996.
- Panda, S and Guha, A. 2009. Development Inputs among the Lodhas in a District of West Bengal: Problems of Implementation and Recommendations. *Journal of the Indian Anthropological Society* 44: 69-75.
- Topal, Y.S and Samal, P.K. 2001. Causes for variation in social and economic conditions among tribes of Indian Central Himalaya: A comparative study. *Man in India* 81:87–88.
- WHO Expert consultation. 2004. Appropriate body-mass index for Asian population and its implication for policy and intervention strategies. *Lancet* 363: 157–163.

FEASIBILITY OF INCORPORATING JACKFRUIT FOR THE DEVELOPMENT OF INSTANT PAYASAM MIX

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ABSTRACT

This study was conducted (2016-2018) to develop jackfruit based instant vermicelli *payasam* mix by using jackfruit flour and jackfruit seed flour. Based on organoleptic evaluation, mean scores was high for vermicelli and *payasam* prepared with 70 % raw jackfruit flour and 30 % jackfruit seed flour with an overall acceptability of 8.55 and 8.57, respectively. The nutrient content of selected jackfruit based vermicelli observed to have moisture (7.18 %), energy (284 Kcal 100g⁻¹), carbohydrate (63.7g 100g⁻¹), protein (3.4g 100g⁻¹), fat (0.80g 100g⁻¹) and fibre (3.9g 100g⁻¹). The vermicelli was rich in calcium (53mg 100g⁻¹), iron (6.7mg 100g⁻¹), sodium (18.14mg 100g⁻¹) and potassium (242mg 100g⁻¹). An instant *payasam* mix was standardized using the selected jackfruit vermicelli along with sugar, nuts, raisins and flavourings. The jackfruit instant *payasam* mix had good sensory characteristics with an overall acceptability was 8.62. The market potential of jackfruit can be promoted if the fruits are made available to the consumer in a ready to cook form throughout the year.

Keywords: Instant *payasam* mix, Jackfruit flour, Jackfruit seed flour, Nutritional qualities, Sensory qualities, Vermicelli

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam.) a member of the family Moraceae is a fairly large sized tree and bears the largest fruit among the edible fruits. It is a popular fruit consumed in the tropics. It is widely grown in India, Bangladesh, South East Asia and West Africa (Chowdhury *et al.*, 2012). In our country, the trees are found distributed in southern states like Kerala, Tamil

Nadu, Karnataka, Goa, coastal Maharashtra and other states like, Assam, Bihar, Tripura, Uttar Pradesh and foothills of Himalayas.

Among the fruit crops grown in Kerala, jackfruit has a prominent position, which occupies 89702 hectares (Govt. of Kerala, 2014). Jackfruit is rich in carbohydrates, proteins, vitamins and minerals such as potassium, calcium and iron. Along with nutrients it contains appreciable

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amount of isoflavones, phytonutrients and antioxidants and their health benefits are wide ranging from anticancer, antihypertensive, antiaging, antimicrobial and antiulcer (Tejpal and Amrita, 2016). In every year, a considerable amount of jackfruit, specially obtained in the glut season goes waste due to lack of proper postharvest knowledge during harvesting, transporting and storing both in quality and quantity. Jackfruit has a delicious taste, captivating flavour, attractive colour and excellent quality, which make it suitable for processing and value addition (Panja and Ghosh, 2016). The jackfruit seeds are the main produce of a plant containing large number of nutrients. Carbohydrate, protein and fibre are the major constituents of seeds and these nutrients interact with each other during product development and play an important role in determining the final quality of the food products. As jackfruit seeds are bland in taste with no untoward flavour, there is potential opportunity for utilizing the seed in the form of flour for value addition in the industrial sector. Products with incorporated jackfruit seed flour possess better nutraceutical appeal, leading to improved consumer acceptability (Sulthana et al., 2014). Promising varieties with enhanced production of quality fruits, suitable for value addition and product diversification would transform the status of jackfruit from the "neglected" category to an export-oriented crop. Utilization of the wonder fruit will strengthen the self-employment opportunities and economic security.

The demand of instant food mixes is increasing day by day due to increase in urbanisation, breaking up of the traditional joint family system, time, convenience and changing

lifestyles. Low calorie and high nutritious instant food mixes are most preferred by consumers (Karthi, 2015). There lies a great opportunity for non-traditional uses of jackfruit in the form of convenience foods like vermicelli. *Payasam* mix is a food item which consists of roasted vermicelli along with toasted raisins and cashew nuts, mixed with other ingredients, packed in polypropylene bags (Srinivasan and Nirmala, 2014.) Developing acceptable products can reduce the wastage and make the jackfruit an economically profitable one. Hence, the study was conducted to develop jackfruit based instant vermicelli *payasam* mix by using roasted jackfruit flour and roasted jackfruit seed flour with improved nutritional and organoleptic qualities.

MATERIALS AND METHODS

The study was carried out from 2016 to 2018 at College of Agriculture, Kerala Agricultural University, Thrissur, Kerala. For this study raw jackfruit (*koosha* type) was collected from households and the flour was prepared using procedure suggested by Pandey (2004). The raw jackfruit were washed and separated into bulbs and seeds. The bulbs are sliced into 2.5cm×1cm and then blanched in boiling water for 1 minute. The blanched slices were cooled and immersed in 0.2 percent KMS solution for 10 minutes. The immersed slices were then dried in a cabinet drier at 60°C for 12 hours. The dried chips were milled into flour and sieved through 0.5 mm mesh. Jackfruit seeds were cleaned and the white arils were peeled off manually. It was then washed thoroughly in running water and subjected to thermal treatment (pressure cooked for 20 minutes) to inactivate anti-nutritional factors. Spermoderm layer was removed by rubbing the seeds between hands. The sliced

seeds were dried (60°C for 12 hours) and powdered. Refined wheat flour (which is served as control) was procured from the local market. The raw jackfruit flour, seed flour and whole wheat flour was roasted for 10 minutes in medium flame.

Preparation of vermicelli

Vermicelli was prepared with the combination of raw jackfruit flour and jackfruit seed flour (Table 1) were mixed thoroughly and the dough was prepared with 30 percent of water and kept for proofing for 30 minutes at room temperature. The prepared dough was extruded through manual extruder. The extruded vermicelli was dried in a cabinet drier for 4 to 5 hours. The dried vermicelli was packed in a polyethylene pouches. Treatment T₀ refined wheat flour, served as control.

Organoleptic evaluation

The sensory evaluation was carried out for the prepared vermicelli and *payasam* using nine point hedonic scale with a panel of 15 judges considering the six sensory parameters (appearance, colour, flavour, texture, taste and overall acceptability). Panel of fifteen judges between age group of 18 to 35 years are selected by conducting a series of organoleptic trails using a simple triangle test at laboratory level as suggested by Jellinek (1985).

Nutrient analysis

The nutritive qualities like moisture (A.O.A.C. 1980), carbohydrate, protein, fat, fibre (Sadasivam and Manickam, 1997.), calcium, iron (Perkin- Elmer, 1982), sodium and potassium (Jackson, 1973) of best selected jackfruit based vermicelli was determined initially and during the second and fourth month of storage.

Moisture

To determine moisture content 10g of the sample was dried in a hot air oven at 60°C to 70°C, cooled in a desiccator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the sample was calculated from the loss in weight during drying.

Carbohydrates

A dried sample of 100mg sample was hydrolysed with 5ml of 2.5N HCl for 3 hours by boiling in water bath and cooled to room temperature. The residue was neutralized with sodium carbonate until effervescence ceases. The volume was made upto 100ml and centrifuged. An aliquot 0.2ml from the supernatant was pipetted out and made upto 1ml and then 4ml of anthrone reagent was added. Heated for 8 minutes in a boiling water bath, cooled rapidly and the intensity of green to dark colour was read at 630nm (OD) in spectro

Table 1. Treatments for the standardization of jackfruit based vermicelli

Treatments	Combinations
T ₀	Control (100% refined wheat flour vermicelli)
T ₁	70% RJF + 30% RJSF
T ₂	60% RJF + 40% RJSF

(RJF- Roasted jackfruit flour, RJSF – Roasted Jackfruit seed flour)

photometer. A standard graph was prepared using standard glucose by applying the serial dilutions. From the standard graph, the amount of total carbohydrate present in the sample was estimated and expressed in gram per 100g of sample.

Protein

A sample of 500mg was extracted using 5 to 10 ml of buffer (Tris buffer GR – tris hydroxymethyl amino methane) and centrifuged. An aliquot 0.1ml from the supernatant was taken in a test tube, 5ml alkaline copper solution were mixed well and allowed to stand for 10 minutes. Folin-Ciocalteu reagent of 0.5 ml was added and incubated at room temperature in the dark for 30 minutes and the developed blue colour was read at 660nm (OD) in spectrophotometer. A standard graph was prepared using alkaline copper solution and Folin-Ciocalteu reagent by applying serial dilutions. From the standard graph, the amount of total protein present in sample was estimated and expressed in gram per 100g of sample.

Fat

Five gram of sample was taken in a thimble and plugged with cotton. The material was extracted with petroleum ether for six hours without interruption by gentle heating in a soxhlet apparatus. Extraction flask was then cooled and ether was removed by heating and the weight was taken. The fat content was expressed in gram per 100g of the sample.

Fibre

Powdered vermicelli sample of two grams was boiled with 200 ml of 1.25 percentsulphuric acid for 30 minutes. It was then filtered using

muslin cloth and washed with boiling water. The residue was again boiled with 200 ml of 1.25 percent of sodium hydroxide for 30 minutes. Repeat the filtration through muslin cloth and residue was washed with 25 ml of boiling 1.25 percent of sulphuric acid, three 50 ml portion of water and 25 ml of alcohol. The obtained residue was taken in an ashing dish (W_1) and dried at 130°C for 2 hours. Cool the dish in a desiccator which was reweighed and noted as W_2 . The residue was again ignited in muffle furnace at 600°C for 30 minutes, cooled in a desiccator and reweighed (W_3).

Calcium and iron

Onegram of the vermicelli was pre-digested using 10 ml of 9:4 ratio of nitric and percholoric acid. The prepared diacid extract of the vermicelli sample was used for estimation of calcium in Atomic Absorption Spectrophotometer. The amount of calcium and iron content present in sample can be expressed as mg per 100g.

Sodium and Potassium

One gram of the vermicelli was digested using diacid solution. The pre-digested sample will be used to measure sodium and potassium content in flame photometer and it was expressed as mg per 100g of the sample.

Standardisation of instant *payasammix*

From the selected jackfruit based vermicelli, instant *payasammix* was standardised with 200g vermicelli with 2 proportions of milk and 3 proportions of sugar based on organoleptic qualities. In all treatments 10g toasted cashew nuts and raisins, and 5g crushed cardamom were added. The best treatment was selected based on organoleptic qualities.

Statistical Analysis

The statistical analysis was carried out for the mean score obtained from sensory evaluation. The best treatment was identified from the interpretation of Kendall's Coefficient of Concordance (W). Nutritional qualities of vermicelli during storage was analysed based on relative change over the previous month of storage.

Cost of production of jackfruit vermicelli instant *payasam* mix

The cost of production of the most acceptable combination of jackfruit vermicelli *payasam* mix was computed based on the market price of procured ingredients used for preparation of products along with labour charge, fuel charge, electricity charge and packaging cost. The cost was calculated for 1kg of the product and compared with similar products available in the market.

RESULT AND DISCUSSION

Organoleptic evaluation

The mean scores and the mean rank scores obtained for different sensory attributes of vermicelli and *payasam* prepared with roasted jackfruit flour in combination with roasted jackfruit seed flour are presented in Tables 2 and 3. Among jackfruit based vermicelli, the highest mean score for different quality attributes were noticed in vermicelli prepared with 70 percent roasted jackfruit flour and 30 percent jackfruit seed flour (T_1). For jackfruit based *payasam*, the highest mean score and mean rank score for all the sensory attributes namely appearance (8.44), colour (8.44), flavour (8.51), taste (8.6), texture (8.42) and overall acceptability (8.57). The mean score for different quality attributes

of jackfruit based *payasam* were found to be lower than control. The scores of organoleptic evaluations were assessed by Kendall's coefficient of concordance and it was found that there was agreement between the judges. Kumari (2015) standardised jackfruit based noodles with raw jackfruit flour, jackfruit seed flour and wheat flour in different combination (T_1 -40:30:30, T_2 -50:25:25, T_3 -50:30:20, T_4 -50:40:10, T_5 -50:10:40, T_6 -50:20:30). The prepared noodles and control (commercial noodles) was cooked and evaluated by 10 panel members. Overall acceptability of prepared noodle revealed that treatment T_5 (4.81) had high score followed by T_3 and T_6 with the score of 4.71 and 4.14 respectively. The present study reveals that as the level of incorporation of jackfruit flour increases, the sensory qualities of vermicelli and *payasam* also increased. This finding was very compatible with Sahoo (2016), who prepared raw jackfruit based rusk and buns along with wheat flour in different proportions (40:60, 45:55, 50:50, 60:40, 70:30, and 80:20) along with control (refined wheat flour). Buns and rusk prepared with 80 percent of raw jackfruit flour was highly acceptable for taste, texture, flavor and overall acceptability than other treatments. The thermoplastic nature and sugary taste of jackfruit flour increased the sensory qualities. Incorporation of medium amount of roasted jackfruit seed flour for the preparation of different food products was acceptable. Roasted jackfruit flour was suitable for the preparation of extruded products due to the less soluble capacity than raw jackfruit flour (Odoemelam, 2015). Roasting is a most important pre-treatment for flours and starches by the application of dry heat. Roasting of flours enhances the colour and texture of products. As a result of roasting, smaller units of

starch called dextrin is formed and is easily digested by the body (Srilakshmi, 2010). Roasting increases the antioxidant activity, brown colouration and enhances the flavour of products due to the formation of maillard reaction products. Roasting increases the amylose content in jackfruit seed flour (Ejiofor, 2014). Abraham and Jayamuthunagai (2014) observed that the firmness of pasta increased with the addition of jackfruit seed flour. Ten percent

jackfruit seed flour substituted pasta showed greater consumer acceptability, in relation to flavour, mouth feel, appearance, colour and overall quality. Addition of roasted flour in food products results good taste and slight crispy texture. Incorporation of roasted flax seed flour in biscuits increase the flavour, texture and overall acceptability than biscuits prepared from raw flax seed flour (Masoodiet *al.*, 2012).

Table 2. Mean score for organoleptic evaluation of vermicelli prepared with roasted jackfruit flour and jackfruit seed flour in comparison with control

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T ₀ (control)	8.46 (1.97)	8.53 (2.13)	8.35 (2.00)	8.6 (2.37)	8.57 (2.37)	8.4 (1.97)
T ₁ (70%RJF:30%JSF)	8.53 (2.07)	8.51 (2.07)	8.48 (2.07)	8.42 (2.3)	8.4 (2.03)	8.55 (2.20)
T ₂ (60%RJF:40%JSF)	8.35 (1.97)	8.48 (1.80)	8.33 (1.93)	8.32 (1.70)	8.2 (1.60)	8.35 (1.83)
Kendalls W	0.004**	0.043**	0.006**	0.177**	0.181**	0.275**

(RJF - Roasted jackfruit flour, JSF- Roasted jackfruit seed flour)

Value in parentheses is mean rank score based on Kendall's W

**Significance at 1 % level

Table 3. Mean score for organoleptic evaluation of payasam prepared with roasted jackfruit flour and roasted jackfruit seed flour in comparison with control

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T ₀ (control)	8.66 (2.20)	8.62 (2.47)	8.62 (2.23)	8.6 (2.40)	8.66 (2.33)	8.71 (2.33)
T ₁ (70%RJF:30%JSF)	8.44 (2.07)	8.44 (1.93)	8.51 (2.20)	8.42 (2.07)	8.6 (2.30)	8.57 (2.13)
T ₂ (60%RJF:40%JSF)	8.28 (1.50)	8.4 (1.60)	8.28 (1.57)	8.17 (1.53)	8.15 (1.37)	8.26 (1.53)
Kendalls W	0.124**	0.225**	0.166**	0.244**	0.401**	0.254**

(RJF - Roasted jackfruit flour, RF- Roasted jackfruit seed flour)

Value in parentheses is mean rank score based on Kendall's W

**Significance at 1 % level

Nutrient analysis

Moisture is an important parameter of quality determination in food products. The products with low moisture content have enhanced shelf life quality by lowering the microbial load. From Table 4, it is clear that moisture content of jackfruit based vermicelli was 7.18 percent, found to be low compared with the results noodles with raw banana flour and the moisture content was 8.67 percent (Ritthiruangdej *et al.*, 2011). The moisture content increased during storage period may be due to relative humidity and atmospheric temperature. The formulated vermicelli contains 63.7g 100g⁻¹ of carbohydrate, 3.4g 100g⁻¹ of protein, 0.80g 100g⁻¹ of fat and 3.9g 100g⁻¹ of fibre. The jackfruit based vermicelli had calcium, iron, sodium and potassium of 53mg 100g⁻¹,

6.7mg 100g⁻¹, 18.14mg 100g⁻¹ and 242mg 100g⁻¹, respectively.

Kumari (2015) developed raw jackfruit based noodles by mixing refined flour, raw bulb flour and jackfruit seed flour at different proportions. The results of study indicated that samples of jackfruit bulb flour and jackfruit seed flour added noodles contained more protein, fibre and minerals and was less in energy and carbohydrate as compared to control (refined wheat flour noodles) sample. Twenty percent incorporation of jackfruit seed flour noodles has the fibre content of 1.6g 100g⁻¹ (Nandkule *et al.*, 2015). The nutrients decreased with storage and the decrease in carbohydrate, protein and fat content during storage could be attributed to the degradation of polysaccharides, dissociation of protein into amino acids, lipolytic activities of the

Table 4. Nutrient analysis of jackfruit vermicelli

Nutrients (100 g ⁻¹)	Initial	Second month	Fourth month
Moisture (g)	7.18	7.23 (0.69)	7.28 (0.69)
Energy (KCal)	284	266.42 (0.22)	262.54 (1.45)
Carbohydrate (g)	63.7	60.49 (1.56)	59.18 (2.15)
Protein (g)	3.4	2.73 (0.36)	2.69 (1.46)
Fat (g)	0.80	0.86 (6.38)	0.82 (3.4)
Fibre (g)	3.9	3.74 (2.14)	3.71 (1.09)
Calcium (mg)	53	48.01 (0.31)	47.90 (0.28)
Iron (mg)	6.7	6.59 (3.80)	6.51 (4.18)
Sodium (mg)	18.14	17.93 (1.12)	16.69 (1.60)
Potassium (mg)	242	234.02 (0.07)	222.39 (0.09)

Values in parenthesis indicates percent relative change over the previous month

enzymes lipase and lipoxidase, and decomposition of complex molecule into simple sugars (Murugkar and Jha, 2011). Mineral content decreased on storage may due to the utilisation of nutrients for the growth and multiplication of microbes present in food products (Sunday and Dayo, 2012).

Standardisation of instant *payasam* mix

In this study, instant *payasam* mix was standardised from jackfruit based vermicelli with varying proportions of milk (1 L and 1.5 L) and sugar (100,125 and 150g). Among these treatments, the mean score for all the sensory attributes like appearance (8.62), colour (8.62), flavor (8.53), taste (8.64), texture (8.64) and

overall acceptability (8.62) was highest in T₆ (*payasam* prepared with 200g vermicelli, 1.5 L milk and 150 g sugar) than other treatments. Divakaret al.(2014) developed instant banana based *payasam* mix and reconstituted with 950 ml of coconut milk, 300 g of sugar, and 10g of cashew nuts, raisins and sago. The prepared *payasam* was highly acceptable in terms of colour (4.88), mouth feel (4.92), taste (5), flavour (4.9) and overall acceptability (4.9). Guptaet al. (2014) developed instant *kheer* mix with cowpea, malted wheat flour, rice, skimmed milk powder and sugar. The optimized product was high in protein (10.27) and had good sensory characteristics (8.05).

Table 5. Mean score for organoleptic evaluation of roasted jackfruit and roasted jackfruit seed flour based instant *payasam* mix

Treatments	Sensory parameters					
	Appearance	Colour	Flavor	Texture	Taste	Overall Acceptability
T ₁ (1 L M + 100 g S)	6.53 (1.43)	6.84 (2.00)	6.88 (1.73)	6.6 (1.83)	6.71 (1.83)	6.73 (1.77)
T ₂ (1 L M + 125 g S)	6.8 (1.83)	6.86 (1.97)	7.22 (2.70)	6.71 (2.27)	6.73 (2.00)	6.82 (1.93)
T ₃ (1 L M + 125 g S)	7.22 (2.83)	6.95 (2.10)	7.15 (2.37)	6.71 (2.03)	7.02 (2.60)	7.02 (2.47)
T ₄ (1 L M + 125 g S)	7.95 (4.03)	7.95 (4.33)	7.77 (3.90)	8.02 (4.40)	7.68 (3.93)	7.82 (4.20)
T ₅ (1 L M + 125 g S)	8.35 (5.07)	8.37 (5.03)	8.04 (4.57)	8.15 (4.67)	8.2 (4.93)	8.22 (4.97)
T ₆ (1 L M + 125 g S)	8.62 (5.80)	8.62 (5.57)	8.53 (5.73)	8.64 (5.80)	8.64 (5.70)	8.62 (5.67)
Kendalls W	0.926**	0.833**	0.685**	0.847**	0.764**	0.817**

(M – Milk, S –Sugar)

Value in parentheses is mean rank score based on Kendall's W

** Significant at 1% level

The cost of production

The cost of production of control vermicelli (Rs.76.24/kg) and instant *payasam* mix (Rs.230.24/kg) was lower compared to jackfruit based vermicelli (Rs.83/kg) and instant *payasam* mix (Rs.237/kg). The cost of prepared vermicelli and *payasam* mix was lower than the market price. The market price of wheat vermicelli, ragi vermicelli, and wheat based instant vermicelli *payasammix* was observed as Rs.165/kg, Rs.180/kg and Rs.500/kg respectively. Incorporation of underutilised fruits like jackfruit for the development of instant mixes increases the nutritive value and reduces the cost.

CONCLUSION

Vermicelli and *payasam* prepared with roasted jackfruit flour and roasted jackfruit seed flour (70: 30) were acceptable in all the sensory qualities and have good nutritional profile. From the study, it was clear that an acceptable instant *payasam* mix can be prepared from jackfruit flour and jackfruit seed flour. The market potential of jackfruit can be promoted if the fruits are made available to the consumer in a ready-to-eat or ready-to-cook form throughout the year. There lies a great opportunity for non-traditional uses of jackfruit in the form of convenience foods such as vermicelli.

REFERENCES

- A.O.A.C. 1980. Official and Tentative Methods of Analysis. Association of Official Analytical Chemists, Washington. pp1018-1124.
- Abraham, A and Jayamuthunagai, J. 2014. An analytical study on jackfruit seed flour and its incorporation in pasta. *Journal of Pharmaceutical, Biological and Chemical Sciences*. 5 (7):1597-1610.
- Chowdhury, A.R., Bhattacharya, A.K and Chattopudhyay, P. 2012. Study on functional properties of raw and blended jackfruit seed flour for food application. *Indian Journal of Natural Products Resource*. 3 (1):94-99.
- Divakar, S., Ukkuru, M and Krishnaja, U. 2014. Development of a banana-based "*payasammix*". *Studies on Home and Community Science*. 8 (3): 41-43.
- Ejiofor, E.J. 2014. The effect of processing methods on the functional and compositional properties of jackfruit seed flour. *International Journal of Nutrition Food Science*. 3(4): 166-173.
- Govt. of Kerala. 2014. Area under crops 2012-13, Farm Information Bureau, Government of Kerala, pp 339.
- Gupta, K, Verma, M, Jain, P and Jain, M. 2014. Process optimization for producing cowpea added instant kheer mix using response surface methodology. *Journal of Nutritional Health and Food Engineering*. 5(6): 1-9.
- Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Private Ltd, New Delhi. pp.299.
- Jellinek, G. 1985. Sensory evaluation of food. Theory and practice. Ellis Horwood, Chichester. England, pp.596-598.
- Karthi, B. 2015. Consumer attitude and behavior towards the instant noodles especially Maggi in India. *International Journal of Economic Review*. 3 (5):212-217.
- Kumari,V. 2015. Development of noodles from raw jackfruit. M. Sc (Home Science) Thesis submitted to Kerala Agricultural University, Vellayani, Kerala.

- Masoodi, L., Aeri, V and Bashir, K. 2012. Fortification of biscuit with flaxseed: biscuit production and quality evaluation. *International Journal of Environmental Science and Technology*. 1(5): 6-9.
- Murugkar, D.A and Jha, K. 2011. Influence of storage and packaging conditions on the quality evaluation of sensory attributes biscuits developed using single and multiple blend nutraceuticals. *International Journal of Pure and Applied Bioscience*. 5 (4): 433-440.
- Nandkule, V.D., Masih, D., Sonkar, C., Devendrasing D and Patil, D.D. 2015. Development and quality evaluation of jackfruit seed and soy flour noodles. *International Journal of Science, Engineering and Technology*. 3(3): 802-806.
- Odoemelam, S.A. 2015. Functional properties of raw and heat processed jackfruit (artocarpushetero phyllus) flour. *Pakistan Journal of Nutrition*. 4(3):366-370.
- Pandey, S. 2004. Value added products and by products from jackfruit. Ph. D Thesis submitted to Kerala Agricultural University, Vellayani, Kerala.
- Panja. P and Ghosh. U. 2016. Value addition of jackfruit. Poster presented at the national symposium on bio resource management. West Bengal, 26-27 October 2016. pp. 34.
- Perkin- Elmer. 1982. Analytical Methods for Atomic Absorption Spectrophotometry. Perkin- Elmer Corporation, USA. pp.114-146.
- Ritthiruangdej, S., Parnbankled, S., Donchedee, R and Wongsagonsup. 2011. Physical, chemical, textural and sensory properties of dried wheat noodles supplemented with unripe banana flour. *Journal of Natural Science Biology and Medicine* 45(5): 500-509.
- Sadasivam, S and Manickam, A. 1997. *Biochemical Methods*. New Age International private limited, New Delhi and Tamil Nadu Agricultural University, Coimbatore, pp.254-256.
- Sahoo, A. 2016. Value added baked products from raw jackfruit. Ph D thesis submitted to Kerala Agricultural University, Vellayani, Kerala.
- Srilakshmi, B. 2010. *Food Science*. New Age International Publisher, New Delhi. pp. 430.
- Srinivasan, K and Nirmala, R. A. 2014. Study on consumer behaviour towards instant food products. *Journal of Business Management*. 16 (7):17-21.
- Sultana, A., Rahman, M. R., Islam, M., Rahman, M and Alim, M. A. 2014. Evaluation of quality of chapaties enriched with jackfruit seed flour and bengal gram flour. *IOSR Journal of Environmental Science, Toxicology and Food Technology*. 8(5): 73-78.
- Sunday, F.O and Dayo, F.E. 2012. Effect of storage on the proximate, mineral composition and microflora of tinco. *Global Journal of Bioscience and Biotechnology*. 1(1): 54-58.
- Tejpal. A and Amrita. P. 2016. Jackfruit: a health boon. *International Journal of Research Ayurveda Pharmacy*. 7 (1): 59-64.

KNOWLEDGE ON DIABETES AND ITS RELATED FACTORS AMONG TYPE -2 DIABETIC PATIENTS IN SAMBALPUR, ODISHA

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ABSTRACT

Increased awareness among population is a major factor for the prevention of diabetes and its complications and related metabolic disorders. Knowledge is the most important element of awareness that need to be studied in various population groups in specific cultural contexts. On this backdrop the present study was undertaken to explore knowledge regarding diabetes mellitus (DM) among type 2 diabetes mellitus (T2DM) patients in Sambalpur district of Odisha during the year 2021. The study also investigated association between knowledge with different socio-demographic characteristics of the patients. Three hundred (300) diabetic patients of District Head Quarter Hospital, Sambalpur, Odisha were included in the study. Knowledge regarding diabetes was judged by using a self administered questionnaire. The scores were analysed against the variables to determine the association of knowledge with socio demographic variables. Out of those 300 respondents maximum responds (63%) had fair knowledge followed by good and poor (26% and 11%) knowledge respectively. Significant association was found between age, area of residence, family income, family type and duration of diabetes with diabetes knowledge. No significant association was found with gender, education, occupation, age of onset of disease, and family history of diabetes. Awareness related to all the aspects of diabetes mellitus need to be increased among the diabetic patients for better control of the disease and its complications.

Key Words: Diabetes Mellitus, Knowledge, Sambalpur (Odisha), Socio-demographic variables

INTRODUCTION

Diabetes mellitus, a common non-communicable disease has emerged as a global public health problem in low-and middle-income countries facing the greatest burden. (Unwin *et al.*, 2009) The ninth edition of the IDF Diabetes Atlas indicated that recently 463 million adults are living with diabetes in the world. In the year

2019, India ranks second in the list of diabetes among people aged 20–79 years next to China. India had 77 million diabetic people aged 20–79 years, while China had over 116 million people and this is expected to increase up to 109.0 million by 2035 in India. (IDF, 2019). Very commonly obesity and hypertension increase morbidity and mortality of diabetes in the general

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population. (Ciulla *et al.*, 2003) These two health problems are important predisposing factors for diabetic complications (Sachdev and Sahani 2010). According to the World Health Organization (WHO) 24 million cases of diabetic neuropathy, 5 million cases of retinopathy, and 6 million cases of amputation occurred due to diabetes and in 2019, it was estimated 1.5 million deaths were directly due to diabetes.

The change in life style, lack of appropriate health-care facility, lack of proper guidance, and most probably lack of proper knowledge on diabetes are in part responsible for the outstanding rise in the incidence of this disease (Misra *et al.*, 2011). The IDF estimates that 10% of global health expenditure is being spent on diabetes.

Diabetes is a chronic disease and it requires multiple approaches for its management. The patient has to play an important role for management. Certain self-care practices are helpful to achieve an optimal glycemic control and to prevent diabetes related complications. These practices include regular physical activity, appropriate dietary practices, daily foot care practice, compliance with treatment regimen and tackling complications such as hypoglycemic episodes (American Diabetes Association, 2013)

Proper management of the disease require adequate knowledge on diabetes. Good knowledge on diabetes and its complications is a key component of diabetic care. Studies have shown that increasing patient knowledge regarding disease and its complications have significant benefits with regard to patient compliance to treatment and for decreasing complications associated with disease

(Murugesan *et al.*, 2007). On this back drop the study was conducted with the following objectives.

To study the socio-economic profile of the patients and to assess the level of knowledge of the patients and to find association between demographic variables and knowledge level of the diabetic patients.

MATERIALS AND METHODS

A cross-sectional descriptive study was conducted among diagnosed type 2 Diabetes Mellitus patients attending the OPD of Sambalpur District Headquarter Hospital. The study was conducted for a period of 6 months (January 2021 – June 2021). A total of 300 patients diagnosed with Type-2 diabetes mellitus were selected as the study sample. All the selected study subjects were interviewed using a pretested semi-structured questionnaire after obtaining their informed consent. The questionnaire comprised of the following items

- i. Socio-demographic information
- ii. Information regarding blood sugar level and status of diabetes
- iii. Knowledge regarding diabetes.

Respondents' knowledge was assessed by Diabetes Knowledge Questionnaire (DKQ). This product was adapted from the DKQ "Diabetes Knowledge Questionnaire," - Garcia and Associates for the diabetes self management project at Gateway Community Health Center, Inc. with support from the Robert Wood Johnson Foundation in Princeton, NJ. DKQ consists of 24-items, used to elicit information about patients' understanding of the cause of their disease, its associated complications, blood glucose levels, diet, and physical activity. Each correct response under knowledge attracted one point, whereas

any wrong answer attracted no mark. Overall, total score of 24 points was designed for assessing the knowledge of the study participants. For the final assessment of knowledge of the participants, subjects were categorized as having poor knowledge (0-8 points); fair knowledge (9-17 points) and good knowledge (18-24 points). Rapport was established with each of the participant in order to retrieve correct information.

RESULTS AND DISCUSSION

Socio-Demographic characteristics of the respondents

Table 1 describes the socio-demographic characteristics of the study population. It is revealed majority of the participants (35.33%) belonged to the age group of 56-65 years and were males (65%). Most (38%) of them were graduate and in case of occupation nearly 50% were govt./ private employees and only 10.33 % of them were farmers. Most (64.33%) of the respondents were from urban area and almost 60% of the respondents belonged to nuclear family system. 37.66% of the respondents had monthly income in the range of 29,973-49,961/- and only 3.66% respondents were in the range of 74,756-99,930.

A study by Vankudre *et al.* (2013) indicated that most of their respondents were females and majority of the individuals were in the age group of 46 – 60 years. Kurian *et al.* (2016) observed in their study most of the respondents completed high school and higher secondary education.

Ahmed *et al.* (2019) found 19.6% respondents were unemployed which is similar with the findings study and 34.2% were government / private employees.

Diabetes related information of the respondents

Table 2 reveals the varied status of diabetes among the study participants. It was observed that 46.7% of the subjects were diagnosed at the age of 46-55 years and very few (2.333%) were diagnosed after the age of 66 years. Fifty one point three percent respondents had a positive family history of diabetes. Kurian *et al.* (2016) had quite similar findings in respect of family history, but in case of Shiferaw (2020) result was quite different. Almost 50% of the respondents were suffering from diabetes since 5 years. Ahmed *et al.* (2019) found that 21.3% respondents were diagnosed with diabetes mellitus over 20 years ago. Consumption of allopathic medicine was found to be common among the respondents and very few were taking some indigenous medicine with allopathic medicine. It was also observed that 56% had uncontrolled and 44% had controlled glycemic level.

Knowledge regarding diabetes

Table 3 depicts about the response of question regarding diabetic knowledge. Out of 300 participants, approximately 67.66% respondent had correct knowledge of common cause of diabetes i.e. lack of effective insulin in the body and 34.33% opined kidneys produce insulin. 74% knew about its hereditary nature and 54.33% said it is incurable. It was observed that 51.3% knew diabetes often causes poor circulation and only 24.66% said tremors and sweating are signs of high sugar in the blood. In addition, most of the respondents had knowledge regarding risk factors, sign and symptoms of diabetes. It was interesting to note that 55.33% told tight elastic shoes or shocks

are not bad for diabetics. Study by Chandalia *et al.* (2008) observed that, diabetic patients had more awareness about footwear, foot care and symptoms relating to diabetic foot.

Overall Knowledge on diabetes of respondents

The graph-1 showed the overall knowledge of diabetes among the respondents. The overall knowledge regarding the disease was categorised into three classes i.e. good, fair and poor. Out of the three hundred respondents maximum (63%) respondents had fair knowledge followed by 26% and 11% had good and poor knowledge respectively. Study by Shiferaw *et al.* (2020) and Sajai (2017) found that most of the participants had good general knowledge about diabetes mellitus.

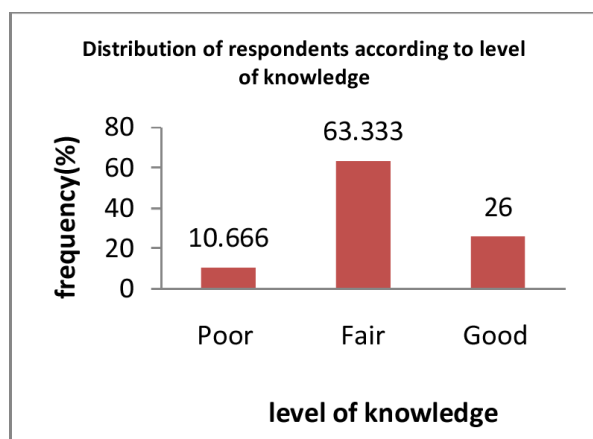


Fig.1 Overall Knowledge about diabetes respondents

Association between level of knowledge regarding diabetes and socio-demographic variables of the respondents

Table 4 depicts the association between socio-demographic parameters and level of knowledge about diabetes among the study subjects. Higher proportion (70.96%) of the

elderly (66 and above year) had fair knowledge on diabetes in comparison to other age groups and it was also observed that 37.5% respondents had good knowledge among age group 35-45 years. Age was significantly associated with patient's level of knowledge of diabetes ($p = 0.05$). The present study found no significant association between gender and the level of knowledge of the disease ($p = 6.85$). However most of male participants had good knowledge compared to their female counterparts. This result is consistent with the findings of a study conducted by Menezes and Mohammed (2015). There was significant association between area of residence and the knowledge on diabetes ($p = 0.02$). It was observed that patients from the urban (31.088%) had good knowledge than their counterparts from the rural settings (16.822%). In case of education the findings revealed that most (63.076%) respondents having post-graduate had good knowledge in comparison to others. The result of the present study is similar with findings of study conducted by Ullah *et al.* (2015). Other study conducted by Anil, *et al.* (2014) in Bangladesh also supports that higher education level was significantly associated with better knowledge but study by Choudhary and Choudhary (2015) differ from the result of the present study. Interestingly no statistical significant association was found between education and knowledge ($p = 7.61$) of respondents. It was observed that most of the employed respondents had good knowledge in comparison to farmers, business man and unemployed. Most (19.354%) farmers had poor knowledge in comparison to others. It also observed that there was no significant association between occupation and knowledge ($p = 1.08$) of respondents. Significant association was found

between family income and diabetic knowledge ($P = 0.00$) of the respondents. There was a significant variation in level of knowledge among both the family type ($P = 0.003$). Age of onset of diabetes had no significant association with knowledge of respondents. But the duration of disease was significantly ($p = 0.001$) associated with the level of knowledge. Here it was observed that patients who had lived many years with diabetes (>21 years) were more knowledgeable. Family history of diabetes had significant ($p = 0.64$) association with knowledge on diabetes.

From the above discussion it is clear that there is significant statistical association between age, area of residence, family income, family type,

and duration of diabetes with knowledge of the respondents and no association was found between gender, education, occupation, age of onset of disease, family history of diabetes with level of knowledge. Another study by Choudhary *et.al.* (2015) found family history and regular contact with health care provider were significantly associated with awareness about diabetes. Gender and education was not associated with awareness about diabetes. In another study by Shiferaw *et al.* (2020) found marital status, family history of diabetes and exposure to health education were associated with good knowledge. The study by Kanizet *al.* (2017) showed knowledge scores strongly associated with education, income, residence.

Table -1 Socio-Demographic characteristics of the respondents

Variables	Category	Frequency	%
Age(years)	35-45	64	21.333
	46-55	99	33
	56-65	106	35.333
	66 and above	31	10.333
Gender	Male	195	65
	Female	105	35
Area of residence	Rural	107	35.666
	Urban	193	64.333
Education	Illiterate	4	1.333
	Upto 10 th	65	21.666
	Intermediate / diploma	41	13.666
	Graduate	114	38
	Professional / others	76	25.333
Occupation	Unemployed	58	19.333
	Service	136	45.333
	Agriculture	31	10.333
	Business /others	75	25

Family income	≤ 10,001	43	14.333
	10,002-29,972	50	16.666
	29,973-49,961	113	37.666
	49,962-74,755	46	15.333
	74,756-99,930	11	3.666
	99,931-1,99,861	37	12.333
Family type	Nuclear	179	59.666
	Joint	121	40.333

Table 2: Diabetes related information of the respondents

Variables	Options	Frequency	%
Age of onset of diabetes(years)	25-35	26	8.666
	36-45	99	33
	46-55	140	46.666
	56-65	28	9.333
	66 and above	7	2.333
Duration of diabetes	0-5	149	49.666
	6-10	105	35
	11-15	27	9
	16-20	5	1.666
	21 and above	14	4.666
Family history of diabetes	Yes	154	51.333
	No	146	48.666
Medication status	Oral sugar medicine only	144	48
	Combination of diet, exercise, Oral sugar medicine	145	48.66
	Combination of diet, exercise & Insulin	11	3.666
	Insulin only	0	0
	Both oral medicine and insulin		
Type of treatment	Allopathic	300	100
Use of indigenous medicine	Yes	119	39.666
	No	181	60.333
Level of FBS	Controlled	132	44
	Uncontrolled	168	56

Table -3: Frequency distribution of respondents on knowledge regarding Diabetes

Sl. No	Items	Right Answer Frequency (%)	Wrong Answer Frequency (%)
1	Eating too much sugar and sweet foods is a cause of Diabetes.	114(38)	186(62)
2	A common cause of diabetes is lack of effective insulin in the body.	203(67.6)	97(33)
3	Diabetes is caused by failure of the kidneys to keep sugar out of the urine.	193(64.3)	107(35.6)
4	The kidneys produce insulin.	197(65.6)	103(34.3)
5	In untreated diabetes, the amount of blood sugar usually rises.	232(77.3)	68(22.66)
6	If you are diabetic your children are at greater risk to be diabetic.	222(74)	78(26)
7	Diabetes can be cured.	163(54.3)	137(45.6)
8	The fasting blood sugar level of 210 is very high.	233(77.6)	67(22)
9	The best way to assess your diabetes is making urine tests.	158(52.6)	142(47.3)
10	Regular exercise will increases the need for insulin or other medicine for diabetes.	161(53.6)	139(46.3)
11	There are two main types of diabetes: Type I ("insulin-dependent" / "insulin-treated) and Type2 (" not insulin-dependent ")	227(75.6)	73(24.33)
12	Hypoglycaemia (low blood sugar) is caused by too much food.	187(62.3)	113(37.6)
13	The medication is more important than diet and exercise to control diabetes.	95(31.66)	205(68.3)
14	Diabetes often causes poor circulation.	154(51.3)	146(48.6)
15	Cuts and wounds heal more slowly in diabetics.	217(72.3)	83(27.66)
16	Diabetics should take special care when cutting the nails of the toes.	204(68)	96(32)
17	A person with diabetes should clean a wound with an iodine solution and alcohol.	168(56)	132(44)
18	The way you prepare your food is as important as the food you eat.	211(70.3)	89(29.66)
19	Diabetes can damage the kidneys.	217(72.3)	83(27.66)
20	Diabetes can lead to decreased sensitivity of the hands, fingers and feet.	188(62.6)	112(37.3)
21	Tremors and sweating are signs of high sugar in the blood.	74(24.66)	226(75.3)
22	Frequent urination and thirst are signs of low blood sugar.	300(100)	
23	Tight elastic shoes or shocks are not bad for diabetics..	134(44.6)	166(55.3)
24	A diabetic diet consists essentially of special foods.	180(60)	120(40)

Table No. 4: Association between level of knowledge regarding diabetes and socio-demographic variables of the respondents.

Variables	Category	Knowledge			p-value	
		Poor	Fair	Good		
Age(years)	35-45	7(10.937)	33(51.56)	24(37.5)	0.05	Association
	46-55	17(17.171)	64(64.64)	18(18.181)		
	56-65	8(7.547)	71(66.98)	27(25.471)		
	66 and above	0	22(70.96)	9(29.032)		
Gender	Male	14(7.179)	116(59.47)	65(33.333)	6.85	No association
	Female	18(17.142)	74(70.47)	13(12.380)		
Area of residence	Rural	11(10.280)	78(72.897)	18(16.822)	0.02	Association
	Urban	21(10.880)	112(58.01)	60(31.088)		
Education	Illiterate		4(100)		7.61	No association
	Upto 10 th	9(13.846)	53(81.538)	3(4.615)		
	Intermediate / diploma	4(9.756)	33(80.487)	4(9.756)		
	Graduate	15(13.157)	76(66.666)	23(20.175)		
	Postgraduate	0(0)	24(41.538)	41(63.076)		
	Higher than P.G.	4(36.363)	0	7(63.636)		
Occupation	Unemployed	3(5.172)	51(87.931)	4(6.896)	1.08	No association
	Service	19(13.970)	69(50.735)	48(35.294)		
	Agriculture	6(19.354)	22(70.967)	3(9.677)		
	Business /others	4(5.333)	48(64)	23(30.666)		
Family income	≤ 10,001	11(25.581)	29(67.441)	3(6.976)	0.00	Association
	10,002-29,972	4(8)	34(68)	12(24)		
	29,973-49,961	10(8.849)	77(68.141)	26(23.008)		
	49,962-74,755	7(15.217)	23(50)	16(34.782)		
	74,756-99,930		5(45.454)	6(54.545)		
	99,931-1,99,861		22(59.459)	15(40.540)		

Family type	Nuclear	25(13.966)	100(55.85)	54(30.167)	0.00	Association
	Joint	7(5.785)	90(74.380)	24(19.834)		
Age of onset of diabetes (years)	25-35	5(19.230)	15(57.692)	6(23.076)	0.758537	No association
	36-45	10(10.101)	60(60.606)	29(29.292)		
	46-55	17(15.044)	89(78.761)	34(30.088)		
	56-65	00	19(67.851)	9(32.142)		
	66 and above	00	7(100)	00		
Duration of diabetes (days)	0-5	19(12.751)	94(63.087)	36(24.161)	0.001203	Association
	6-10	9(8.571)	66(62.857)	30(28.571)		
	11-15	00	21(77.777)	6(22.222)		
	16-20	4(80)	00	1(20)		
	21 and above		9(64.285)	5(35.714)		
Family history of diabetes	Yes	18(12.328)	90(61.643)	38(26.027)	0.648924	No association
	No	14(9.090)	100(64.935)	40(25.974)		

CONCLUSION

Knowledge is the most powerful weapon to fight against diabetes. Information can help people to find out their risk of diabetes, motivate them to seek proper treatment and care, and inspire them to take care of their disease. The current study showed that most of the respondents belonged to the age group of 56-65 years and 38% of them were graduate. It was observed that most of the subjects were diagnosed at the age of 46-55 years. About 50 % had a positive family history of diabetes. Half of the respondents were suffering from diabetes since 5 years. Out of the three hundred respondents 63% respondents had fair knowledge followed by 26% and 11% had good and poor knowledge respectively. Significant statistical association was found between age,

area of residence, family income, family type, and duration of diabetes with knowledge of the respondents and no association between gender, education, occupation, age of onset of disease, family history of diabetes with level of knowledge. It was also observed that knowledge among the study population is not even in all the aspects of the disease. The health care centres need to develop a comprehensive health education programme where all aspects of diabetes like, knowledge about the disease and complications, self care, self monitoring etc. are covered.

REFERENCES

Ahmed, I.B., Binnwejim, M.S., Alnahas, T. M., Ali Raes, A.A., Mansour, A. and Eidhah, A. 2019. Level of diabetic patients' knowledge of diabetes mellitus, its

- complications and management. *Archives of Pharmacy Practice*. 10(4):80-86.
- American Diabetes Association 2013. Standards of medical care in diabetes. *Diabetes Care*. 36(Suppl 1):S11–66.
- Anil, C.M., Jacob, N., Jose, S., Rathan, P. and Suvetha, K. 2014. knowledge about risk factors, symptoms and complications of diabetes among adults in South India. *International Journal of Medical Science in Public Health*. 3(9): 1086-1092.
- Chandalia, H.B., Singh, D., Kapoor, V., Chandalia, S.H. and Lamba, P.S. 2008. Footwear and foot care knowledge as risk factors for foot problems in Indian diabetics. *International Journal of Diabetes Developing Countries*. 28(4): 109–113.
- Choudhary, V.S. and Chaudhary, G. 2015. A Descriptive study to assess the knowledge regarding diabetes mellitus, Its risk factors and complication among the rural community, Sadiq, Faridkot (Punjab). *Asian Journal of Nursing Education and Research*. 5(2): 250-253.
- Ciulla, T. A., Amador, A.G. and Zinman, B. 2003. Diabetic retinopathy and diabetic macular edema. *Diabetes Care*. 26(9):2653-64.
- IDF Diabetes Atlas 2019. 9th ed. Belgium: International Diabetes Federation.
- Kurian, B., Qurieshi, M.A., Ganesh, R. and Kamalamma, L. 2016. A community based study on knowledge of diabetes mellitus among adults in a rural population of Kerala. *International Journal of Non-communicable Diseases*. 1(2):59-64.
- Kaniz, F., Sharmin, H., Khurshid, N., Chowdhury, H. A., Akter, j., Khan, T. and Ali, L. 2017. Knowledge attitude and practice regarding diabetes mellitus among non-diabetic and diabetic study participants in Bangladesh. *BMC Public Health*. 17(364):2-10.
- Menezes, S. and Mohammed, B.M. 2015. A study on awareness of diabetic complications among type 2 diabetes patients. *IOSR J Dent Med Sci* 14: 2279-2861.
- Misra, P., Upadhyay, R.P., Misra, A. and Anand, K. 2011. A review of the epidemiology of diabetes in rural India. *Diabetes Research Clinical Practice*. 92:303–11.
- Murugesan, N., Snehalatha, C., Shobhana, R., Roglic, G. and Ramachandran, A. 2007. Awareness about diabetes and its complications in the general and diabetic population in a city in southern India. *Diabetes Research Clinical Practice*. 77(3):433–37.
- Sachdev, N. and Sahni, A. 2010. Association of systemic risk factors with the severity of retinal hard exudates in a north Indian population with type 2 diabetes. *Journal of Postgrad Medicine*. 56(1):3-6.
- Sajai, B.N. 2017. A descriptive study to assess the knowledge regarding self administration of insulin injection among diabetes mellitus patients in diabetic clinic of primary health centre at Alnamas. *Journal of Community & Public Health Nursing*. 3(3):1-5.
- Shiferaw, W.S., Gatew, A., Afessa, G., Asebu, T. Petrucka, P.M. and Yared, A. 2020. Assessment of knowledge and perceptions towards diabetes mellitus and its

- associated factors among people in DebreBerhan town, Northeast Ethiopia . PLOS ONE. 15(10): 1-13.
- Unwin, N., Whiting, D., Gan, D., Jacqmain, O. andGhyoot, G 2009. The global burden. IDF Diabetes Atlas. 4th ed. Belgium: International Diabetes Federation. 21–37.
- Ullah, F., Afridi, A.K., Rahim, F., Ashfaq, M., and Khan, S., 2015. knowledge of diabetic complications in patients with diabetes mellitus. Journal of AyubMededical College Abbottabad. 27(2):360-363.
- Vankudre, A. J., Padhyegurjar, M. S., Jennifer, M.S. and Padhyegurjar, S. B. 2013. A study to assess awareness regarding diabetes mellitus andfactors affecting it, in a tertiary care hospital in Kancheepurum District. Healthline. 4(2) : 44-49.

DYNAMICS OF CROPPING PATTERN IN KRISHNA ZONE OF ANDHRA PRADESH- MARKOV CHAIN APPROACH.

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ABSTRACT

The cropping pattern plays a vital role in determining the level of agricultural production and reflects the agricultural economy of an area or region. The present study was conducted to know the changes in the cropping pattern of the Krishna zone of Andhra Pradesh using Markov chain analysis. Time series data on the area under different crops grown from the period 2000-01 to 2019-20 were collected and analyzed for 3 districts in the Krishna zone separately for *kharif* and *rabi* seasons. The results revealed that in the Krishna district, blackgram retained 88 per cent in *rabi* season and just 6.9 per cent in *kharif* season. Maize as an emerging crop retained more than 75 per cent of its share in both Krishna and Guntur districts. Redgram being a *kharif* crop, retained 37.5 per cent in Krishna district and its retention was more in Guntur (57.5 per cent) and Prakasham district (63.8 per cent). At zonal level redgram retained 45.1 per cent of its previous acreage. Zonal level retention values range in between their district wise retention. A high degree of substitutability was noticed between two commercial crops i.e, cotton and chillies. Paddy has emerged as one of the stable crops in all three districts irrespective of the season. Greengram's ability to retain its area was less in the study period.

Keywords: Cropping pattern, Markov chain analysis, Transitional probability matrix

INTRODUCTION

Agriculture is an important sector for economic growth in India, as more than 54.6 per cent of the population is involved in agriculture and its allied activities for their livelihood. The share of agriculture in the country's Gross Domestic Product (GDP) has fallen from 20 percent in 2003-04 to 18.8 percent in the year 2021-22 (agricoop.nc.in). With the advancement

of the green revolution, a drastic change has been witnessed in the agricultural sector in our country.

This technological development in crop varieties and other yield increasing factors of production influenced the farmers' behaviour which has been reflected in the cropping pattern from the cultivation of low-value crops to high-value crops in most of the regions.

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Agriculture plays a crucial role in the economy of Andhra Pradesh. This sector contributes 34.12 percent of the total Gross State Domestic Product (GSDP) at the current price and 29.51 percent at constant price 2020-21 (apsdps.ap.gov.in). A large segment of the population is dependent on the agriculture sector for employment and income. About 66 percent population of Andhra Pradesh lives in rural areas and depends on agriculture and the rural non-farm sector.

A cropping pattern is defined as a combination of crops that are grown in a particular geographical area. A change in cropping pattern means a change in the proportion of area under different crops. According to Vinayak Jalikatti and Poddar (2019), the long-term changes in the cropping pattern in any region could be due to the development of irrigation infrastructure, whereas the vagaries of nature including rainfall and other institutional factors led to short term fluctuations in the cropped area as well as productivity. These short term and long term changes have a significant effect on the economic returns to the farmer as well as on the environment. The assessment of shifts in cropping patterns in different regions is crucial for a better insight into the agricultural development process. In this context, an attempt to analyze the cropping pattern in Krishna zone of Andhra Pradesh through Markov chain analysis for both crop seasons.

MATERIAL AND METHODS

The present study was conducted for three districts of Krishna zone viz., Krishna, Guntur and Prakasham which was purposively selected as the zone is covered by Regional Agricultural Research Station (RARS) activities of Acharya

N G Ranga Agricultural University (ANGRAU), Guntur. Time series data on the area under different crops grown in these districts from the period between 2000-01 and 2019-20 were collected from publications of the Directorate of Economics and Statistics, Andhra Pradesh. For *kharif* and *rabi* seasons, transition probability matrix were constructed using Lingo 18.0 software for the three districts individually as well as for zonal level using Markov chain analysis (Wali et al., 2019).

MARKOV CHAIN ANALYSIS

Markov chain analysis is an application of dynamic programming to the solution of a stochastic decision process that can be described by a finite number of states to study the changes in the cropping pattern (Dayakar Rao and Parwez, 2005). The Markov process was used to study the crop shifts in the rayalaseema region by Ragamaliika *et al.* (2021); Reddy and Lalith Achoth (2000) applied it to know the dynamics of the cropping pattern changes in Kerala.

THE MARKOV PROBABILITY MODEL

A stochastic process can analyze a set of trials or experiments probabilistically. For a stochastic process, it is assumed that the movements (transitions) of objects from one state (possible outcome) to another are governed by a probabilistic mechanism. A finite Markov process is a stochastic process whereby the outcome of a given trial 't' ($t = 1, 2, \dots, T$) depends only on the outcome of a preceding trial ($t-1$) and this dependence is the same at all stages of the sequence of trials (Lee *et al.*, 1965). Consistent with this definition, let the S_i represent i^{th} state or possible outcomes; $i = 1, 2, \dots, r$, W_{it} represent the probability that state S_i occurs on trial t

or proportion observed in trial 't', in alternative outcome state i of a multinomial population based on sample size n, i.e. $P_r(S_{it})$. P_{ij} represent the transitional probability which denotes the probability that if for any time t the process is in state S_i , it moves on next trial to state S_j ,

$$\text{i.e. } P_r(S_j, t+1/S_{it}) = P_{ij}$$

$P_r = (P_{ij})$ represent transitional probability matrix which denotes transitional probability for every pair of states ($i, j = 1, 2, \dots, r$) and has the following properties;

$$0 \leq P_{ij} \leq 1 \dots \dots \dots (1)$$

$$\sum_{j=1}^r P_{ij} = 1 \dots \dots \dots (2)$$

Given this set of notations and definitions for a first order Markov chain, the probability of particular sequence S_i on trial t and S_j on trial t + 1 may be represented by

$$P_r(S_{it}, S_{j,t+1}) = P_r(S_{it}) P_r(S_{j,t+1}/S_{it}) = W_{it} P_{ij} \dots \dots \dots (3)$$

and the probability of being in state j at trial t + 1 may be represented by

$$P_r(S_{j,t+1}) = \sum_i W_{it} P_{ij} \text{ or } W_{j,t+1} = \sum_i W_{it} P_{ij} \dots \dots \dots (4)$$

The data for study are the proportion of area under crops. The proportion changes from year to year as a result of factors like weather, technology, price and institutional changes etc. It is reasonable to assume that the combined influence of these individually systemic forces approximates to a stochastic process and propensity of farmers to move from one crop to another differs according to the crop state involved. The process of cropping pattern change may be described in form of matrix P of first order transition probabilities. The element P_{ij} indicates the probability of a crop state i in

one period will move to crop state j during the following period. The diagonal element P_{ii} measures the probability that the proportion share of ith category of crop will be retained (Ardeshta and Shiyani, 2013).

Estimation of Transitional Probability Matrix (TPM)

Equation (4) can be used as a basis for specifying the statistical model for estimating transitional probabilities. If errors are incorporated in equation (4), it becomes,

$$W_{it} = \sum_j W_{it} W_{j,t-1} P_{ij} + U_{it} \dots \dots \dots (5)$$

or in matrix form it can be written as,

$$Y_t = X_t P + U_t \dots \dots \dots (6)$$

Where $Y_t = (T \times 1)$ vectors of observations reflecting the proportions in cropping pattern j in time t,

$X_t = (T \times r)$ matrix of realized values of the proportions in cropping pattern in time t – 1,

$P_j = (r \times 1)$ vectors of unknown transition parameters to be estimated and

U_t = vectors of random disturbances.

Results and Discussion

The results of Markov chain analysis to find out changes in the direction of different crops in three districts were presented in the form of a transition probability matrix. As the diagonal elements approach zero, the crops become less and less stable and as they approach one, implies that they become more and more stable over a period of time. In the transition probability matrix rows showed the previous period acreage of the corresponding crop lost to the other crops in the current period and columns indicate area gained from the other crops (Ramya Lakshmi and Bhavani Devi (2012); Rajini Devi *et al.* (2019); Srivastava *et al.* (2019).

Table 1: TPM for shift in cropping pattern in Krishna district during *kharif* season

CROP	Paddy	Redgram	Greengram	Blackgram	Cotton	Chillies	Groundnut
Paddy	0.967	0.000	0.003	0.005	0.014	0.010	0.002
Redgram	0.000	0.375	0.585	0.041	0.000	0.000	0.000
Greengram	0.081	0.169	0.495	0.104	0.000	0.151	0.000
Blackgram	0.915	0.000	0.017	0.069	0.000	0.000	0.000
Cotton	0.047	0.005	0.000	0.000	0.826	0.116	0.005
Chillies	0.475	0.000	0.000	0.000	0.525	0.000	0.000
Groundnut	0.000	0.000	0.000	0.000	0.590	0.000	0.410

KRISHNA DISTRICT

The Transitional Probability Matrix (TPM) in Table 1 showed the shifts in area of different crops in Krishna district during *kharif* season. Among all the crops, paddy has the highest retention probability with 96.7 per cent. Paddy was the most important crop with a cultivated area of 3.15 lakh hectares in the year 2019-20 which contributed 46.65 per cent share in total Gross Sown Area (GSA) of Krishna district. Paddy lost its minor share of 1.4 per cent to cotton, 1.0 per cent to chillies, 0.5 per cent to blackgram, 0.3 per cent to greengram and 0.2 per cent to groundnut. Paddy had gained 91.5 per cent from blackgram, 47.5 per cent from chillies, 8.1 per cent from greengram and 4.7 per cent from cotton.

Cotton retained 82.6 per cent of its area and lost 11.6 per cent to chillies, 4.7 per cent to paddy and 0.5 per cent to redgram and groundnut each. Cotton grabbed 59 per cent of its area from groundnut, 52.5 per cent from chillies and 1.4 per cent from paddy.

Redgram had retained to an extent of 37.5 per cent. It lost 58.5 per cent to greengram and 4.1 per cent to blackgram. Redgram gained 16.9 per cent from greengram and 0.5 per cent from cotton. Greengram has a retention capacity of 49.5 per cent and it lost 16.9 per cent of its previous acreage to redgram, 15.1 per cent to

chillies, 10.4 per cent to blackgram and 8.1 per cent to paddy. Blackgram retained only 6.9 per cent of its previous area. Meanwhile, it has lost 91.5 per cent of its area to paddy, 11.6 per cent to chillies and 0.5 per cent to redgram and groundnut each. On the other hand, it grabbed an area of 59 per cent from groundnut, 52.5 per cent from chillies and 1.4 per cent from paddy.

Chillies was the most unstable crop and it lost mainly to 2 crops i.e., 52.5 per cent to cotton and 47.5 per cent to paddy. This is in line with observations made by Ragamlika et.al, (2021) in which chillies showed instability in the Kurnool district of Andhra Pradesh during the study period. Groundnut retained 41 per cent of its previous acreage and it lost only to one crop i.e., cotton. It gained minor shares from cotton (0.5 per cent) and paddy (0.2 per cent).

The results of TPM for a shift in cropping pattern in Krishna district during *rabi* season is presented in Table 2. In AP, blackgram is grown mostly in Krishna district approximately 42 per cent in the year 2019-20. Blackgram had retained to an extent of 88.4 per cent. It lost minor shares of 5.5 per cent to paddy, 2.8 per cent to maize, 2.7 per cent to greengram, 0.4 per cent to bengalgram and 0.1 per cent to groundnut. Paddy retained 79.7 per cent of its area and lost its share to only one crop i.e., blackgram (20.3 per cent). The acreage under blackgram

Table 2: TPM for shift in cropping pattern in Krishna district during *rabi* season

CROP	Paddy	Maize	Blackgram	Bengalgram	Greengram	Groundnut
Paddy	0.797	0.000	0.203	0.000	0.000	0.000
Maize	0.000	0.764	0.233	0.003	0.000	0.000
Blackgram	0.055	0.028	0.884	0.004	0.027	0.001
Bengalgram	0.506	0.000	0.000	0.494	0.000	0.000
Greengram	0.000	0.000	1.000	0.000	0.000	0.000
Groundnut	0.228	0.000	0.000	0.000	0.000	0.772

increased due to non-availability of irrigation for paddy in *rabi* season. Maize has retained 76.4 per cent of its previous acreage. Maize had lost 23.3 per cent of its area to blackgram, 0.3 per cent to bengalgram and gained 2.8 per cent from blackgram. In 1997, pulses and rice were dominant crops but maize emerged as the third dominant crop after pulses and rice during 2006 and the second dominant crop in 2016 (Siva Jyothi *et al.*, 2020).

Groundnut has a retention capacity of 77.2 per cent. Groundnut had lost its share of 22.8 per cent to paddy. Aravind kammar and Basavaraja (2012) also observed a shift in area from groundnut to paddy in the Northern transitional zone during 1991-92 to 2006-07 in Karnataka. Bengalgram could retain only 49.4 per cent of its area and 50.6 per cent of its area was substituted by paddy. Greengram was found highly unstable with no retention. Low retention of pulses might be due to late release of water

to Krishna western delta resulting in late transplantation of *kharif* paddy.

Table 3 presents the results of TPM for a shift in cropping pattern in Guntur district during *kharif* season. Paddy was the most stable crop among the major crops grown during *kharif* season in Guntur district. Paddy crop was the highest retainer (79.2 per cent) while greengram was unable to retain its previous acreage. Redgram, greengram and cotton lost its share of 24.9 per cent, 87.4 per cent and 26.4 per cent to paddy respectively. Redgram was the another crop with more than 50 per cent of retention capability (57.5 per cent). Redgram had lost 24.9 per cent to paddy, 11.2 per cent to greengram and 6.4 per cent to sesamum.

Cotton showed retention of 46.2 per cent. This retention of the area was further reinforced by the gain from greengram (10.6 per cent). Earlier, the farmers who cultivated greengram

Table 3: TPM for shift in cropping pattern in Guntur district during *kharif* season

CROP	Paddy	Redgram	Greengram	Blackgram	Cotton	Chillies	Sesamum
Paddy	0.792	0.027	0.000	0.001	0.096	0.081	0.002
Redgram	0.249	0.575	0.112	0.000	0.000	0.000	0.064
Greengram	0.874	0.000	0.000	0.000	0.106	0.000	0.020
Blackgram	0.000	0.053	0.000	0.246	0.000	0.701	0.000
Cotton	0.264	0.000	0.000	0.003	0.462	0.271	0.000
Chillies	0.000	0.000	0.000	0.000	0.977	0.023	0.000
Sesamum	0.000	0.482	0.232	0.007	0.000	0.000	0.279

Table 4: TPM for shift in cropping pattern in Guntur district during *rabi* season

CROP	Paddy	Jowar	Maize	Blackgram	Bengalgram	Greengram
Paddy	0.477	0.050	0.179	0.253	0.023	0.018
Jowar	0.000	0.711	0.000	0.000	0.000	0.289
Maize	0.130	0.000	0.805	0.000	0.005	0.059
Blackgram	0.020	0.000	0.119	0.791	0.069	0.001
Bengalgram	0.271	0.119	0.353	0.000	0.257	0.000
Greengram	0.000	0.000	0.000	0.412	0.263	0.325

suffered losses due to declined prices by importing pulses by the central government.

A very low degree of retention was observed in chillies (2.3 per cent), it lost completely to cotton (97.7 per cent) due to disappointing prices of red chillies in previous years.

Blackgram retained 24.6 per cent of the area and it lost a major share of 70.1 per cent to chillies, 5.3 per cent to redgram. Blackgram had gained minor shares from sesamum (0.7 per cent), cotton (0.3 per cent) and paddy (0.1 per cent). Sesamum lost its major share to redgram (48.2 per cent), greengram (23.2 per cent) and negligible share to blackgram (0.7 per cent) with retention of 27.9 per cent.

It is inferred from Table 4 that, maize has the highest retention of 80.5 per cent and it lost 13 per cent to paddy, 5.9 per cent to greengram and 0.5 per cent to bengalgram. Maize grabbed

35.3 per cent of its area from bengalgram, 17.9 per cent from paddy and 11.9 per cent from blackgram. This is in line with observations made by Siva Jyothi et al. (2020) in which farmers switched over to maize crop from pulses, which proved to be remunerative. Jowar retained its maximum share of 71.1 per cent and it lost its minor area share of 28.9 per cent to greengram. It slightly gained 11.9 per cent from bengalgram and 5 per cent from paddy.

Paddy had retained 47.7 per cent of its area which is less compared to *kharif* season (79.2 per cent). It lost its area shares to blackgram (25.3 per cent), maize (17.9 per cent), bengalgram (2.3 per cent) and greengram (1.8 per cent). The fall in paddy area may be attributed to a lack of irrigation water and an increase in the production cost of paddy (Ramana and Rekha, 2012). However, it was benefitted by gaining a major share from

Table 5: TPM for shift in cropping pattern in Prakasham district during *kharif* season

CROP	Paddy	Redgram	Greengram	Blackgram	Cotton	Chillies	Groundnut
Paddy	0.628	0.063	0.061	0.012	0.167	0.055	0.014
Redgram	0.149	0.638	0.000	0.000	0.096	0.106	0.010
Greengram	0.140	0.151	0.563	0.000	0.142	0.000	0.004
Blackgram	0.000	0.000	0.000	0.284	0.000	0.567	0.150
Cotton	0.000	0.124	0.000	0.018	0.701	0.148	0.008
Chillies	0.000	0.899	0.000	0.078	0.000	0.019	0.004
Groundnut	0.000	0.807	0.000	0.000	0.000	0.000	0.193

bengalgram (27.1 per cent), maize (13 per cent) and a minor share from blackgram (2 per cent).

Among major pulses, blackgram had an advantageous position with the retention of 79.1 per cent of its area during the period under study. About 11 per cent of its area was lost to maize and marginally to bengalgram, greengram and paddy crops.

Greengram could retain only 32.5per cent and it was replaced by other pulses namely blackgram (41.2per cent) and bengalgram (26.3per cent). On the other hand, bengalgram lost its major share of 35.3per cent to maize, 27.1 per cent to paddy and 11.9 per cent to jowar. Low retention of pulses may be due to unexpected heavy rains and yellow mosaic virus (Siva Jyothi *et al.*, 2020).

The transition probability matrix presented in Table 5 showed the changes in areas of different crops in Prakasham district during *kharif* season. Cotton as one of the major commercial crop has shown highest stability by retaining of 70.1 per cent of its previous acreage. Mean while it lost 14.8 per cent of its area share to chillies, 12.4 per cent to redgram, 1.8 per cent to blackgram and 0.8 per cent to groundnut. Madhuri *et al.* (2017) also observed shifting of cotton area to redgram in Arvi tehsil of Wardha district in Maharashtra.

Paddy had retained 62.8per cent and lost about 16.7 per cent to cotton and the remaining

area to all the selected crops. But it gained 14.9 per cent from redgram and 14 per cent from greengram. An area of 63.8 per cent was retained by redgram and it lost 14.9 per cent of its area to paddy, 10.6 per cent to chillies, 9.6 per cent to cotton and 1 per cent to groundnut.

Greengram had retained 56.3 per cent of its previous acreage. It has lost 14 per cent to paddy, 15.1 per cent to redgram, 14.2 per cent to cotton and a minor share of 0.4 per cent to groundnut. Blackgram could able to retain only 28.4 per cent of its previous acreage. It lost its major share of 56.7 per cent to chillies and a minor share of 15 per cent to groundnut.

Groundnut retains its minor share of 19.3 per cent of its previous acreage and lost a major share of 80.7 per cent to a single crop i.e, redgram. However, it gained 15 per cent from blackgram, 1.4 per cent from paddy, 1 per cent from redgram and 1.6 per cent from remaining crops. A very low degree of retention is observed in chillies (1.9 per cent). Major competing crops for chillies are redgram and blackgram grabbing 89.9 per cent and 7.8 per cent respectively.

The results of the TPM for crops in Prakasham district during *rabi* season are presented in Table 6. *Rabi* paddy could retain 80.3 per cent of its area more than *kharif* paddy (62.8 per cent). However, it lost its area of 12.8 per cent to blackgram and 6.9 per cent to

Table 6: TPM for shift in cropping pattern in Prakasham district during *rabi* season

CROP	Paddy	Jowar	Maize	Blackgram	Bengalgram
Paddy	0.803	0.000	0.000	0.128	0.069
Jowar	0.206	0.179	0.310	0.306	0.000
Maize	0.000	0.569	0.277	0.155	0.000
Blackgram	0.000	0.000	0.000	0.211	0.789
Bengalgram	0.154	0.023	0.022	0.000	0.800

Table 7: TPM for shift in cropping pattern in Krishna zone during *kharif* season

CROP	Paddy	Redgram	Greengram	Blackgram	Cotton	Chillies	Groundnut	Sesamum
Paddy	0.810	0.040	0.019	0.002	0.066	0.058	0.005	0.000
Redgram	0.513	0.451	0.000	0.000	0.000	0.036	0.000	0.000
Greengram	0.454	0.033	0.264	0.000	0.247	0.000	0.002	0.000
Blackgram	0.000	0.000	0.000	0.426	0.000	0.574	0.000	0.000
Cotton	0.151	0.070	0.000	0.000	0.603	0.173	0.003	0.000
Chillies	0.000	0.218	0.000	0.000	0.683	0.086	0.013	0.000
Groundnut	0.210	0.000	0.000	0.543	0.000	0.000	0.011	0.237
Sesamum	0.000	0.000	0.566	0.000	0.000	0.000	0.000	0.434

bengalgram. Meanwhile, it gained 20.6per cent from jowar and 15.4 per cent from bengalgram.

Next to paddy, bengalgram has a high retention capacity of 80per cent, it gained 78 per cent from blackgram and 6.9 per cent from paddy. According to Geetha Mohan(2017) and Suhasini *et al.*(2009) bengalgram is emerging as a commercial crop in the black cotton soil of AndhraPradesh, particularly, because of higher returns and consistent yields. Besides, a low-risk crop is suitable in diverse dryland agroclimatic conditions (Suhasini *et al.*, 2009).Maize had retained 27.7per cent of its previous acreage. It has lost its major share of 56.9per cent to jowar and 15.5 per cent to blackgram. But it gained 31 per cent from jowar and 2.2per cent from bengalgram.

Blackgram has lost its major share of 78.9 per cent to bengalgram and retained only 21.1per cent of its area. However, it was benefited by gaining shares from jowar (30.6 per cent), maize (15.5per cent) and paddy(12.8 per cent). Only 17.9 per cent of its previous area was retained by jowar. Major competing crops for jowar are maize, blackgram and paddy. It grabbed 56.9 per cent of area from maize and 2.3per cent from bengalgram. Similar results were observed by Aravind kammar and

Basavaraja(2012) in which jowar grabbed 83 per cent from maize.

Table 7 showed the shift in cumulative cropping pattern in 3 districts of Krishna zone. In Krishna zone, during *kharif* season, paddy retained 81 per cent of its previous acreage. Paddy retention ranges from 62.8 per cent to 96.7 per cent in each district. Productivity of paddy is 5250 kg/ha in Andhra Pradesh during 2019-20. Paddy lost 6.6 per cent to cotton, 5.8 per cent to chillies, 4 per cent to redgram, 1.9 per cent to greengram and 0.5 per cent to groundnut. Next to paddy, cotton had retained to an extent of 60.3 per cent of its area. It lost 17.3 per cent to chillies, 15.1 per cent to paddy, 7 per cent to redgram and 0.3 per cent to groundnut. It is clear from the above tables that cotton lost its area to chillies and paddy mostly.

Redgram hadretained 45.1 per cent of its area, but lost its major share of 51.3 per cent to paddy and minor share of 3.6 per cent to chillies. It gained 21.8 per cent from chillies, 7 per cent from cotton, 4 per cent from paddy and 3.3 per cent from greengram. Blackgram lost its major share to chillies (57.4 per cent) by retaining only 42.6 per cent of its area. On the other hand, it gained 54.3 per cent from groundnut and 0.2 per cent from paddy. Greengram has retained

Table 8: TPM for shift in cropping pattern in Krishna zone during *rabi* season

CROP	Paddy	Maize	Jowar	Blackgram	Bengalgram	Greengram	Groundnut
Paddy	0.691	0.000	0.000	0.306	0.000	0.000	0.003
Maize	0.000	0.656	0.025	0.000	0.193	0.126	0.000
Jowar	0.000	0.000	0.704	0.000	0.000	0.296	0.000
Blackgram	0.000	0.028	0.021	0.698	0.227	0.017	0.009
Bengalgram	0.382	0.241	0.000	0.000	0.376	0.000	0.000
Greengram	0.000	0.000	0.000	1.000	0.000	0.000	0.000
Groundnut	0.859	0.000	0.000	0.000	0.000	0.000	0.141

26.4 per cent of its area by losing 45.4 per cent to paddy, 24.7 per cent to cotton, 3.3 per cent to redgram and 0.2 per cent to groundnut.

Sesamum being an oilseed crop, gained 23.7 per cent from another oilseed crop i.e, groundnut. Meanwhile, it lost 56.6 per cent to greengram by retaining 43.4 per cent. Only 1.1 per cent of groundnut area was retained and lost 54.3 per cent to blackgram, 21 per cent to paddy and 23.7 per cent to sesamum. It gained only minor shares from chillies (1.3 per cent), paddy (0.5 per cent), cotton (0.3 per cent) and greengram (0.2 per cent). As we see in all the districts separately, chillies had very low retention probability, same case with zonal level also. Chillies retained 8.6 per cent and lost 68.3 per cent to cotton, 21.8 per cent to redgram and 1.3 per cent to groundnut.

It is clear from Table 8 that jowar has a high retention probability (70.4 per cent) among the selected crops. It lost 29.6 per cent to only one crop i.e, groundnut. It gained minor shares from maize (2.5per cent) and blackgram (2.1per cent). Next to jowar, blackgram has more retention i.e, 69.8 per cent and it lost 22.7 per cent to bengalgram, 2.8 per cent to maize, 2.1 per cent to jowar, 1.7 per cent to greengram and 0.9 per cent to groundnut.

Paddy had retained to an extent of 69.1 per cent of its previous acreage. It lost 30.6 per

cent to blackgram and 0.3 per cent to groundnut. 65.6 per cent of its area was retained by maize and lost 19.3 per cent to bengalgram, 12.6 per cent to greengram and 2.5 per cent to jowar. But it gained 24.1 per cent from bengalgram and 2.8 per cent from blackgram.

Bengalgram with 37.6per cent of retention capacity gained shares from blackgram (22.7per cent) and maize (19.3per cent), but 38.2 per cent of its area was lost to paddy and 24.1 per cent to maize. Only 14.1 per cent of the area was retained by groundnut and lost 85.9 per cent to paddy. Greengram was highly unstable and it lost 100 percent to blackgram. This loss was compensated by gaining from jowar (29.6per cent), maize (12.6per cent) and blackgram (1.7 per cent).

CONCLUSION

Paddy retained more than 50 per cent of its area in both *kharif* and *rabi* seasons in all the 3 districts, except in Guntur during *rabi* season. In Krishna district during *kharif* season, paddy and cotton are more stable, whereas chilli was most unstable crop where it lost mainly to paddy and cotton. Coming to *rabi* season in Krishna district, almost all crops shower retention capacity except greengram. Blackgram has more retention in *rabi* season (88.4 per cent) than in *kharif* season (6.9 per cent) in Krishna district.

Greengram lost a major area to paddy in Guntur in *kharif* season whereas in *rabi* season it lost to other pulses. In Guntur district, greengram could not able to retain its area in *kharif* season but in *rabi* season, it retained 32.5 per cent of its previous acreage. Maize and jowar are the most stable crops in Guntur district during *rabi* season. Cotton is the most stable crop in Prakasham district during *kharif* season. Most of the area of chillies and groundnut was grabbed by redgram in Prakasham district. Paddy and bengalgram showed more than 80 per cent of stability in Prakasham district during *rabi* season. Almost similar findings were observed at the zonal level also. Redgram was more stable in Guntur and Prakasham districts than in Krishna district. Maize retained 76.4 per cent in Krishna district and 80.5 per cent in Guntur district whereas in Prakasham district it retained only 27.7 per cent of its previous acreage. Coming to zonal level it retained 65.6 per cent of its previous acreage. The shift from one crop to various crops is a sign of crop diversification. Hence, there is huge scope for decision-making in the selection of crops to put agriculture on the pedestal of sustainable growth which needs to be considered in research and extension programs.

POLICY IMPLICATIONS

- ✖ Paddy consumes about 2500 litres of water per kg of grain produced. It is imperative to the farming community not to take up paddy cultivation in the *rabi* season. In the present scenario of having more than required rice stocks for consumption, the cultivation of paddy may be curtailed in less water available ecosystems in Krishna zone. The possibilities of increasing the area in *rabi* season for pulses and vegetables should be explored.
- ✖ The major source of irrigation in Krishna zone is the canal networks of Krishna western delta and Nagarjuna Sagar right canal. Sometimes, late release of canal water results in the late *kharif* season. Receiving of irrigation water by the tail end area farmers is a considerable problem. Hence Irrigated Dry (ID) crops like maize, jowar, pulses etc., may be promoted in tail-end regions of canals.
- ✖ Greengram was unstable during the study period; hence price support mechanism can make farmers to boost up its cultivation.
- ✖ Promote intensive cultivation of chilli, cotton, redgram using micro-irrigation techniques to minimize water consumption, increase the yield and quality of the produce.
- ✖ Though chilli is a major commercial crop in Krishna zone, its retention of area was found less. Under the One District One Product (ODOP) initiative, Guntur district of Andhra Pradesh has declared chilli as its signature product. The below said initiatives need to be encouraged with the involvement of Farmer Producer Organization (FPO) especially the marketing side i.e.,
- ✖ Encouraging value-added products like chilli powder, sauce, pickles etc.,
- ✖ Production of organic chilli
- ✖ Contract agreements with timely supply of products may promote commercial cultivation through shade nets, poly houses, greenhouses etc.,
- ✖ Growing some specific varieties for a specific purposes like Byadgi variety for natural colouring agent; chilli black pearl, medusa varieties as ornamental chilli etc.,

- ✖ Growing exportable cultivars on consumer choice of the destination countries.
- ✖ Disease / pest-resistant varieties can retain the crop area as being evident from blackgram due to the development of Yellow Mosaic Virus (YMV) resistant varieties in the zone. Hence suitable cultivars resistant to existing devastative pests/diseases should be developed to promote commercial crops like cotton, turmeric and chillies.
- ✖ Organic cotton cultivation may be promoted because of its increasing demand coupled with the consistent price rise in the world market.
- ✖ There is an increasing demand throughout the world for organic foods. Hence efforts are required to promote organic crop production, majorly through contract farming, which will enable favourable changes by converting the inorganic input-intensive agriculture to sustainable and commercial agriculture.
- ✖ Recent mechanization initiatives in cotton and chilli cultivation like Automated Cotton Picking Robot (ACPR) using image processing, aerial application through agricultural drones etc., may be promoted through FPO to enable collective utilization of these expensive technologies.

REFERENCES

- Aravind Kammar and Basavaraja, H. 2012. Structural Changes in Cropping Pattern in Northern Transitional Zone of Karnataka. *International Research Journal of Agricultural Economics and Statistics*, 3(2): 197-201.
- Ardesbna, N.J. and Shiyani, R.L. 2013. Dynamics of Cropping Pattern in Gujarat State: A Markov Chain Approach. *Asian Academic Research Journal of Social Sciences & Humanities*, 1(9) - 56-66.
- Socio-economic survey, 2020-21 www.apsdps.ap.gov.in, Government of Andhra Pradesh.
- Dayakar Rao and Shahid Parwez, 2005. Dynamics of Cropping Pattern in Sorghum growing States of India. *Indian Journal of Agricultural Economics*, 60(4): 644-659.
- Geetha Mohan, 2017. Determinants of Cropping Pattern Changes in Andhra Pradesh, India. *Asian Journal of Agricultural Extension, Economics & Sociology*, 20(3): 1-15.
- Lee, J.C., Judge, G.G. and Takagama, T. 1965. On Estimating the Transitional Probabilities of Markov Process. *Journal of Farm Economics*, 47 (3): 742-762.
- Madhuri, K. Manwar and Nagpure, S.C. 2017. Structural Changes in Cropping Pattern, *International Journal of Science, Environment and Technology*, 6(5): 2885 – 2892.
- Ragamalika, V., Rajeswari, S., Aparna, B. and Ravindra Reddy, B. 2021. Crop Shifts in Rayalaseema Region of Andhra Pradesh: A Markov Chain Approach. *Andhra Pradesh Journal of Agricultural Sciences*: 1-9.
- Rajini Devi, D.A., Uma Reddy, R., Madavi, B., Ravi, P. and Sadvi, P. 2019. Dynamics of Cropping Pattern in Karimnagar District of Telangana – A Markov Chain Approach. *Asian Journal of Agricultural Extension, Economics & Sociology*, 37(4): 1-5.
- Ramana, M.R.V. and Rekha, M. 2012. Pricing of paddy: A case study of Andhra Pradesh.

- Department of Economic and Policy Research, Reserve Bank of India, study no. 38: 11-52.
- Ramya Lakshmi, S.B. and Bhavani Devi, I. 2012. Crop Shifts in Coastal Region of Andhra Pradesh: A Markov Chain Approach. *Agricultural Situation in India*, 69(7): 363-368.
- Reddy, D.R. and Achoth, L. 2000. Dynamics of the Cropping Pattern Changes in Kerala: A Markov Chain Approach. *Mysore Journal of Agricultural Sciences*, 34: 376-381.
- Siva Jyothi, V., Prasuna Rani, P., Ramana, K.V., Ratna Prasad, P. and Sree Rekha, M. 2020. Cropping pattern changes: A case study in Krishna delta region of Andhra Pradesh. *International Journal of Chemical Studies*, 8 (1): 494-500.
- Suhasini, P., Kiresur, V.R., Rao, G.D.N. and Bantilan, M.C.S. 2009. Adoption of chickpea cultivars in Andhra Pradesh: Pattern, trends and constraints. Baseline research report for Tropical Legumes-II, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); 1-69.
- Srivastavaa, S.K., Sivaramane, N. and Mathura, V.C. 2010. Diagnosis of Pulses performance of India. *Agricultural Economics Research Review*, 23: 137-148.
- Vinayak Jalikatti and Poddar, R.S. 2019. An Economic Analysis of Changing Cropping Pattern in Almatti Command Area of Karnataka, India. *International Journal of Current Microbiology and Applied Sciences*, 8(10): 1052-1059.
- Wali, V.S., Poddar, R., Mundinamani, S.M. and Yenagi, B.S. 2019. An Analysis of Cropping Pattern in Malaprabha Project Command Area. *International Journal of Agriculture Sciences*, 11(2): 7739-7742.

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