

Volume 29
Number 1
June 2023

ISSN 0972 - 6977

RNI No. UP - ENG/2001/6732

Journal of Farming Systems Research & Development



Farming Systems Research and Development Association
Modipuram, Meerut - 250 110

Farming Systems Research and Development Association Modipuram, Meerut (Regd. No. 2666)

Patron : Dr. Suresh Kumar Chaudhari, DDG (NRM), ICAR, New Delhi-12

Executive Council (2022-2023)

President : Dr. A. S. Panwar, Director, ICAR-IIFSR, Modipuram

Vice Presidents

Zone A : Dr. Vivek Dhama, Professor (Agronomy), CoA, SVPUA & T, Meerut

Zone B : Dr. Shanti Kumar Sharma, Director Research, MPUA & T, Udaipur

Zone C : Dr. G. Ravindra Chary, Project Coordinator, ICAR-CRIDA, Hyderabad

Zone D : Dr. Shivani, Principal Scientist (Agronomy)
ICAR - Research Complex for Eastern Region, Patna

Secretary : Dr. R. P. Mishra, Acting Head, Division of OAS, ICAR-IIFSR, Modipuram

Joint Secretary: : Dr. M. Shamim, Senior Scientist, ICAR-IIFSR, Modipuram

Treasurer : Dr. N. Subash, Principal Scientist, ICAR-IIFSR, Modipuram

Editorial Board

Chief Editor : Dr. M. Shamim, Senior Scientist, ICAR-IIFSR, Modipuram

Editors : Dr. N. Ravisankar, Acting Project Coordinator, PC Unit, ICAR-IIFSR, Modipuram
Dr. R. P. Mishra, Acting Head, Division of OAS, ICAR-IIFSR, Modipuram
Dr. Nirmal, Scientist, ICAR - IIFSR, Modipuram

Membership Fee

Individual Membership	Scientist/Researcher /Faculty Members (Rs.)	Students (Rs.)	Institutional (Rs.)	Foreign (US \$)
Annual (including admission fee)	1100/-	700/-	1600/-	50
Lifetime (including admission fee)	5100/-	3100/-	—	210

The "Journal of Farming Systems Research and Development" is published bi-annually in June & December by the Farming Systems Research and Development Association (FSRDA), Modipuram, Meerut-250 110 (UP)

All correspondence may be addressed to:

The Secretary

FSRDA, C/o ICAR - IIFSR, Modipuram, Meerut-250 110, U.P.

Journal of Farming Systems Research and Development

Volume 29	June 2023	Number 1
-----------	-----------	----------

CONTENTS

		Page
Livelihood Sustainability through Landscape Planning for Rainfed Farming System	<i>Adikant Pradhan, S.K. Nag, T. Chandrakar and G.C. Ravindra Chary</i>	1-13
Studies on Efficacy of Entomopathogenic Fungus <i>Metarhizium Anisopliae (Metsch) Against Termite Odontotermes Obesus (L.)</i> Under Contoled Condition	<i>Kalvindar Pal, Ajay Kumar, Shailendra Sharma, Rajendra Singh, Prahlad Yadav Pankaj Kumar and S.P.Singh</i>	14-21
Growth, Yield and Quality of Kharif Onion (<i>Allium Cepa L.</i>) Varieties under Different Planting Geometry	<i>B.L. Sharma, S.S. Kushwah and P.P. Singh</i>	22-29
Evaluation of Boron Doses on different Varieties of Pea (<i>Pisum Sativum L.</i>) with Respect to Growth, Nodulation, Yield, Quality and Nutrients Status in Plant and Soil	<i>Mukesh Kumar Nagar, S.S. Kushwah, R.K. Sharma, R. Gallani and P.P.Singh</i>	30-38
Evaluation of physico-chemical properties of Cucumber Chips Fried in differentiatedible oils	<i>Awadhesh Kumar Yadav, Suresh Chandra, B.R. Singh, Jaivir Singh, Neelash Chauhan, Deepak K. Mishra, Tarun Kumar and S.P. Singh</i>	39-48
Socio-Economic Dynamics in Rural Meghalaya: A Comparative Study of Selected Villages of East Khasi Hills and West Jaintia Hills districts	<i>Andreana Tariang, Lasara Chynnamsuting, Manish Kumar, Prabhakar Manori, Sandhya Goswami and Vikaspal Singh</i>	49-54
Plants used in Traditional Medicine by Rai Community of East Sikkim, India	<i>Nisha Rai, Sandhya Goswami, Sas Biswas, Manish Kumar and Vikaspal Singh</i>	55-60
Impact of Intensive Cultivation on Physico-Chemical Properties of Soil of Bulandshahr	<i>Siddhant Tomar, Satendra Kumar, B.P. Dhyani, Yogesh Kumar, P.K. Singh And Lalit Kumar</i>	61-69
Identification of Suitable Mustard Varieties for Organic Production System	<i>D. Kumar, L. R. Meena, S. Malik And Anuj Kumar</i>	70-76
Studies of Direct and Indirect Effects of Yield and Yield Attributing Characters in Urdbean (<i>Vigna Mungo (L.) Hepper</i>)	<i>H. Vanlalhmuliana, C. Rachael, Lalthasangi and Meenakshi Malik</i>	77-86
Studies on Intercropping of Cash Crops in Populus Deltoides Plantation	<i>Afreen Mohsin</i>	87-92
An Assessment of Wild Edible Plants Diversity in Tehri District, Uttarakhand	<i>Pantisingliu Ruangmei, Vikaspal Singh, Anil Kumar Uniyal, Sandhya Goswami and Manish Kumar</i>	93-97
Population Dynamics of Mango Fruit Fly (<i>Bactrocera Dorsalis</i>) Trapped through Methyl Eugenol Traps in Western Uttar Pradesh	<i>Rajendra Singh, D. Raghvendra, P.N. Meena, Subhash Chander, Navneet Kumar, and S.P. Singh</i>	98-101

LIVELIHOOD SUSTAINABILITY THROUGH LANDSCAPE PLANNING FOR RAINFED FARMING SYSTEM

ADIKANT PRADHAN^{1*}, S.K. NAG², T. CHANDRAKAR³ AND G.C. RAVINDRA CHARY⁴

^{1*}*Natural Resource Management, S.G. CARS, IGKV, Jagdalpur, India*

²*Agricultural Economics, KVK, Jagdalpur, India*

³*Soil Science, S.G. CARS, IGKV, Jagdalpur, India*

⁴*Director, ICAR-CRIDA, Hyderabad, India*

Corresponding author's email: adi19agro@gmail.com

ABSTRACT

The research was conducted in selected cluster villages (*Tahkapal, Tandpal, Gumiyapal, Bademarenga, Gudramarenga and Telimarenga*) of Bastar region, Central India. The region is one of the higher prone to rainfed area due to topographical undulating surface. For effective study of rainfall change which might be assessed to know the variation in quantity and frequency of rainfall directly to rainfed farming. The villages and farmers were randomly sampled. The most important issue were lack of technical knowledge (98.24%) followed by upland utilization (97.06%), drought or moisture stress (96.48%) and marketing (96.42%), respectively in the particular villages. Fifth row opening across slope with country plough at 25 DAS in dry seeding attained higher grain yield (3894.2 kg/ha), net returns (Rs. per ha), B:C (2.18) and WUE (3.00). The rice based double cropping system under *gabhar* situation with conventional tillage (2 pass of country plough and sowing of seed) for field pea recorded higher yield (1823 kg/ha), net returns (Rs. 63812/ha), B:C ratio (3.48) and RWUE (3.41). Whereas, manual removal of weeds at 25 DAS found to be effective in reducing weeds with significant grain yield (5390.58 kg/ha) consuming energy 314.09 MJ/ha. Sowing of ragi in between fruit plantation was recorded higher yield of 1912.03 kg/ha, 8088.54 Rs/ha net return, B:C ratio (1.62) alongwith 2.59 rain water use efficiency.

Key words: Diversified farm, climate change, rain water use, doubles cropping

Surveyor General of India reported the geographical area of the district is 10469.50 sq km which is 7.74 % of the total area of the Chhattisgarh state in India. The total population of Bastar district is 14,13,199 with 6,98,487 males and 7,14,712 females. Rural population is 12,19,705 whereas urban population is only 1,93,494. The district has registered growth rate of 18.0% in the state during the decade 2001-2011. The proportion

of Scheduled Tribes population in the district is 65.93% in Census 2011, against 65.42% in Census 2001. There has been an increase of 0.51 percentage point in the proportion of ST population during the decade 2001- 2011. The maximum area covered by rural population and their main occupation is agriculture which is now almost in edge of gambling of rainfall under rainfed agriculture alongwith consequences of migration and distraction

from agriculture are main burning issue in the region. The rainfed agro-ecologies constitute 55 percent of the net sown area, 100 percent of the forest and 66 percent of the livestock which provide livelihood, income, employment and environmental security. Half of the total area of the district is mountainous and rocky. The district has 10,10,288 hectares of agricultural land out of which 2,38,800 hectares is covered with forests. Non-agricultural land is 73,153 hectares; wasteland and unproductive land 40,766 hectares, agricultural land 52,189 hectares and fallow land 28,820 hectares. Looking to scenario of district agriculturally important land resources have been planned to execute the research project.

Bastar district has seven blocks (*Bakwand, Bastar, Tokapal, Darbha, Bastanar, Jagdampur* and *Lohandiguda*) extending between 81°27'03 N to 82°7'58 N latitudes and 18°40'25 E to 19°38'45 E longitudes and encompasses an area of 10470.00 km². The district comprises of 606 villages in the seven blocks. Habitats of villages on hamlet and sloping down areas is designated *viz.*, Uplands (*Baadi, Marhan, Tikra*), midlands (*Mall*), lowlands (*Gabhar*) and extreme lowlands (*Bahar*) farming situation from hamlet top to *Bahar*. The village land resource is divided into upland, midland and lowland as relief is varied throughout farming system, top hamlet provides habitat attached with *Baadi* which is higher organic matter than rest of farming situations (Pradhan *et al.* 2019).

The study area receives about 1404.80mm rainfall annually, the amount of water receives through rainfall and lose as runoff is important in sustainability for crop fitting ideology, resource conservation and planning. The annual maximum, minimum and average temperature of the study area was at 42°C, 18°C and 28°C, respectively (Sharma and Chaudhary, 2014). Often rain starts from 1st

fortnight of June and 1 to 2 week break of monsoon is common in the region which affects largely during vegetative phase of the kharif crops. Pradhan *et al* (2018) explained that the thermal requirement was fulfilled with timing of crop sowing on various farm of landscapes in the region. Heavy down pour is always happened in July to September, this period having high intensity of rain that influences to newly established crops.

Diversified form of farming on different pieces (upland/midland/lowland) of lands having with farming community in the region demands vulnerable rainfed technologies to combat the projected issues. The forms of land have various degree of capacity provides crop cultivation under water conservation by measures to land capacity classes on existing landforms. Soil depth, moisture retention capacity, inherent capacity of soils and management of crop were to restore the soil health in prime aims. Some of the landforms are typical in the farm setting, like high moisture retained in lowland and upland holds moisture only with rainfalls, as rainfall dwindled, the soil moisture gets dried. Another side, midland behaves intermediate due to lying in between upland and midland under our observations (Sharma *et al.* 2015).

Farming community belonged to the landless, small and marginal category had their own problems which required various degrees of potential resources. Income from farming was meager with the available holders. They compensated the demand from outside income during off-season. Medium category farmers compelled to do mono-cropping or 20-30% lands are used for double cropping. Double cropping could gain momentum with availability of assured or supplemental irrigation depending from available water resources in villages was revamped to use for changing behavior of localites on farm ponds/community ponds.

Baadi based cultivation were continued with irrigating from open dugwells and seasonal streams that supports to open dug wells till January to pumping through government provided subsidize electricity for agriculture, but meanwhile source of water resources needed to increase to utilize the sources. Maize cultivation is being adopted widely because of hike and regular market price, now in bloom owing to demand of poultry feed which requires huge quantity that promotes the cultivation of maize by replacing maximum upland crops and large area of uplands were being converted. This cultivation suppressed the diversity of uplands, not only covering more but also increased water use 3-4 times greater than single rainfed crop with assured irrigation.

The consequences were paramount important in depletion of stream water, bore well and other water sources. The management prospect of land resources became wider due to huge gap in mining and applying nutrients in the soil after maize, there was hardly any crop grown on same piece of lands, the alternated incidence of recurrent small drought and flood had devastating consequences (Bekele *et al.*, 2010). The effect is aggravated by degradation of landscapes and limited capacity of agriculturists to respond to the se extreme events (Erkossa *et al.*, 2013). These extreme weather events, which are expected to get worse due to climate change and variability (Gummadi *et al.*, 2017), while many more are dropping out or exiting into low-return economic activities (Catley *et al.*, 2016; Lind *et*

al., 2016). Problems associated with farming and farming community are surfaced after rigorous survey and observation, mean time personal interview with farming community, which has been further, aligned point wise.

MATERIALS AND METHODS

The research was conducted in selected cluster village: a) Tahkapal cluster (Tahkapal, Tandpal and Gumiyapal) and b) Bademarenga (Bademarenga, Gudramarenga and Telimarenga) of Bastar region, Central India. The Region is one of the higher prone to rainfed area due to topographical undulating surface taken under study. Procedure for selection of villages and farmers, random sampling survey method was adopted. The selected villages were represented real rainfed situations.

Tahkapal and Bademarenga clusters were surveyed and classified the problems of farming, land resources, water resources, climate and socio-economical issues, which were further divided into various categories under acute, moderate and less for cluster villages. Acute problems were prime focus to consider under technical intervention after discussion with farmers *i.e.* weed, moisture and erosion in land resource, runoff and storage in water resources, food and income generations under present situation separately. Later problems falls under moderate level that issues were dealt with intervention. Prepared a list of all farm households in all the selected villages category-wise marginal (up to 1 ha), small (1-2 ha), medium (2-4 ha)] and larger (>4 ha).

Table 1: Status of selected villages at inception of works

S. No.	Particulars	At beginning (ha)		Change (%)	
		Tahkapal	Bade Marenga	Tahkapal	Bade Marenga
1	Total Geographical Area (ha)	349.98	470.97	-	-
2	Net Cropped Area (ha)	185.99	356.99	295.25	415.78
3	Double Cropped Area (ha)	4.3	25.31	124.03	123.75
4	Waste Land (ha)	49.89	23.15	23.21	15.32
5	Fellow Land (ha)	7.77	8.12	4.21	4.74
6	Cropping Intensity (%)	130	152	152.23	175.24
7	Irrigated	12.7	24.51	21.35	34.25
8	Water Bodies	13	7	18	21
9	Well	13	11	21	19

Both clusters were situated in different farming zones of the region but facing similar kind of problems were exhibited in the villages as prevailing in the district. The situation of the cluster was 19°07'02.62N and 81°51'47.88E along with 601 m in Tahkapal, whereas Bademarenga is between 19°12'33.39N, 81°51'15.41E with elevation of 603m.

Table 2: cropping system of study villages

Cropping system	Tahkapal	Bademarenga
Rice- ChickPea	✓	✓
Rice-Maize	✓	×
Maize-Fallow	✓	✓
Small millets-Fallow	✓	×
Horse gram-Fallow	✓	✓
Niger-Fallow	✓	✓
Vegetables- Fallow (Baadi situation)	✓	✓

Table 3: Degree of associated problems in villages

Problem	Tahkapal			Tandpal		
	Acute	Moderate	Less	Acute	Moderate	Less
Farming						
Choice of crop			✓			✓
Varietal intervention		✓			✓	
Weed	✓			✓		
Nutrient management		✓			✓	
Tillage		✓			✓	
Land resource						
Land degradation		✓			✓	
Moisture	✓			✓		
Erosion	✓			✓		
Water resource						
Runoff	✓			✓		
Storage	✓			✓		
Utilization		✓			✓	
Climate						
Flood	✓			✓		
Drought		✓			✓	
Social-economical						
Consumption pattern			✓			✓
Food security						
Income generation	✓			✓		

Ranking of problems

At the time of entry in villages of Tahkapal cluster ranked problematic issues, the most important issue was lack of technical knowledge (98.24%) followed by upland utilization (97.06%), drought or moisture stress (96.48%) and marketing (96.42%), respectively in rainfed farming sequences of the particular villages. Similarly Bademarenga had taken in same process for ranking of problems and found first in land reforms (90.75%) then lack of agricultural implements (90.12%), marketing (85.86%) prior improving interventions which have been brought down 50% regardless problems. In Tahkapal cluster, highest reduction of issue in check dam was noticed meant 12.05% problems remained which was 84.72% in rank occupied prime position because they wanted 4 check dam and 3 were constructed. The prominent problem faced by farmers was lack of knowledge having remarkably 81.10% due

to continuous training and HRD activities. Another village- Bademarenga had acute problems of landforms natural depression from both side carried more runoff and highly hampered agricultural activities which was solved by intervening graded and scaled technologies and it brought down the 23.50% from earlier 90.75%. Hence, again lacks of knowledge on technologies kept behind in production with sustainability were undertaken in technical programme leading to higher prospective for adopting technologies. Market was not big issue in this cluster because highway is passed nearby town so ranked behind. The production system of tribal are not huge in quantity, mostly they grows in backyard by self consumption, after intervention increased in production from self consumption to market selling for uplifting livelihood of tribal farmers.

Table 4 Ranking of problems in the selected villages

S.No.	Problem	BI		AI		BI		AI	
		Tahkapal	Rank	Tahkapal	Rank	Bademarenga	Rank	Bademarenga	Rank
1	Improved Seed & fertilizer	88.25	VI	45.25	IX	75.25	VII	27.53	VII
2	FYM/ Composting	86.49	VII	25.26	III	78.25	VI	28.62	VI
3	Lack of Agricultural implements	78.85	X	28.56	IV	90.12	II	32.97	II
4	Land Reforms	89.42	V	35.62	VI	90.75	I	33.20	I
5	Check dam	84.72	VIII	12.05	I	75.24	VIII	27.52	VIII
6	Drought	96.48	III	41.25	VIII	74.85	IX	27.38	IX
7	Marketing	96.42	IV	53.26	X	85.96	III	31.44	III
8	Lack of technical knowledge	98.24	I	18.56	II	72.25	X	26.43	X
9	Upland utilization	97.06	II	32.15	V	79.25	IV	28.99	V
10	Employment	82.37	IX	35.64	VII	79.54	V	29.10	IV
11	More cost of cultivation	52.14	XI	56.21	XI	64.25	XI	23.50	XI

Socio-economic survey data collection

We have conducted district and village level informal baseline surveys and key

informant discussions in November, 2017-19 in Tahkapal and January 2017-19 Bademarenga, in Bastar districts. The team of

researchers comprised of various disciplines (agronomist, Soil Science, socio-economists and farm machinery expert) visited the sites thoroughly and made direct observations on the target villages, it has collected the baseline data through semi-structured interview, focus group discussions along with key informants. A valid, semi-structured questionnaire was developed to collect base-line and objective oriented data by face to face interview of about 65 house holds in Tahkapaland 56 in Bademarenga villages. Every village was treated as unit for focus group discussions involving 20-20 participants and also held in the presence of the *Sarpanch* (village head) and age old experience persons in order to cross check and complement the information collected through individual interview. The community challenges was identified by group discussion in terms of natural resources availability, drought, flood, food security, conflicts etc. We also organized survey in mid way of the project implementation in February, 2018 in both locations to assess the outcomes and impacts. Besides the communities, we also collected relevant data from government departments and Rural Agriculture Extension officers (ADO) simultaneously

RESULTS AND DISCUSSION

Rainwater Management (In situ moisture conservation)

The onset of rain is first fortnight of June every year but after that dry spell consort in coming month with wide variability of rain during cropping season, this condition commonly encounters scarcity of moisture which affects seriously to growing crop and turn the situation worse to achieve yield from the farming. Farmers having small holdings they start moving out from village for earning. That is why early situation is so hard under rainfed farming and very a smaller number of options is avail with farmers which can

mitigate the situation for betterment through in-situ moisture conservation (Murali *et al.* 2012). Runoff water flows tremendous in July and August and moisture stress prevails in coming 15 days when rainfall suddenly breaks and affects to the crop growth creating moisture stress because sudden termination of rain does not support much by unsaturated soil profile due to fast depletion of soil moisture. Under such situation, harvested rain water was collected (Pradhan *et al.*, 2018) in peak period of rain in storage structure which was further used in recycling for supplemental irrigation to eliminate moisture stress and meanwhile quickly recover. Rainwater management is an integrated strategy that enables drought-prone agricultural systems to systematically capture, store, efficiently use of rain water and nutrient resources on farms and watersheds in a sustainable way for agricultural and domestic purposes. Managing runoff at landscape scale accounts accompanied benefit of regulating soil erosion enhancing ecosystem services (Vanmaercke *et al.*, 2010).

The higher grain yield was noted with 5th row opening across slope with country plough at 25 DAS under dry seeding attaining higher grain yield (3894.2 kg/ha), net returns (Rs. per ha), B:C (2.18) and WUE (3.00) followed by seeding *Dhaincha* with rice in same row by seed drill and spraying of 2,4-D at 25 DAS in case of grain yield, net returns, B:C and RWUE were 3823.10 kg/ha, Rs. 41163.12, 2.54 and 2.95, respectively. on *in-situ* moisture conservation in *Maal* conditions, highest rice grain yield (2035 kg/ha) was recorded with seeding *Dhaincha* with rice in same row by seed drill and spraying of 2,4-D at 25 DAS followed by than *Biasi* (beushening) (1902 kg/ha) using country plough at 25 DAS under dry seeding. Similarly, net returns (Rs.13424/ha) and RWUE (2.69 kg/ha-mm)

were higher in the same treatment (Table 6) (Thakur *et al.*, 2014).

The catchment-storage-command relationship for enhancing water productivity in last 10 years, the treatment comprised of tomato growing with two irrigation gave higher fruit yield (3768.66 kg/ha) along with higher net return, B:C and rain water use efficiency of Rs. 68475.72/ha, 3.79 and 2.81 kg/ha-mm (Table 6) as compared to chick pea and field pea under ex-situ rainwater management from 30x20x1.5m dimension ponds

Double cropping/relay cropping

The rice based double cropping system under *gabhar* situation was experimented with conventional tillage (2 pass of country plough and sowing of seed) for field pea recorded higher seed yield (1823 kg/ha), net returns (Rs. 63812/ha), B:C ratio (3.48) and RWUE (3.41) followed by relay cropping of field pea (*Utera*) (1234 kg/ha) compared to other treatments (Table 6). Conventional tillage (2 pass of country plough and sowing of seed) for field pea was recorded higher value of grain yield (1823.20 kg/ha), net return (Rs. 63812.0/ha), B:C (3.48) and RWUE (3.41) followed by relay cropping of field pea (*Utera*) due to sufficient moisture remained after rainfed rice crop.

Energy management

Manual removal of weeds at 25 DAS was found to be efficient method in reducing weeds and attaining yield of 5390.58 kg/ha with high investment cost of Rs. 3251.30, energy used 314.09 MJ/ha whereas net returns of Rs. 48407.40, B:C ratio, 2.09 and 4.66% rain water use efficiency was recorded under same treatment which was comparable with running country in between rows of rice at 25 DAS. Removal of weeds at 25 DAS gave more congenial condition for reducing competition

than other methods of weed management led higher grain yield and comparable with running of country in between rows of rice at 25 DAS. Rain water use efficiency (5.46 kg/ha-mm) and energy use efficiency (22.58%) were also recorded higher under manual removal (Pradhan *et al.*, 2014).

Alternate Land Use System

For better utilization of sloppy land intercropping of annuals was undertaken in fruit plantation to enhance farmers' income by growing different rainfed crops in between row space of mango fruit crop. Sowing of ragi in between fruit plantation was recorded as efficient crop in earning more income than rest of crops due to less input in cultivation and higher sustainability with 1912.03 kg/ha grain yield, 8088.54 Rs/ha net return, higher B:C ratio (1.62) and 2.59 rain water use efficiency followed by multi cut sorghum in between fruit plantation under upland (Table 6 and 7).

The uplands are allocated mostly for vegetables, cereals (Maize and Sorghum), *Hibiscus sabdariffa*, beans etc., as moves down to low lying areas from habitat first encounters uplands which is divided into unbunded and banded uplands mostly prefers for upland rice (90-100 days), small millets (finger millet, kodo millet and little millet), horsegram and urd with occupying significant areas of the uplands. Midlands are intermediate of upland and lowland characterized by compartmental bunding for rain water impounding (Pradhan *et al.* 2014) which increases infiltration and supports rice crop during short dry spells, this method is also preferred for rice cultivation in low lying area demarcated by variable rate in midland and lowland. Generally lowlands is situated in end of farming sequence, but sometime under extreme lowlands are promoted for stream flow creating natural drain lines as *Bahara* situation or *Jhodi*, and moisture lasting till

January in this farming situation, this *Gabhar* is only used for early (10-15th April) seeding of rice in *Kharif* season.

Table 5: Significant treatment effects on yield, net returns, B:C and WUE

Intervention	Grain yield (kg/ha)	net returns (ha)	B:C	WUE (kg/ha-mm)
T1: 5th row opening across slope	3894.2	40065.2	2.18	3.00
T2: Seeding Dhaincha with rice in same row by seed drill and spraying of 2,4-D at 25 DAS	2035.0	13424.0	2.01	2.69
T3: Catchment-storage-command relationship	3768.6	68475.7	3.79	2.81
T4: Rice based inter-cropping of field pea	1823.2	63812.0	3.48	3.41
T5: Running country in between rows of rice at 25 DAS	5390.6	48407.4	2.09	4.66
T6: Sowing of ragi in between fruit plantation (ALU)	1912.1	8088.54	1.62	2.59

Table 6: Level of significance for treatments

Significance level	Parameter					
	T1	T2	T3	T4	T5	T6
P=0.05 & 0.01	**	**	*	**	*	NS

S significant, *NS* non significant, * $p < 0.01$, ** $p < 0.05$

Various scholars pointed out that changes in land use with different management could increase to negative consequences affecting the local populations, landscape functionality and ecosystem services (Statuto *et al.*, 2016). With change towards positive outcomes on landscape, many issues should be accounted into consideration (German *et al.*, 2007) as demarcated (a) planning is executed (b) either on the multiple issues (drought and flood management) or specific issues moving around farm productivity, same time decision

making to address social trade-off. Our findings showed that there is a high chance to restore the productivity on degraded landscapes, including the diversified systems, through participatory planning, feasible management with responsive partnerships. Feasible management need sustained support to test and refine feasible strategies understanding complex systems and extract management opportunities using near term climate mitigation (Hardegree *et al.*, 2017). These principles are widely used in management partnerships to explore solutions for natural resource management (Bradford *et al.*, 2018). However, change requires intensive engagement in diversified systems and to tryout new farming methods and practices at the outset. Initially, there was a strong resistance by villagers with the fear that the introduction of the structures would bring about unintended consequences, including local conflicts due to dependency on available resources. This local resistance softened, once they were witnessed of high potential and positive change on landscape particularly the amount of feed and fodder generated at farm and landscape levels accelerated the population. The high yielding varieties tested to minimize climate risk served as an entry point to motivate large number of community on new interventions. Early success at the farm level helped to move the discussion on complex factors particularly through the support of trusted inter-relationship of institute and villagers.

In the flow diagram, policy of government support to the farmers in various ways (mechanization support, minikits, crop insurance and bonus on production) led to holistic development bridging the gap technologies and institutional support. The technological support involves Baadi based technology, rice production technology, cropping system improvement and similarly

institutional support covers the capacity building, community approaches with development of leadership changing behavior of the farmers (Fig 1). These all supports boosted to farming community as a whole in generation of income, maintaining production pace, due to high earning farmers easily bears the risk alongwith confidence and finally it leads to sustainable agriculture at village unit (van Steenberg *et al.* 2011).

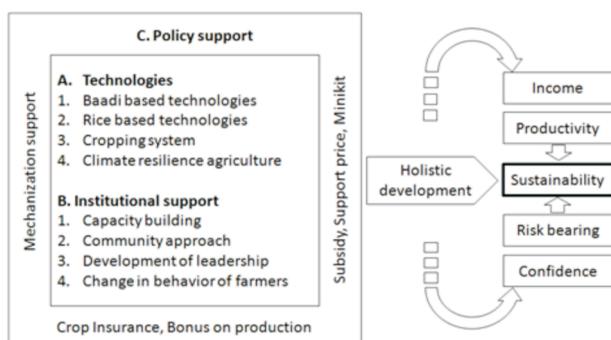


Figure 1 Flow chart of project management

Participatory Seed Production

The participatory seed production with farmers' choice is a paramount important in making the system effective for providing seed chain at farm level. The system of seed production was conceptualized among farmers who hold KCC (*Kisaan Credit Card*) of the cluster village through subsidized rate and simultaneously NABARD also helped by

giving grant in support to the farmers for the necessary inputs with technological support and guidance of AICRPDA (All India Coordinated Research Project on Dryland Agriculture), Jagdalpur for crop production under climate aberrations which has been obtained after long term trials and experiences has been shared in whole planning at village level to develop a well prove seed bank (Pradhan *et al.* 2015) at field level which could be a great effort in managing production strategies to escape adverse weather events like breaks in monsoon, no rain after sowing, dry spells etc. during crops growth period in seed production success. The quick change in landscape involved new actors in system. The land holder who had large area but could not covered under cultivation converted their landscapes in high productive system and preferred the best management practices. German *et al.* (2017) also found that those pushing for individualized landholdings were found to be those spending considerable time outside their communities due to earning could be brought under the practices. These experiences had inculcated in their ideologies for moving towards modernization, to economic resources to be used in increasing income returns from land.

Table 6: Indicators for assessing impacts on villages

Indicators	Before 2005	Tahkapal	Before 2005	Tandpal
Number of producing crops	3	12	4	11
Number of growers	25	125	32	142
Total area under production (ha)	50	128	38	94
Crops planted at least for two seasons	Maize	Maize, vegetables	None	Maize, vegetables
Grain yield of rice (t ha-1)	1.24	2.56	0.97	2.45
Grain yield of millets (t ha-1)	0.5	1.75	0.45	1.57
Sundried biomass of rice (t ha-1)	21.5	94.5	19.2	65.2

Sundried biomass of millets (t ha ⁻¹)	8.12	22.3	6.45	34.1
Seed stock (better/worse/no change)	Worse	Better	Worse	Better
Number of small ruminant	75	302	65	286
Conflicts due to resources competition (improved/decreasing/no change)	High conflict	Decreasing	High conflict	Decreasing
No. of food deficit months	6.0	1.5	6.0	2.0
No. of feed deficit months	6.0	2.0	5.0	2.5
No. of months of migration	6.0	2.0	6.0	2.5
No. of visit by agriculture expert	0.0	5.0	0.0	4.0
Availability of dry season feed (% of total annual feed)	15%	75%	9.5	65%
Water resource to livestock watering points (improved/ worsen/no change)	low	Improved	low	Improved
Visit from neighboring farmers (improved/ decreasing/no change)	No	Improved	No	Improved
Poverty level (improved / worsen / no change)	Medium	Improved	Medium	Improved

Table 7: Impacts on grain yield and biomass

Crop type	Area covered (ha)	Biomass (t ha ⁻¹)	Grain yield (t ha ⁻¹)	Area (ha)	Biomass (t ha ⁻¹)	Grain yield (t ha ⁻¹)
Rice	100.28	125.35	3.23	94.51	118.14	3.04
Maize	26.32	32.90	4.12	24.81	31.01	3.88
Sorghum	11.28	14.10	1.50	10.63	13.29	1.41
Millets	10.03	12.54	1.23	9.45	11.81	1.16
Green gram	6.27	7.83	0.45	5.91	7.38	0.42
Black gram	7.52	9.40	0.34	7.09	8.86	0.32
Vegetables	16.30	20.37	85.26	15.36	19.20	80.36
Horse gram	2.51	3.13	0.82	2.36	2.95	0.77
Chickpea	25.07	31.34	1.54	23.63	29.54	1.45

Landmarks of interventions

First assessment was change in net cropped area of 109.26 and 58.79 ha⁻¹ in Tahkapal and Bademarenga, respectively; due to association of various lands like wastelands, fallow lands and community lands which were brought under cultivation with technical interventions on cultivation and management made this conversion easy, ultimately molded to the farmers on waste and fallow lands that shrank after interventions finger count crops were 3 and 4 in beginning of works in both villages which increased 12 and 11 in Tahkapal and Bademarenga, respectively due to proper allocation of

resources as per benchmark survey. The increasing rate of crop number was a summation of many factors increasing area in both villages. Area under production (ha) was more pronouncedly enhanced in Tahkapal than Bademarenga. Earning was apparent with maize grown in two seasons involving vegetables at Tahkapal and Bademarenga. Rice is life sustaining crop of the region and grain yield of rice and millets increased nearly 4 times triggering rice and millet biomass from 21.5 to 94.5 t ha⁻¹ at Tahkapal where as 19.2 to 65.2 t ha⁻¹ at Bademarenga. Similar trend was noticed with millets gained biomass production. Stocking of seed in villages were

better as earlier neglected by farmers (Chary *et al.*, 2014). Due to enhancing biomass, by-products in villages alongwith year round availability ensured the rearing small ruminant on bio-waste of homes, led to increasing number of ruminant in villages. Societal level issues like conflicts due to resources sharing was improved remarkably compared to earlier situation, which enhanced farm level production but increasing rainfed production brought down competition with available resources. In most cases, farmers were used to migrate for earning wages during off-season, which was short fallen in farm engagement for targeted doubling crops and reduction in feed and food deficit which compels farmers to move out. These all improved availability of dry feed up to 75% in total annual feed. Schemes applied on community as well as own lands also improved rain water strategy for domestic and livestock watering points. Ultimately, number of visiting farmers from neighboring villages increased to see the improvement. It has been measured by monthly income per households and expenditure level, which was also improved with the level of poverty (Srinivasrao *et al.*, 2016).

The major growing crops in the region are rice, maize, sorghum, millets, green gram, black gram, horsegram, chickpea and vegetables which are represented in both villages. Rice crop covered almost 100 ha area spreading on entire whole farming situations in kharif by maize, millets, sorghum, greengram, blackgram, horsegram in same period of time when rice is grown, whereas vegetables that are grown in *Baadi* throughout year, chickpea mostly preferred in low lying area of lowlands. The higher grain yield and biomass by growing in large area of rice in both villages then maize had higher grain yield as well as biomass and similar trend was seen with chickpea, even vegetables

occupied comparable quantity of yields. Among other commodity, millets and sorghum were similar in trends than remaining commodities. The selected two villages were typical representation of rainfall depended existing agriculture and most of the time pronounced as rainfed agriculture. The basic characteristic of rainfed agriculture was surplus or deficit rain and farmers opt subsistence agriculture. Both the conditions might be gain or loss situations, the excess rainfall washes out cultivation eroding huge amount fertile top soils and topographical situation promotes this event more in the region. Runoff was another issue to store either in soil profile or in storage structures which was almost negligible and the available structures were defunct or lost their capacity to storing rainwater. Uncertainty of rainfall with uneven distribution during peak period of crop growth strikes on the time of sowing, transplanting, weeding, fertilizer application etc. ultimately leads to unsustainable production (Rajani *et al.* 2016).

CONCLUSION

In some cases, converting wastelands to farmlands reported to cause degradation and biodiversity loss (Louhaichi *et al.*, 2016). Our findings demonstrate that restoration of an abandoned bare land through flood and drought conservation measures and appropriate food and feed crops could bring about a significant contribution to ruminant based livelihoods. By employing adaptive management, sustaining support to test and refine feasible strategies.

ACKNOWLEDGEMENT

This research was supported by All India Coordinated Research Project on Dryland Agriculture, ICAR-CRIDA, Hyderabad and Indira Gandhi Krishi Vishwavidyalaya, S.G. CARS, Jagdalpur under core study of rainfed farming.

REFERENCES

- Bekele G., Demeke F. and Zahra Ali Z. 2010. Livelihood-Based Drought Response in Afar. Impact assessment report. Addis Ababa. 25 pages.
- Bradford B.J., Betancourt L.J., Butterfield J.B., Munson M.S. and Wood E.T. 2018. Anticipatory natural resource science and management for a changing future. *Frontiers in Ecology and the Environment* 16:295-303.
- Catley A., Lind J. and Scoones I. 2016. The futures of pastoralism in the Horn of Africa: pathways of growth and change. *Revue scientifique et technique - Office international des épizooties* 35:389-403.
- Devasenapathy, P., Ramesh, T. and Gangwar, B. 2008. Efficiency indices for agriculture management research. New India Publishing Agency, New Delhi. 146p.
- Erkossa T., Hagos F. and Lefore N. 2013. Flood-based farming for food security and adaptation to climate change in Ethiopia: potential and challenges. *Proceedings of a Workshop, Oct 30–31, 2013*. Adama, Ethiopia. International Water Management Institute (IWMI).
- Gbegbelegbe, S., J. Serem, C. Stirling, F. Kyazze, M. Radeny, M. Misiko, S. Tongruksawattana, L. Nafula, M. Gakii, and K. Sonder. 2017. Smallholder farmers in eastern Africa and climate change: A review of risks and adaptation options with implications for future adaptation programmes. *Climate and Development* 10 (4):1–18.
- Gebrechorkos, S. H., S. Hülsmann, and C. Bernhofer. 2019. Long-term trends in rainfall and temperature using high-resolution climate datasets in East Africa. *Scientific Reports* 9 (1):11376. doi:10.1038/s41598-019-47933-8.
- Generoso, R. 2015. How do rainfall variability, food security and remittances interact? The case of rural Mali. *Ecological Economics* 114:188–98. doi:10.1016/j.ecolecon.2015.03.009.
- Gill, M. S., Singh, J. P. and Gangwar, K.S. 2009. Integrated farming system and agriculture sustainability. *Ind. J. Agron.* 54 (2): 128-139.
- Githui, F., W. Gitau, F. Mutua, and W. Bauwens. 2009. Climate change impact on SWAT simulated stream flow in western Kenya. *International Journal of Climatology* 29 (12):1823–34. doi:10.1002/joc.1828.
- Gummadi S., Rao K.P.C., Seid J., Legesse G., Kadiyala M.D.M., Takele R., Amede T. and Whitbread A. 2017. Spatio-temporal variability and trends of pre-cipitation and extreme rainfall events in Ethiopia in 1980–2010. *Theoretical and Applied Climatology* 134:1315-1328.
- Lind J., Sabates-Wheeler R., Kohnstamm S., Caravani M., Eid A., Nightingale D.M. and Oringa C. 2016. Changes in the drylands of eastern Africa: case studies of pastoralist systems in the region. IDS- University of Sussex, UK
- Murali K.G., Amede T., Getnet M., Pinjarla B., Panjal a P., Legesse G., Tilahun G., Vanden Akker E., Berdel W., Keller C., Siambi M. and Whitbread A.
- Oweis T., Prinz D. and Hachum Y.A. 2012. *Rainwater Harvesting for Agriculture in Dry Areas*. London, UK: Balkema, Taylor and Francis, CRC Press.
- Perrin B. 2002. How to - and how not to - evaluate innovation. *Evaluation* 8:13-28.
- Pradhan A., Nag S.K., Sao A., Patil S.K., Patel D.P., Rao S.S. and Mukherjee S.C. 2015. Participatory seed production of small millets among tribal farmers of Bastar region, Chhattisgarh, India *African Journal of Agricultural Research*. 10(49):4505-4514
- Pradhan Adikant, Rajput A.S. and Thakur A. 2012. Predominant weed flora of cropped and non-cropped fields of Bastar in Chhattisgarh *Indian Journal of Weed Science* 44(1):65-67.
- Pradhan Adikant., Nag S. K., Sao A. and Mukherjee S. C. 2018. Distribution of Weekly Rainfall and Probability Analysis for Crop Planning in Bastar Region of Chhattisgarh *Journal of Experimental Agriculture International* 25(2):1-7
- Pradhan Adikant., Nag S.K. and Mukherjee, S.C. 2018. Thermal requirement of small millets in Chhattisgarh plateau under rainfed cropping

- situation *Journal of Agrometeorology* 20(3): 244-245
- Pradhan Adikant., Patil S.K., Marothia D.K., Chandrakar T., Nag S.K. and Mukherjee S.C. 2018. Effect of Catchment and Hydrology of Ancient Dalpatsagar Reservoir on Water Resources of Jagdalpur City, Bastar India. *International Journal of Current Microbiology and Applied Sciences* 8(1):2215-2231
- Pradhan Adikant., Sao A. and Nag S. K. 2018. Sustainable Nutrient Management in Aerobic Finger Millet (*Eleusine coracana* (L.) Gaertn) under Rainfed Agriculture *Journal of Experimental Agriculture International* 22(6):1-5.
- Pradhan Adikant., Thakur A. and Mukherjee S.C. 2014. Weed dynamics and system productivity under rice-based cropping system *Indian Journal of Weed Science* 46(3):224-228.
- Pradhan Adikant., Thakur A. and Sonboir, H.L. 2014. Response of rice (*Oryza sativa*) varieties to different levels of nitrogen under rainfed aerobic ecosystem *Indian Journal of Agronomy* 59 (1):50-53.
- Ravindra Chary G., Rao G.R., Naidu L.G.K., Srinivas S., Sunil N., MaruthiSankar G.R., Ch. Srinivasarao, Ramamurthy V., Pratibha G. and Rani N. 2014. Climate and soil-site suitability criteria for *Jatropha curcas* L. cultivation under non-arable marginal lands in different agro-ecological regions of India *Range Management and Agroforestry* 35(2):210-219
- Rejani R., Rao K.V., Osman M., Rao C.S., Reddy K.S., Chary J Samuel. 2016. Spatial and temporal estimation of soil loss for the sustainable management of a wet semi-arid watershed cluster. *Environmental monitoring and assessment*. 188 (3):1-16.
- Sharma G.K. and Chaudhary J.L. 2014. Time trends in temperature of Bastar plateau agro-climatic zone of Chhattisgarh. *Mausam* 65(1):29-36.
- Sharma G.K., Mishra V.N., Maruti Sankar G.R., Patil S.K., Srivastava L.K., Thakur D.S. & Srinivasa Rao, Ch. 2015. Soil Test based Optimum Fertilizer Doses for attaining Yield Targets of Rice under Midland Alfisols of Eastern India. *Communications in Soil Science and Plant Analysis*, 46 (17): 2177-2190
- Srinivasarao, Ch., Chary. G.R., Rani, N., and Baviskar, V.S (2016) Real time implementation of agricultural contingency plans to cope with weather aberration in Indian agriculture. *Mausam* 67(1): 183-194
- Thakur A.K., Pradhan A. Patel R. and Kumar P. 2015. Effect of Different Nitrogen, Phosphorus and Potassium Levels on Sesame (*Sesamum indicum*) in Bastar Plateau of Chhattisgarh. *The Bioscan*, 10(3):1241-1243.
- Thakur, A. K., Thakur, D. S., Patel, R. K., Pradhan A. and Kumar, P (2015) Effect of different plant geometry and nitrogen levels, in relation to growth characters, yield and economics on sweet corn (*Zea mays Sachharata* l.) at Bastar plateau zone. *The Bioscan*, 10(3):1223-1226.
- Thakur, D. S., Sharma, G K, Naik, R K, Khalkho, D, Chaudhary, J L and Patil, S K (2014) Evaluation of rice establishment methods with nutrient and weed management options for improving productivity and livelihood of tribals under rainfed farming situations of Bastar plateau. *Journal of Soil and Water Conservation*, 13(1):36-41
- VanSteenbergenF,HaileAM,AlemehayuT,Almirew TandGeletaY(2011)Status and potential of spate irrigation in Ethiopia. *Water Resources Management* 25, 1899-1913. doi: doi:10.1007/s11269-011-9780-7.
- Vanmaercke M, Abraha ZA, PoesenJ, NyseenJ, Verstraeten Gand Deckers J (2010) Sediment dynamics and the role of flash floods in sediment export from medium-sized catchments: a case study from the semi-arid tropical highlands in northern Ethiopia. *Journal of Soils and Sediments* 10, 611– 627. doi: DOI:10.1007/s11368-010-0203-9.

STUDIES ON EFFICACY OF ENTOMOPATHOGENIC FUNGUS *METARHIZIUM ANISOPLIAE* (METSCH) AGAINST TERMITE *ODONTOTERMES OBESUS* (L.) UNDER CONTROLLED CONDITION

KALVINDAR PAL¹ AJAY KUMAR^{1*}, SHAILENDRA SHARMA¹, RAJENDRA SINGH², PRAHLAD YADAV¹
PANKAJKUMAR AND S.P.SINGH³

^{1*}*Department of Plant Protection Ch. Charan Singh University, Meerut, Uttar Pradesh*

²*SVPUA&T., Meerut, Uttar Pradesh*

³*ICAR-Indian Institute of Farming Systems Research, Modipuram, Uttar Pradesh*

Corresponding author's email:

ABSTRACT

The present investigations were undertaken in laboratory to quantify the efficacy of entomopathogenic fungus *Metarhizium anisopliae* (Metsch) against termite *Odontotermes obesus* (L.) during 2024. The mortality of *O. obesus* after twenty-four to one hundred twenty hours of treatment was recorded from 53.33 to 95.33 per cent. The highest mortality recorded in the treatment 2×10^{10} spores/ml with 95.33 per cent which was on par with 2×10^9 spores/ml (91.10 per cent). The second best treatment 2×10^9 spores/ml was also on par with the treatment 2×10^8 spores/ml (88.88 per cent). The lowest mortality observed in the treatment 2×10^3 spores/ml (53.33 per cent). The highest concentration of *M. anisopliae* gives the less LT50 and LT90 value. The highest LT50 and LT90 value was at the concentration of 2×10^3 spores/ml with 4.75 and 7.71 days, while the lowest value of LT50 and LT90 was at the concentration of 2×10^{10} spores/ml with 2.68 and 4.33 days followed by 2×10^9 spores/ml, 2×10^8 spores/ml, 2×10^7 spores/ml, 2×10^6 spores/ml, 2×10^5 spores/ml and 2×10^4 spores/ml with the LT50 values of 3.03, 3.42, 3.65, 4.02, 4.21 and 4.50 day and 5.08, 5.92, 6.25, 6.92, 7.21 and 7.08 days LT90 values respectively.

Key words: Efficacy, Termite, Entomopathogenic fungus

Termites eat all plant remains, including dying wood materials, which make them wonderful decomposers (Mugerwa, 2015). Annually one-third dead wood is recycled and broken down by termites in subtropical and tropical environments (Verma *et al.*, 2009). Agricultural crops, including legumes, vegetables, root crops, fruits, sugarcane, cotton, tea and tobacco are damaged by termites (Qasim *et al.*, 2015). Termites not only damage crops but also trees (Rao *et al.*,

2012). Approximately 300 species of trees from 76 families have suffered from termite attack. About 40–60% of trees die due to termite attack in southern hilly areas of China. Termites also damage structures, including houses, dams, bridges, decks (Li *et al.*, 2010a), roads, poles, walls, underground pipes, cables (Lenz *et al.*, 2013), historical materials, archives, and works of art with high historical value (Liotta and Agr`o, 1999). Damage and repair costs due to termite infestations exceed

40 billion dollars per year around the world (Rust and Su, 2012). Different strategies are used to effectively manage termite population (Ahmad *et al.*, 2021). Biological control has excellent potential for controlling termites commercially (Chouvenc *et al.*, 2011a). The biological control of termites, focusing on entomopathogenic fungi (EPF) and strategies to minimise termites' population by Vega *et al.*, 2009. Metchnikoff led to programs in Europe and United States for experimentation with "friendly fungi" against insect pests. It is commonly used for controlling various agricultural and forestry pests including locusts, cockroaches, termites, rice planthoppers, and *Spodoptera litura* (Li, Z.; Alves *et al.*, 2010). *M. anisopliae* it has been effective against spittlebugs in sugarcane (St. Leger *et al.*, 2010). Additionally, *M. acridum* has been it is widely employed for controlling desert locusts *Schistocerca gregaria* (Peng, G. *et al.*, 2008). The most important genera are: *Beauveria*, *Metarhizium*, *Aschersonia*, *Entomophthora*, *Fusarium*, *Hirsutella*, and *Verticillium* (Hemasree, 2013), while *Metarhizium* and *Beauveria* are frequently used to control insect pests (Qu and Wang, 2018). EPF have different stages of infection; spores attach with the waxy cuticle of the host with the help of passive electrostatic forces, hydrophobic forces, and protein interactions between the epicuticle and conidia (Ment *et al.*, 2010a). *B. bassianai* also considered an effective EPF, which parasitizes more than 200 species of insects (Dorworth, 1997). *Bassiana* also showed promising results against termites (Hussain *et al.*, 2010a; Singha *et al.*, 2011, Ambele *et al.*, 2020; Roy *et al.*, 2020). Termite's defence against fungal infections the use of EPF has some drawbacks, such as the need of favourable environmental conditions for germination and infection, being costly to produce commercially, having a short shelf life, and requiring technical expertise for

spray (Islam *et al.*, 2021). One of the most critical aspects of this strategy is to stop direct interaction with pathogens. Termites avoid places where fungal pathogens are present and spread warnings through vibratory behaviour among nestmates to prevent further contact with pathogens (Myles, 2002; De Roode *et al.*, 2012). Social insects use antifungal material collected from surroundings or produced by themselves to increase border defense of the colony nest. Termites produce and add antifungal chemicals during the formation of nest (Rosengaus *et al.*, 1998a). The use of symbiotic microorganisms in nesting structures is also common to stop pathogenic infections (Chouvenc *et al.*, 2013). Termites have the ability to detect the odor of conidia, which leads to the start of all grooming behaviour (Mburu *et al.*, 2009). Meanwhile, soldiers are unable to provide grooming activities, but they produce volatiles or chemicals to contribute in sanitary care (Mitaka *et al.*, 2017; He *et al.*, 2018). Termites eat infected individuals or bury dead ones (Yanagawa *et al.*, 2011). Besides external defence, termites also use the immune system to serve colony-level defenses. Termites infected with the fungus *Metarhizium* can transmit low doses of pathogens to caregivers through allogrooming, and after acquiring a low level of infection, caregivers can trigger active immunization against fungal growth (Liu *et al.*, 2015). The present investigation has been undertaken with a view to generate a database on microbial pathogens especially fungi associated with termites and to evaluate the efficacy of fungal pathogens *Metarhizium anisopliae* (Metsch.) against available termite species *Odontotermes sp.* in laboratory conditions. Therefore, keeping this in view, present investigations were taken-up to study the "Studies on efficacy of entomopathogenic fungus *Metarhizium anisopliae* (Metsch) against termite *Odontotermes obesus*

MATERIALS AND METHODS

The experiment was conducted on Efficacy of entomopathogenic fungus *Metarhizium anisopliae* (Metsch) against termite *Odontotermes obesus* (L.) the experiment was carried out during 2024 at Bio control laboratory, Department of Entomology, SVPUA&T., Meerut (U.P.) India.

The glassware *viz.*, Petri plates, graduated cylinder, culture tubes, conical flask, beakers, funnels, glass rod, dropper, microscopic slides and cover slips were used in the current research. The glassware was sterilized by immersing them in water overnight and washed with detergents. The air-dried glassware's were autoclaved at 121^o C for 15 minutes under 15 lbs pressure/inch². The steam sterilized glassware's were dry sterilized at 180^oC temperature for two hours in hot air oven (Aneja, 2005). The chemicals such as ethyl alcohol, sodium hypochlorite, streptomycin was used in the present study. The equipment such as weighing balance, B.O.D. incubator, autoclave, refrigerator, microscope, micropipette and hot air oven were used in the study. The miscellaneous materials *viz.*, spatula, scissors, tissue paper, sterile blade, What man No. 1 filter paper, cork borer, forceps, cotton, blotter paper, wash bottle, spirit lamp, micropipette tips, rubber bands, aluminium foil and inoculation loop were used.

Preparation of conidial suspension:

After cleaning the Haemocytometer along with the cover slip thoroughly, placed cover slip on the slide exactly over the depression in counting chamber, the spore suspension was dropped below the cover slip so as to fill it completely. The conidia concentration of the isolate were adjusted to 10⁵ conidia/ml by adding measured quantity of sterilized distilled water. Average number of conidia per

cell was calculated as a mean of conidia counting from the four corners and one central cell. The concentration of fungal suspension was calculated as per the formula(mentioned reference...)

$$\text{No. of conidia/ml of suspension} = X \times 10^5 \times D$$

Where X = Average number of conidia per big square of haemocytometer

D = Dilution factor

Effect of substrate on sporulation of *M. anisopliae*: The spore of the fungus grown on various substrates was estimated by using haemocytometer. For this purpose, 10 g or ml homogenous grains or solutions sample? (which forms used in present study) was drawn from each replicate of uniformly sporulating flask and was transferred to 100 ml sterilized distilled water containing Tween 80 (0.05%) solution in 250ml conical flask. The flasks were shaken in mechanical shaker for 10 minutes. The suspension was filtered through double layered muslin cloth. Counting of spore's were made after the serial dilution of the suspension using double ruled Neubauer haemocytometer for determining the number of conidia in 1 g of the substrate (Hokkanen and Lynch 1998). Observations were taken on 10th, 20th and 30th day after inoculation of the fungus.

Statistical analysis: The observed parameters were then analyzed *via* variance analysis with SPSS package. When a significant F-value (p<0.05) was found, differences between observed parameter were compared using The Duncan's Multiple Range Test (DMRT) 5% mean separation test. Statistical analysis the data, thus, obtained were statistically analysed by using one factor analysis (CRD) with the help of online software (OPSTAT) available at Hissar Agricultural University, Hissar.

RESULT AND DISCUSSION

Bioassay of *M. anisopliae* on Termite *Odontotermes obesus* during - 2024

Second instar: The *M. anisopliae* on Termite *Odontotermes obesus* is presented in table 1 and depicted in fig 1.

Twenty-four hours after treatment: The mortality of Termite *Odontotermes obesus* after twenty-four hours of treatment were zero. All the concentration of *M. anisopliae* did not caused any mortality.

Table 1. Efficacy of *M. anisopliae* on Termite *Odontotermes obesus* during 2024

Treatments	Concentrations (Spores ml-1)	Mortality Per cent at different time interval					LT50 (Days)	LT90 (Days)
		24 hours	48 hours	72 hours	96 hours	120 hours		
T ₁	2 × 10 ³	0.00 ± 0.00	0.00 ± 0.00	13.33 ± 0.39	33.33±1.00	53.33 ± 1.59	4.75	7.71
T ₂	2 × 10 ⁴	0.00 ± 0.00	0.00 ± 0.00	15.55 ± 0.46	37.77 ±1.13	59.99 ± 1.79	4.50	7.08
T ₃	2 × 10 ⁵	0.00 ± 0.00	2.22 ± 0.06	27.21 ± 0.81	39.99 ± 1.20	66.66 ± 1.99	4.21	7.21
T ₄	2 × 10 ⁶	0.00 ± 0.00	4.44 ± 0.13	28.88 ± 0.86	42.22 ± 1.26	73.33±2.19	4.02	6.92
T ₅	2 × 10 ⁷	0.00 ± 0.00	8.88 ± 0.26	33.33 ± 0.99	51.10 ± 1.53	82.22 ± 2.46	3.65	6.25
T ₆	2 × 10 ⁸	0.00 ± 0.00	13.33 ± 0.39	37.77 ± 1.13	53.33± 1.60	88.88± 2.66	3.42	5.92
T ₇	2 × 10 ⁹	0.00 ± 0.00	17.77 ± 0.53	46.66 ± 1.39	73.33 ± 2.20	91.10 ± 2.73	3.03	5.08
T ₈	2 × 10 ¹⁰	0.00 ± 0.00	26.66 ± 0.79	53.33 ± 1.59	88.88 ± 2.66	95.33 ± 2.85	2.68	4.33
T ₉	Control	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	-	-

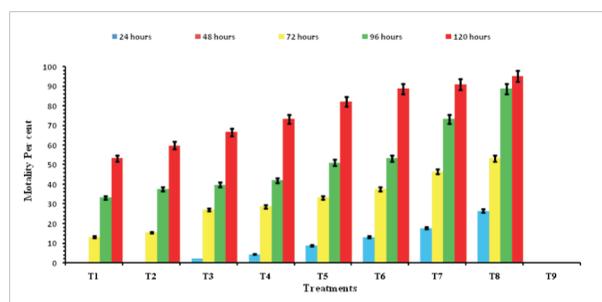


Fig. 1: Efficacy of *M. anisopliae* on Termite

Forty-eight hours after treatment: The larval mortality of Termite *Odontotermes obesus* at forty eight hours after treatment ranged from 0.00 to 26.66 per cent. The highest larval mortality was 26.66 per cent recorded in the treatment 2 × 10¹⁰ spores/ml. The treatment 2 × 10¹⁰ spores/ml was significantly superior over all the treatments. The second best treatment was 2 × 10⁹ spores/ml with 17.77 per cent larval mortality followed by 2 × 10⁸ spores/ml, 2 × 10⁷ spores/ml, 2 × 10⁶ spores/ml and 2 × 10⁵

spores/ml with 13.33, 8.88, 4.44 and 2.22 per cent larval mortality. The treatments 2 × 10⁴ spores/ml, 2 × 10³ spores/ml and control were not significantly differing with 0.00 per cent mortality.

Seventy two hours after treatment: At seventy two hours after treatment the larval mortality per cent ranged from 13.33 to 53.33 per cent. The treatment 2 × 10¹⁰ spores/ml was significantly superior over all the treatments with highest Termite *Odontotermes obesus* mortality 53.33 per cent. The next best treatment was 2 × 10⁹ spores/ml (46.66 per cent). The treatments 2 × 10⁶ spores/ml (28.88 per cent), 2 × 10⁵ spores/ml (27.21 per cent) was on par with each other and the treatments 2 × 10⁴ spores/ml (15.55 per cent) and 2 × 10³ spores/ml (13.33 per cent) also showed non-significant relation with each other.

Ninety six hours after treatment

All the treatments were superior to control. The mortality per cent ranged from 33.33 to

88.88 per cent. The treatment 2×10^{10} spores/ml (88.88 per cent) was significantly superior over all other treatments. The second best treatment was 2×10^9 spores/ml with 73.33 per cent. The treatment 2×10^8 spores/ml (53.33 per cent) was on par with 2×10^7 spores/ml (51.10 per cent). The concentration of 2×10^6 spores/ml (42.22 per cent), 2×10^5 spores/ml (39.99 per cent) and 2×10^4 spores/ml (37.77 per cent) were also found on par with each other. The lowest mortality (33.33 per cent) was recorded in the treatment 2×10^3 spores/ml.

One hundred twenty hours after treatment

The *M. anisopliae* on Termite *Odontotermes obesus* mortality ranged from 53.33 to 95.33 per cent. The highest mortality recorded in the treatment 2×10^{10} spores/ml with 95.33 per cent which was on par with 2×10^9 spores/ml (91.10 per cent). The second best treatment 2×10^9 spores/ml was also on par with the treatment 2×10^8 spores/ml (88.88 per cent). The lowest mortality observed in the treatment 2×10^3 spores/ml (53.33 per cent).

LT₅₀ and LT₉₀ value

Table 1 show that the highest concentration of *M. anisopliae* gives the less LT₅₀ and LT₉₀ value. The highest LT₅₀ and LT₉₀ value was at the concentration of 2×10^3 spores/ml with 4.75 and 7.71 days, while the lowest value of LT₅₀ and LT₉₀ was at the concentration of 2×10^{10} spores/ml with 2.68 and 4.33 days followed by 2×10^9 spores/ml, 2×10^8 spores/ml, 2×10^7 spores/ml, 2×10^6 spores/ml, 2×10^5 spores/ml and 2×10^4 spores/ml with the LT₅₀ values of 3.03, 3.42, 3.65, 4.02, 4.21 and 4.50 day and 5.08, 5.92, 6.25, 6.92, 7.21 and 7.08 days LT₉₀ values respectively. the above findings are confirmed by the Aliet. al. (2024) Termites are global pest for man-made structures, and in some parts of the world, they infest agricultural crops as well. Termite control relies predominately on

chemical insecticides, but the negative impacts of synthetic termiticides on the environment limit their applications. Entomopathogenic fungi (EPF) are considered an environmentally friendly alternative. Kalpesh *et al* (2023) To overcome the harmful impacts of toxic chemical insecticides on the environment, biological control has been developed. Biological control is the use of natural fungi-extracted products to kill insects and pests. Entomopathogenic fungi are a promising alternative for insect pest control in agriculture. Haydar Al-Farhani *et al.*, (2020) *Micro cerotermes diversus* Silvestri (Blattodea: Termitidae) is a worldwide destructive termite whose control by conventional methods is often difficult. Biological control using entomopathogenic fungi could be an alternative management strategy. the infectivity of both isolates of *M. anisopliae* and *B. bassiana* in different concentrations (1×10^4 , 1×10^5 , 1×10^6 , 1×10^7 , and 1×10^8 conidia/ml) were evaluated under laboratory conditions by two methods, including spray and pipetting against termite, *M. diversus*. Sakthivel & Das (2017) attempted to identify novel materials for the mass production of entomopathogenic fungi, *Metarhizium anisopliae* (Mets.) which are extremely cheap and can be used as alternative media components. Wheat bran, rice bran, tamarind extract and milled rice have been tested as cheap growth media. Among the five different media tested, highest wet and dry biomass of 25.2 ± 0.13 g/100ml and 1.15 ± 0.1 g/100ml was recorded for the milled rice medium whereas the least was observed for rice bran medium. Teja & Rahman (2017) The effect of pH of the media on the biomass growth of seven locally isolated entomopathogenic fungal isolates was evaluated in the present study. The isolates in general had a wide pH range for their growth but had maximum biomass at low pH of 4 or 5

and least biomass growth at higher basic pH. Bich *et al.* (2018) evaluated the use *M. anisopliae*. The influence of photoperiod and incubation time in the production of conidia was also evaluated. This study showed that, broken rice was the most

Seventy two hours after treatment

At seventy-two hours after treatment the larval mortality per cent ranged from 13.33 to 53.33 per cent. The treatment 2×10^{10} spores/ml was significantly superior over all the treatments with highest Termite *Odontotermes obesus* mortality 53.33 per cent. The next best treatment was 2×10^9 spores/ml (46.66 per cent). The treatments 2×10^6 spores/ml (28.88 per cent), 2×10^5 productive substrate for conidial production of both fungal genera, with a yield of 4.62×10^7 and 2.22×10^6 conidia g⁻¹ respectively. Also, under the evaluated solid state multiplication conditions, the best conidia production was achieved with a photoperiod of 24 h of light for *B. bassiana* (with 4.43×10^7 conidia g⁻¹) and *M. anisopliae* (with 1.35×10^6 conidia g⁻¹). The results here demonstrated that these two fungal species could viably be multiplied with good yields of conidia on agro-industrial by-products using solid-state culture and regulating some culture conditions. Anggraini *et al.* (2021) studied to determine the combination media of termite juice concentration for the growth of *Metarhizium anisopliae*. The fungi were inoculated on growth media (Potato Dextrose Agar) supplemented with termite juice using various concentration of 0%(control), 50%, 75% and 100%. The growth media supplemented with termite juice is considered to have more nutritional composition to stimulate spore formation promising its application for promoting media of entomopathogenic fungi. Habibpour (2011). first report on the promising effect of an entomopathogenic

fungus, *Metarhizium anisopliae* (Metschnikoff) Sorokin to control populations of *Micro cerotermes diversus* Silvestri.

CONCLUSION

Since the establishment of the fact that fungi pathogenic to insects can be key components in the fight against insect pests in agriculture, several large-scale research have been undertaken by governments, institutions, organizations and individuals to explore their potentials. To date, a number of mycoinsecticides have been developed and are being used against many insect pests of economic importance in a number of countries. Nonetheless, more fungi, which are pathogenic to insects are still being discovered, a situation which presents brighter future for the use of entomopathogenic fungi in insect pest management. However, use of mycoinsecticides in pest management is generally moving at a slow pace even in the developed countries where production of mycoinsecticides began more than five decades ago. In spite of this, mycoinsecticides are gradually becoming popular of it, use of mycoinsecticides in insect pest management will soon increase dramatically.

REFERENCES

- Ahmad, F., Fouad, H., Liang, S.Y., Hu, Y., Mo, J.C., 2021. Termites and Chinese agricultural system: applications and advances in integrated termite management and chemical control. *Insect Sci.* 28, 2–20.
- Ali Hassan, Zhiqiang Li, Xuguo Zhou, Jianchu Mo, Qiuying Huang. 2024. Termite management by entomopathogenic fungi: Recent advances and future prospects, *Current Research in Biotechnology* 7, 100183
- Alves, R. T., Bateman, R. P., Prior, C. and S. R. Leather. 1998. Effects of stimulated solar radiation on conidial germination of *Metarhizium anisopliae* indifferent

- formulations. *Crop Protection*. 17 (8) : 675 – 679.
- Anggraini, N., Suhartono, S., Alfizar, A., Husni, H., Rusdiana, S., Fauziah, F., & Syaekani, S. 2021. Growth of entomopathogenic fungi colonies *Metarhizium anisopliae* (Metschnikoff) Sorokin enriched with termite juice. In *IOP Conference Series: Earth and Environmental Science* (Vol. 667, No. 1, p. 012084). IOP Publishing.
- Bich, G. A., Castrillo, M. L., Villalba, L. L., & Zapata, P. D. 2018. Evaluation of rice by-products, incubation time, and photoperiod for solid state mass multiplication of the biocontrol agents *Beauveria bassiana* and *Metarhizium anisopliae*. *Agronomy Research* 16 (5), 1921-1930.
- Chouvenc, T., Efstathion, C.A., Elliott, M.L., Su, N.Y., 2013. Extended disease resistance emerging from the faecal nest of a subterranean termite. *Proc. R. Soc. B Biol. Sci.* 280 (1770), 20131885.
- Chouvenc, T., Su, N.Y., Grace, J.K., 2011a. Fifty years of attempted biological control of termites—analysis of a failure. *Biol. Control* 59 (2), 69–82.
- Dorworth, C., 1997. Two models for the development of fungal biological control agents. *Mycol. Sustain. Devel.: Expanding Concepts Vanishing Borders*. 211.
- Habibpour b., A. Cheraghi, M.S. Mossadegh. 2011. Evaluation of cellulose substrates treated with *Metarhizium anisopliae* (Metschnikoff) Sorokin as a biological control agent against the termite *Microcerotermes diversus* Silvestri (Isoptera: Termitidae) *Journal of Entomological and Acarological Research*, Ser. II, 43 (2).
- Haydar Al-Farhani¹ & Reyhaneh Darsouei¹ & Shokoofeh Kamali¹ & Gholamhossein
- Islam, W., Adnan, M., Shabbir, A., Naveed, H., Saddeeq, Y., Qasim, M., Tayyab, M., Noman, A., Shahid, M., Ali, K., Ali, H., 2021. Microbial Pathogenesis Insect-fungal-interactions: A detailed review on entomopathogenic fungi pathogenicity to combat insect pests. *Microb. Pathog.* 159, 105122.
- Kalpesh Sorathiya, Shreya Kalariya, Lensi Patel. 2023. *Metarhizium anisopliae* as an Entomopathogenic fungi: optimization of mass production with diverse grain substrates; *International Journal of Multidisciplinary and Current Educational Research (IJM CER)* ISSN: 2581-7027 Volume-5 Issue:4, pp 87-95.
- Lenz, M., Kard, B., Creffield, J.W., Evans, T.A., Brown, K.S., Freytag, E.D., Zhong, J.H., Lee, C.Y., Yeoh, B.H., Yoshimura, T., Tsunoda, K., Vongkaluang, C., Sornnuwat, Y., Roland, T.A., Santi, M.P. 2013. Ability of field populations of *Coptotermes* spp., *Reticulitermes flavipes*, and *Mastotermes darwiniensis* (Isoptera: Rhinotermitidae; Mastotermitidae) to damage plastic cable sheathings. *J. Econ. Entomol.* 106 (3), 1395–1403.
- Li, H., Xu, Z., Deng, T., Chen, L., Li, J., Wei, J., Mo, J., 2010a. Species of termites (Isoptera) attacking trees in China. *Sociobiology* 56 (1), 109–120.
- Li, Z.; Alves, S.B.; Roberts, D.W.; Fan, M.; Delalibera, I., Jr.; Tang, J.; Lopes, R.B.; Faria, M.; Rangel, D.E.N. 2010. Biological control of insects in Brazil and China: History, current programs and reasons for their successes using entomopathogenic fungi. *Biocontrol Sci. Technol*, 20, 117–136.
- Liotta, G., Agrò, A. 1999. Le infestazioni termitiche nelle biblioteche e negli archivi di Palermo, *quinio*. *Int. J. History Conservation Book*. 1, 73–81.
- Liu, L., Li, G., Sun, P., Lei, C., Huang, Q. 2015. Experimental verification and molecular basis of active immunization against fungal pathogens in termites. *Sci. Rep.* 5, 1–12.
- Ment, D., Gindin, G., Rot, A., Soroker, V., Glazer, I., Barel, S., Samish, M. 2010a. Novel technique for quantifying adhesion of *Metarhizium anisopliae* conidia, to the tick

- cuticle. *Appl. Environ. Microbiol.* 76 (11), 3521–3528.
- Ment, D., Gindin, G., Soroker, V., Glazer, I., Rot, A., Samish, M. 2010b. *Metarhizium anisopliae* conidial responses to lipids from tick cuticle and tick mammalian host surface. *J. Invertebr. Pathol.* 103 (2), 132–139.
- Mitaka, Y., Mori, N., Matsuura, K. 2017. Multi-functional roles of a soldier-specific volatile as a worker arrestant, primer pheromone and an antimicrobial agent in a termite. *Proc. R. Soc. B Biol. Sci.* 284 (1859), 20171134.
- Myles, T.G. 2002. Alarm, aggregation, and defense by *Reticulitermes flavipes* in response to a naturally occurring isolate of *Metarhizium anisopliae*. *Sociobiology* 40 (2), 243–256.
- Peng, G.; Wang, Z.; Yin, Y.; Zeng, D.; Xia, Y. 2008 Field trials of *Metarhizium anisopliae* var. *acridum* (Ascomycota: Hypocreales) against oriental migratory locusts, *Locusta migratoria manilensis* (Meyen) in Northern China. *Crop Prot.* 27, 1244–1250.
- Rosengaus, R.B., Guldin, M.R., Traniello, J.F.A. 1998a. Inhibitory effect of termite fecal pellets on fungal spore germination. *J. Chem. Ecol.* 24 (10), 1697–1706.
- Roy, S., Prasad, A.K., Neave, S., Bhattacharyya, P.N., Nagpal, A., Borah, K., Rahman, A., Sarmah, M., Sarmah, S.R., Pandit, V. 2020. Nonchemical based integrated management package for live-wood eating termites in tea plantations of north-east India. *Int. J. Trop. Insect Sci.* 40 (2), 435–440.
- Rust, M.K., Su, N.Y., (2012). Managing social insects of urban importance. *Annu. Rev. Entomol.* 57, 357–375.
- Sakthivel, A., & Das, S. M. 2017. Laboratory assessment of affordable culture media for the propagation of entomopathogenic fungi, used in mycopesticide production. *Journal Of Agrobiotechnology*, 8(1), 33-42.
- Singha, D., Singha, B., Dutta, B.K. 2011. Potential of *Metarhizium anisopliae* and *Beauveria bassiana* in the control of tea termite *Microtermes obesi* Holmgren in vitro and under field conditions. *J. Pest. Sci.* 84 (1), 69–75.
- St. Leger, R.J.; Wang, C. 2010. Genetic engineering of fungal biocontrol agents to achieve greater efficacy against insect pests. *Appl. Microbiol. Biotechnol.* 85, 901–907.
- Teja, C., & Rahman, S. J. 2017. Effect of media pH on the growth of entomopathogenic fungi isolated from different rhizosphere soils. *Int. J. Bioassays*, 6, 5325-5327.
- Vega FE, Goettel MS, Blackwell M, Chandler D, Jackson MA, Keller S *et al.*, (2009) Fungal entomopathogens: New insights on their ecology. *Fungal Ecology*. 2:149-159.
- Verma, M., Sharma, S., Prasad, R. 2009. Biological alternatives for termite control: A review. *Int. Biodeter. Biodegr.* 63 (8), 959–972.

GROWTH, YIELD AND QUALITY OF KHARIF ONION (*ALLIUM CEPA L.*) VARIETIES UNDER DIFFERENT PLANTING GEOMETRY

B.L. SHARMA¹, S.S. KUSHWAH¹ AND P.P. SINGH²

¹*RVSKVV, College of Horticulture, Mandsaur (MP) – 458002*

²*ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut*

Corresponding author's email: kushwahhort@gmail.com

ABSTRACT

A field investigation was carried out during kharif season at the vegetable research field, College of Horticulture, Mandsaur, Madhya Pradesh. Twenty treatment combinations comprised of four varieties (V1 - N-53, V2 - Agrifound Dark Red, V3 - Bhima Super and V4 - Bhima Red) and five spacing (S1-10 x 10 cm², S2 -15 x 10cm², S3 -15 x 8 cm², S4 -20 x 10 cm² and S5 -20 x 8 cm²) were evaluated underfactorial randomized block design with three replications. Findings revealed that that variety Agrifound Dark Red recorded highest plant height, number of leaves, polar diameter, equatorial diameter, average weight of bulb (88.29g) and marketable bulb yield (274.32 q/ha) followed by Bhima Super. Agrifound Dark Red also recorded highest TSS content (12.03°Brix). Highest pyruvic acid content was estimated with Bhima Red (4.37µmoles/gFW) followed by Bhima Super (4.36 µmoles/gFW). Transplanting of onion at 15x8 cm² registered highest marketable bulb yield. Though, TSS and Pyruvic acid content were higher in case of 20x10 cm² spacing. Combined effect of varieties and spacing revealed best combination of V2S3 as far as marketable yield is concerned. Though, highest TSS and pyruvic acid were determined with V4S4.

Key words: Kharif onion, Growth, Yield, Quality

Onion (*Allium cepa* L.) is a bulbous vegetable crop grown all over the world. It belongs to family Amaryllidaceae. It is cultivated as annual crop for bulb production and as biennial crop for seed production. The edible portion is a modified stem which is known as 'bulb' and develops underground. Onion is used as vegetable in every household in India and has an important role in our daily diet. Both immature and mature bulbs are used as vegetable and condiments. It is used in many homes almost daily primarily for seasoning in a wide variety of dishes. Onion

can be eaten raw or cooked. Raw onion is consumed as young green plants, or as bulbs, which are usually sliced or chopped. Mild flavoured or colourful bulbs of onion are often chosen for salads. For cooking, green onions are used. It is also used in processing and value addition like flakes, powder, making pickles and dehydration of onion. Onion is a source of carbohydrate (11.0 g), protein (1.2 g), calcium (180 mg), phosphorus (50 mg), iron (0.7 mg), nicotinic acid (0.4 mg), riboflavin (0.01 mg) and vitamin-C (11.0 mg) in each 100 g of edible portion (Bose *et al.* 2000). The

pungency in onion is due to the presence of sulphur bearing compound in the volatile oil known as allyl-propyl disulphide ($C_6H_{12}S_2$). It has got many medicinal values and is commonly used as diuretic and antidiabetic drugs. It is very useful against sun-strokes (Loo) in summer.

In India, the main onion growing states are Maharashtra, Gujarat, Karnataka, Tamil Nadu, Orissa, Madhya Pradesh, Uttar Pradesh, Andhra Pradesh, Bihar and Punjab. India ranks second in area and production of onion in the world after china. Generally, onion is cultivated in Rabi season at large scale. The produce of Rabi season is stored for consumption in summer and kharif but due to lack of proper storage conditions and losses due to spoilage in the monsoon season and afterwards the availability of onion becomes less and prices goes up. Hence, production of onion during kharif is required to fill the gap of demand and supply.

Varieties and planting geometry affects the growth and yield of the crop (Mohanty and Prusti, 2001). Ameta *et al.* (2011) tested four varieties of onion during kharif. They found that the maximum plant height (34.55 cm), diameter of bulb (4.95cm) and weight of bulb (64.3g) were noted for Agrifound Dark Red variety. Number of leaves per plant was maximum in Baswant-780, maximum neck thickness was observed in Agrifound Light Red (0.90 cm) and maximum bulb yield was produced by Baswant-780 (20.90 t/ha). Dudhat *et al.* (2010) reported that the spacing between the onion plants significantly affect the size of bulb. Keeping these facts in view an experiment was conducted to find the suitable variety and to standardize the planting geometry for kharif season onion.

MATERIAL AND METHODS

The field experiment was conducted during kharif season at the vegetable researchfield,

College of Horticulture, Mandsaur, Madhya Pradesh. Twenty treatment combinations comprised of four varieties (V_1 - N-53, V_2 - Agrifound Dark Red, V_3 - Bhima Super and V_4 - Bhima Red) and five spacing (S_1 -10 x 10 cm², S_2 -15 x 10cm², S_3 -15 x 8 cm², S_4 -20 x 10 cm² and S_5 -20 x 8 cm²) were tested underfactorial randomized block design with three replications. The soil of the experimental field was light alluvial soil and sandy loam texture. Fifty days old seedlings were transplanted in the field on 4th August.

Gap filling was done at 10 days after transplanting to maintain plant population in each plot. The dose of fertilizers 120:50:100:45 NPKS kg/ha was applied to plots. The source of nutrients were nitrogen (DAP, Urea), phosphorus (DAP), potash (MOP) and sulphur (Elemental Sulphur). Half of nitrogen and whole dose of phosphorus, potash and sulphur were applied as basal dose before transplanting of onion seedlings. While the remaining half dose of nitrogen was given in 2 equal split doses, first at 30 and second 45 days after transplanting. After complete development, the bulbs were harvested on 26th November.

Observations were recorded on plant height, number of leaves per plant, dry weight of shoot per plant (g), dry weight of bulb per plant (g), polar diameter of bulb (cm), equatorial diameter of bulb, average weight of bulb, number of doubles (%), marketable bulb yield (q/ha), neck thickness(cm), TSS (°Brix), pyruvic acid (mg/100g) in bulb. Neck thickness was measured with vernier caliper. TSS in bulb was determined with the help of hand refractometer. Pyruvic acid (μ moles/g FW) in bulb was estimated with the method of Anthon and Barrett (2003). Data obtained from the investigation were statistically analysed as per the standard procedure (Panse and Sukhatme, 1984)

RESULTS AND DISCUSSION

Growth parameters

Among the growth parameters plant height and number of leaves per plant were recorded at 30, 60, 75 and 90 days after transplanting (Table 1). Dry weight of shoot and bulb were observed at harvesting stage. Varieties differed significantly for plant height, number of leaves, dry weight of shoot and dry weight of bulb at all the stages, except number of leaves which showed non-significant difference at 30 days after transplanting. Maximum plant height, number of leaves and dry weight of shoot as well as dry weight of bulb were recorded in case of variety Agri-found Dark Red which was followed by Bhima Super and N-53. Variety Bhima Red exhibited lowest values for all these growth attributes. Genotypic difference might have caused the variation in growth attributes of varieties. These findings corroborates with those of Mohanty *et al.* (2000), Ghaffoor *et al.* (2003) and Ameta *et al.* (2011).

Spacing exhibited significant effect of growth attributes at all the stages under study (Table 1). Maximum plant height, number of leaves, dry weight of shoot and dry weight of bulb were found under S₄ (20x10 cm²) spacing which was followed by S₅ (20x8 cm²), S₂ (15x10 cm²) and S₃ (15x8 cm²). Lowest growth attributes were noted under S₁ (10x10 cm²) spacing. More spacing increased higher growth in plant due to more availability of light and air contributing for more photosynthesis which might have been the reason for increase of leaf area per plant. More photosynthetic area might have resulted in more photosynthates manufacture and accumulation consequently more dry weight of shoot and bulb. These findings are in agreement with those of Kanton *et al.* (2002), Singh *et al.* (2002) and Aliyu *et al.* (2008).

Combined effect of varieties and spacing had significant influence on dry weight of shoot and dry weight of bulb (Table 2). Treatment combination V₂S₄ (Agrifound Dark Red with 20x10 cm²) recorded maximum dry weight of shoot at harvest stage. Maximum dry weight of bulb was recorded with V₃S₄ (Bhima Super with 20x10 cm²) which was at par to V₂S₄ (Agrifound Dark Red with 20x10 cm²).

Yield parameters and yield

Results (Table 3) indicated significant effect of varieties on yield parameters and yield of onion. Variety, V₂ (Agrifound Dark Red) recorded maximum polar diameter, equatorial diameter, average weight of bulb, number of doubles (%) as well as marketable bulb yield which was followed by V₃ (Bhima Super) and V₁ (N-53). Lowest polar diameter, equatorial diameter, average weight of bulb, number of doubles (%) and marketable bulb yield was noted with variety V₄ (Bhima Red). Higher growth and yield attributes might have contributed to highest yield under V₂ (Agrifound Dark Red). These findings are corroborated with those reported by Ghaffoor *et al.* (2003), Khan *et al.* (2003), Gautam *et al.* (2006), Jilani *et al.* (2009) and Ameta *et al.* (2011) and Gupta *et al.* (2011b).

There was significant effect of spacing on polar and equatorial diameter, average weight of bulb, number of doubles of onion bulb. Each increase in level of spacing recorded increase in these yield parameters. Transplanting of onion seedling at S₄ (20x10 cm²) spacing recorded highest polar and equatorial diameter, average weight of bulb and number of doubles followed by S₅ (20x8 cm²), S₂ (15x10 cm²) and S₃ (15x8 cm²). Minimum polar and equatorial diameter, average weight of bulb and number of doubles were observed with S₁ (10x10 cm²) spacing. Kanton *et al.* (2002),

Singh *et al.* (2002), Khan *et al.* (2003), Naik and Hosamani (2003), Vilorio *et al.* (2003), Aliyu *et al.* (2008), Jilani *et al.* (2009) and Dubey *et al.* (2011) also found similar results. Spacing imparted significant influence on marketable bulb yield. Transplanting of onion seedling at S₃ (15x8 cm²) spacing recorded highest marketable onion bulb yield which was followed by S₂ (15x10 cm²), S₁ (10x10 cm²) and S₅ (20x8 cm²). Minimum marketable onion bulb yield was observed in case of S₄ (20x10 cm²) spacing. Higher percentage of doubles and unmarketable size bulbs due to lesser spacing in case of S₁ (10x10 cm²) and S₂ (15x10 cm²) and lesser number of bulbs per unit area may be the reason for these results. These findings are also supported by Stoffella (1996) and Kanton *et al.* (2002). Jilani *et al.* (2009) reported that in closer spacing bulb size was so small but does not suitable to choice of consumers.

Combined effect of varieties and spacing had no significant influence on polar as well as equatorial diameter of onion bulbs, whereas, average weight of bulb, number of doubles and marketable bulb yield was affected significantly. Maximum average weight of bulb was recorded with V₂S₄ (Agrifound Dark Red with 20x10 cm²) which was followed by V₁S₄ (N-53 with 20x10 cm²), V₃S₄ (Bhima Super with 20x10 cm²) and V₃S₅ (Bhima Super with 20x8 cm²). Variety N-53 under S₁ (10x10 cm²) spacing exhibited lowest average weight of bulb. These findings are in accordance with Khan *et al.* (2003) and Awas *et al.* (2010). There was increase in number of doubles with increasing spacing under all the varieties. Highest number of doubles was recorded with V₂S₄ (Agrifound Dark Red with 20x10 cm²). Whereas, minimum number of doubles was recorded with V₁S₁ (N-53 with 10x10 cm²), V₄S₁ (Bhima Red with 10x10 cm²) and V₄S₃ (Bhima Red with 15x8 cm²) which were equal, showing zero number of doubles. Similar

results were noted by Khan *et al.* (2003). Highest marketable bulb yield was observed under V₂S₃ (Agrifound Dark Red with 15x8 cm²) followed by V₂S₂ (Agrifound Dark Red with 15x10 cm²), V₃S₃ (Bhima Super with 15x8 cm²) and V₂S₁ (Agrifound Dark Red with 10x10 cm²). Variety N-53 under S₄ (20x10 cm²) spacing recorded minimum marketable bulb yield. Significant interaction effect of varieties and spacing has also been reported by Jilani *et al.* (2004) and Awas *et al.* (2010).

Quality parameters

Onion bulb quality was evaluated with respect to neck thickness, T.S.S. and pyruvic acid content. Results (Table 4) revealed significant effect of varieties on neck thickness, T.S.S. and pyruvic acid content in bulb. Maximum neck thickness and TSS content in bulb was observed in V₂ (Agrifound Dark Red) followed by V₃ (Bhima Super) with nonsignificant difference. Variety Bhima Red recorded lowest neck thickness and TSS which was at par to N-53. Significant variation in neck thickness and TSS content among varieties have also been reported by Mohanty and Prusti (2001), Ameta *et al.* (2011), Gupta *et al.* (2011a) and Thangasamy *et al.* (2011). Variety V₄ (Bhima Red) recorded highest pyruvic acid content which was followed by V₃ (Bhima Super) with nonsignificant difference. Lowest pyruvic acid content was determined in V₁ (N-53). Thangasamy *et al.* (2011) also reported remarkable difference in pyruvic acid content of onion varieties.

There was significant effect of spacing on neck thickness, TSS and pyruvic acid content in onion bulb. Each increasing level of spacing resulted increase in neck thickness, T.S.S. and pyruvic acid content in onion bulb. Highest neck thickness, T.S.S. and pyruvic acid content were determined with S₄ (20x10 cm²) spacing which was followed by S₅ (20x8 cm²), S₂ (15x10 cm²) and S₃ (15x8 cm²). Lowest neck

thickness, T.S.S. and pyruvic acid content were observed in case of closest spacing that is S₁ (10x7 cm²). These findings are in accordance to Kanton *et al.* (2002), Singh *et al.* (2002) and Naik and Hosamani (2003).

Combined effect of varieties and spacing has exerted significant influence on pyruvic acid content in onion bulb whereas, neck thickness and TSS content showed

nonsignificant impact. Highest pyruvic acid content was estimated with V₄S₄ (Bhima Red with 20x10 cm²) followed by V₄S₅ (Bhima Red with 20x8 cm²), V₃S₄ (Bhima Super with 20x10 cm²) and V₃S₅ (Bhima Super with 20x8 cm²) with nonsignificant difference. The combination V₁S₃ (N-53 with 15x8 cm²) recorded lowest pyruvic acid content in onion bulb.

Table 1: Effect of varieties, spacing and their interaction on growth parameters in Kharif onion

Treatment	Plant height (cm)				Number of leaves per plant				Dry weight of shoot (g) at harvesting	Dry weight of bulb (g) at harvesting
	30 DAT	60 DAT	75 DAT	90 DAT	30 DAT	60 DAT	75 DAT	90 DAT		
Varieties (V)										
V ₁	35.60	43.33	50.32	49.43	5.84	6.53	10.01	11.63	1.57	10.70
V ₂	37.95	45.68	55.45	50.67	6.11	7.76	11.29	12.36	1.88	12.54
V ₃	35.92	43.47	53.17	49.47	6.00	7.45	10.65	11.97	1.61	12.19
V ₄	28.55	40.67	49.77	43.21	5.76	6.37	9.96	11.37	1.53	10.21
S.Em ±	0.56	0.70	0.88	1.16	0.18	0.24	0.26	0.24	0.05	0.32
CD at 5 %	1.60	2.01	2.52	3.32	NS	0.68	0.75	0.68	0.14	0.91
Spacing levels (S)										
S ₁	30.97	40.43	49.97	43.80	5.40	6.10	9.31	10.87	1.22	8.65
S ₂	34.77	43.21	52.17	48.33	6.03	6.93	10.36	11.72	1.59	10.43
S ₃	33.52	41.98	51.05	47.98	5.83	6.45	9.98	11.37	1.51	10.09
S ₄	37.47	46.45	54.63	51.82	6.27	8.05	11.61	12.82	2.05	15.39
S ₅	35.80	44.37	53.08	49.03	6.10	7.62	11.14	12.40	1.86	12.48
S.Em ±	0.63	0.78	0.98	1.29	0.20	0.26	0.29	0.26	0.05	0.35
trightCD at 5 %	1.79	2.24	2.82	3.71	0.57	0.75	0.84	0.76	0.16	1.01

Table 2: Interactive effect of varieties and spacing on dry weight of shoot (g) and bulb in Kharif onion

Treatment	Dry weight of shoot (g) at harvesting	Dry weight of bulb (g) at harvesting
V ₁ S ₁	1.38	8.12
V ₁ S ₂	1.52	10.19
V ₁ S ₃	1.46	9.60
V ₁ S ₄	1.77	13.42
V ₁ S ₅	1.70	12.15
V ₂ S ₁	1.51	10.13
V ₂ S ₂	1.72	10.83
V ₂ S ₃	1.53	10.47
V ₂ S ₄	2.53	17.68
V ₂ S ₅	2.09	13.62
V ₃ S ₁	1.16	7.53
V ₃ S ₂	1.65	10.87
V ₃ S ₃	1.68	10.61
V ₃ S ₄	1.87	18.30
V ₃ S ₅	1.69	13.66
V ₄ S ₁	0.83	8.83
adjustrightV ₄ S ₂	1.46	9.83
V ₄ S ₃	1.36	9.69
V ₄ S ₄	2.02	12.17
V ₄ S ₅	1.96	10.50
S.Em ±	0.11	0.71
CD at 5 %	0.31	2.03

Table 3. Effect of varieties, spacing and their interaction on yield parameters and yield in Kharif onion

Treatment	Polar diameter (cm)	Equatorial diameter (cm)	Av. weight of bulb (g)	Double s (%)	Market able bulb yield (q/ha)
Varieties (V)					
V ₁	4.70	5.43	82.07	0.343	207.75
V ₂	5.17	5.59	88.29	1.045	274.32
V ₃	4.95	5.53	85.82	0.477	241.79
V ₄	4.57	5.31	80.01	0.186	207.25
S.Em ±	0.08	0.06	1.78	0.024	4.52
CD at 5 %	0.23	0.18	5.11	0.068	12.95
Spacing levels (S)					
S ₁	4.55	5.05	64.55	0.133	236.77
S ₂	4.90	5.48	84.98	0.370	238.01
S ₃	4.73	5.27	78.62	0.193	275.26
S ₄	5.11	5.95	101.64	1.334	200.83
S ₅	4.94	5.58	90.44	0.534	213.02
S.Em ±	0.09	0.07	2.00	0.027	5.05
CD at 5 %	0.26	0.20	5.72	0.076	14.48
Interaction (V x S)					
V ₁ S ₁	4.23	5.10	54.83	0.000	228.08
V ₁ S ₂	4.88	5.42	87.63	0.185	192.88
V ₁ S ₃	4.72	5.36	73.33	0.107	250.27
V ₁ S ₄	4.95	5.88	105.10	1.055	158.70
V ₁ S ₅	4.72	5.41	89.43	0.370	208.83
V ₂ S ₁	4.92	4.96	72.60	0.463	271.56
V ₂ S ₂	5.20	5.74	83.87	0.738	303.87
V ₂ S ₃	4.99	5.28	79.30	0.500	304.97
V ₂ S ₄	5.46	6.25	108.87	2.777	259.10
V ₂ S ₅	5.26	5.70	96.83	0.746	232.10
V ₃ S ₁	4.65	5.32	61.03	0.067	233.47
V ₃ S ₂	5.01	5.33	87.50	0.485	240.51
V ₃ S ₃	4.73	5.35	83.57	0.166	296.92
V ₃ S ₄	5.19	5.90	100.47	0.925	216.29
V ₃ S ₅	5.15	5.74	96.53	0.741	221.74
V ₄ S ₁	4.41	4.81	69.73	0.000	213.98
V ₄ S ₂	4.52	5.45	80.93	0.074	214.79
V ₄ S ₃	4.48	5.11	78.27	0.000	248.89
V ₄ S ₄	4.84	5.75	92.13	0.578	169.22
V ₄ S ₅	4.61	5.46	78.97	0.278	189.39
S.Em ±	0.18	0.14	3.99	0.053	10.11
CD at 5 %	NS	NS	11.43	0.152	28.96

Table 4. Effect of varieties, spacing and their interaction on neck thickness, polar diameter and equatorial diameter of bulb (cm) of Kharif onion

Treatment	Neck thickness of bulb (cm)	T.S.S. of bulb	Pyruvic acid (µmoles/gFW)
Varieties (V)			
V ₁	1.11	11.68	1.91
V ₂	1.21	12.03	2.30
V ₃	1.15	11.93	4.36
V ₄	1.05	11.66	4.37
S.Em ±	0.02	0.10	0.01
CD at 5 %	0.07	0.28	0.04
Spacing levels (S)			
S ₁	1.04	11.30	2.99
S ₂	1.13	11.77	3.23
S ₃	1.10	11.58	3.15
S ₄	1.22	12.45	3.42
S ₅	1.18	12.02	3.38
S.Em ±	0.03	0.11	0.02
CD at 5 %	0.08	0.32	0.05
Interaction (V x S)			
V ₁ S ₁	1.05	11.10	1.85
V ₁ S ₂	1.08	11.67	1.90
V ₁ S ₃	1.12	11.55	1.83
V ₁ S ₄	1.19	12.18	1.99
V ₁ S ₅	1.14	11.88	1.96
V ₂ S ₁	1.11	11.78	2.11
V ₂ S ₂	1.23	11.93	2.29
V ₂ S ₃	1.19	11.92	2.27
V ₂ S ₄	1.28	12.48	2.45
V ₂ S ₅	1.27	12.05	2.39
V ₃ S ₁	1.03	11.27	3.94
V ₃ S ₂	1.17	11.87	4.41
V ₃ S ₃	1.10	11.65	4.31
V ₃ S ₄	1.24	12.52	4.61
V ₃ S ₅	1.21	12.33	4.56
V ₄ S ₁	0.96	11.07	4.06
V ₄ S ₂	1.03	11.60	4.33
V ₄ S ₃	1.00	11.22	4.21
V ₄ S ₄	1.17	12.60	4.63
V ₄ S ₅	1.08	11.82	4.62
S.Em ±	0.06	0.22	0.03
CD at 5 %	NS	NS	0.09

CONCLUSION

It may be concluded from the findings of the experiment that among the varieties tested Agrifound Dark Red is best variety followed by Bhima Super with respect to growth and yield. Agrifound dark Red also recorded highest TSS content. But it was containing lower pyruvic acid as compared to Bhima Super and Bhima Red. Transplanting of onion at 15x8 cm² registered highest marketable bulb yield. Though, TSS and Pyruvic acid content were higher in case of 20x10 cm² spacing. Combined effect of varieties and spacing revealed best combination of V₂S₃ as far as marketable yield is concerned. Though, highest TSS and pyruvic acid were determined with V₄S₄.

REFERENCES

- Aliyu, U., Dikko, A.U., Magaji, M.D. and A. Singh. 2008. Nitrogen and intra row spacing effects on growth and yield of onion (*Allium cepa* L.). *Journal of Plant Science*, 3 (3): 188-193.
- Ameta, K.D., Kaushik, R.A., Dubey, R.B., Sarolia, D.K. and A.S. Jodha. 2011. Performance of onion varieties in Udaipur condition during rainy season. In: national symposium on allium: current scenario and emerging trends, held from 12-14 march at Pune, organized by Indian Society of Alliums and Directorate of Onion and Garlic Research, Pune. p 138.
- Awas, G., Abdisa, T., Tolesa, K. and Amenti Chali. 2010. Effect of intra row spacing on yield of three onion (*Allium cepa* L.) varieties. *Journal of Horticulture and Forestry*, 2 (1): 7-11.
- Bose, T.K., Kabir, J., Das, P. and P.P. Joy. 2000. Tropical Horticulture. Vol. 2 Naya Prokash, Calcutta, India. p 175.
- Dubey, B.K., Mishra, R., Bhone, S.R. and R.P. Gupta. 2011. Standardization of planting time and spacing in hybrid onion variety "Colina" for export quality bulb production during late kharif. In: national symposium on allium: current scenario and emerging trends, held from 12-14 march at Pune, organized by Indian Society of Alliums and Directorate of Onion and Garlic Research, Pune, pp 205-206.
- Gautam, I.P., Khatri, B. and P.P. Govinda. 2006. Evaluation of different varieties of onion and their transplanting times for off season production in Mid Hills of Nepal. *Journal of Nepal Agricultural Research*, 7: 21-26.
- Ghaffoor, A., Jilani, M.S., Khaliq, G. and K. Waseem. 2003. Effect of different NPK levels on the growth and yield of three onion (*Allium cepa* L.) varieties. *Asian Journal of Plant Science*, 2 (3): 342-346.
- Gupta, A.G., Lawande, K.E., Mahajan, V., Prasad, V.S.R.K. and Anil Khar. 2011a. Screening and identification of red onion germplasm for kharif season. In: national symposium on allium: current scenario and emerging trends, held from 12-14 march at Pune, organized by Indian society of Alliums and Directorate of Onion and Garlic Research, Pune, p 139-140.
- Gupta, A.G., Lawande, K.E., Mahajan, V. and V.S.R. Krishna Prasad. 2011b. Performance of red onion advanced lines and varieties during kharif, late kharif and rabi season. In: national symposium on allium: current scenario and emerging trends, held from 12-14 march at Pune, organized by Indian society of Alliums and Directorate of Onion and Garlic Research, Pune, p 141.
- Jilani, M.S., Ghaffoor, A., Waseem, K. and J.I. Farooqi. 2004. Effect of different levels of nitrogen on growth and yield of three onion varieties. *International Journal of Agriculture and Biology*, 6 (3): 507-510.
- Jilani, M.S., Khan, M.Q. and Saifur Rahman. 2009. Planting densities effect on yield and components of onion (*Allium cepa* L.). *Journal of Agricultural Research*, 47 (4): 397-404.
- Kanton, R.A.L., Abbey, L., Hilla, R.G., Tabil, M.A. and Jan, N.D. 2002. Density affects plant development and yield of bulb onion (*Allium cepa* L.) in Northern Ghana. *Journal of Vegetable Crop Production*, 8 (2): 15-25.

- Khan, M.A., Hasan, M.K., Miah, M.A.J., Alam, M.M. and M.H. Masum. 2003. Effect of plant spacing on the growth and yield of different varieties of onion, *Pakistan Journal of Biological Science*, 6 (18): 1582-1585.
- Mohanty, B.K. and A.M. Prusti. 2001. Performance of common onion varieties in kharif seasons. *Journal of Tropical Agriculture*, 39 (1): 21-23.
- Mohanty, B.K., Hossain, M.M. and A.M. Prusti. 2000. Varietal assessment of common onion for horticultural traits during kharif season. *Orissa Journal of Horticulture*, 28 (2): 8-11.
- Naik, H.B. and R.M. Hosmani. 2003. Effect of spacing and nitrogen levels on growth and yield of kharif onion. *Karnataka Journal of Agricultural Science*, 16 (1): 98-102.
- Panse, V.G. and P.V. Sukhatme. 1984. *Statistical Methods for Agricultural Workers*. Fourth edition. ICAR publication, New Delhi.
- Singh, A.K., Singh, V. and K. Nainwal. 2002. Effect of size, distance and date of planting of mother sets on quality of kharif onion. *Progressive Horticulture*, 34 (1): 109-112.
- Stoffella, P.J. 1996. Planting arrangement and density of transplants influence sweet Spanish onion yields and bulb size. *Journal of Horticulture Science*, 31 (7): 1129-1130.
- Thangasamy, A., Mahajan, V. Sankar, V. and K.E.Lawande. 2011. Evaluation of biochemical properties of short day onion cultivars. In: national symposium on allium: current scenario and emerging trends, held from 12-14 march at Pune, organized by Indian society of Alliums and Directorate of Onion and Garlic Research, Pune, p 154.
- Viloria, A., Arteaga, L., Diaz, L. and D. Delgado. 2003. Effect of NPK fertilization and planting distance on onion (*Allium cepa* L.) yield. *Bioagro*, 15(2): 129-133.

EVALUATION OF BORON DOSES ON DIFFERENT VARIETIES OF PEA (*PISUM SATIVUM L.*) WITH RESPECT TO GROWTH, NODULATION, YIELD, QUALITY AND NUTRIENTS STATUS IN PLANT AND SOIL

MUKESH KUMAR NAGAR¹, S.S. KUSHWAH^{1*}, R.K. SHARMA¹, R. GALLANI¹ AND P.P.SINGH²

^{1*}*RVSKVV, College of Horticulture, Mandsaur (MP)-458002*

²*ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut*

Corresponding author's email: kushwahhort@gmail.com

ABSTRACT

An experiment was conducted at the Bahadari farm, College of Horticulture, Mandsaur, (M.P.). Twenty treatment combinations consisting of four varieties of pea (V₁-Arkel, V₂-Kashi Nandini, V₃-Pusa Pragati and V₄-Kashi Samarth) and five doses of boron (B₁-0 kg/ha, B₂-1.0 kg/ha, B₃-1.5 kg/ha, B₄-2.0kg/ha and B₅-2.5 kg/ha) were evaluated in factorial randomized block design with three replications. The findings of the study revealed that among the varieties tested, highest number of pod per plant (25.48) and green pod yield (80.76q/ha) was recorded with variety V₄ (Kashi Samarth). It was followed by V₃ (Pusa Pragati) and V₂ (Kashi Nandini). Kashi Samarth (V₄) was superior as indicated through green pod yield and quality as well as economic returns. Application of boron increased growth and yield parameters and yield. Highest growth parameters and yield parameters *viz.*, number of pod per plant (26.46), pod length (9.15cm), number of seed per pod (9.17), ten pod weight (43.96g) and green pod yield (80.74q/ha) was recorded with B₅. Highest TSS (11.19°Brix), reducing sugar (10.67%) and total sugar (7.35%) were also estimated under B₅.

Key words: Pea, Varieties, Boron doses, Nodulation, Yield, Quality

Pea is an important vegetable crop. It is widely cultivated throughout the world. As a cool season crop, it is extensively grown in temperate zone but restricted to cooler altitudes in the tropic and winter season in the subtropics. Pea is an excellent food for human consumption which is taken as a vegetable. Garden pea is cultivated on a large scale in the states like Uttar Pradesh, Madhya Pradesh and Jharkhand. It is also grown in Himachal Pradesh, Punjab, West Bengal, Haryana, Bihar, Uttarakhand, Jammu and Kashmir, Odisha, parts of Rajasthan and Maharashtra.

Despite large number of cultivars in the field, pea yield per unit in India is lower than world due to many factors like poor cultural practices, lack of high yielding varieties, pest attack, etc. The yield and quality of crop are very complex characteristics. It is evident from the study that the pea cultivars differ in their yield potential and adaptability to various climatic conditions (Amjad and Anjum, 2002). Improvement in yield is possible through the selection of high yielding varieties which are adaptable to the particular climatic conditions (Singh *et al.*, 2015b).

Boron is one of the essential micronutrients required for normal growth of the plants and plays a vital role in promoting growth, yield and nodulation in garden pea. The absence of boron in the culture medium resulted in a decrease of the number of nodules and an alteration of nodule development leading to an inhibition of nitrogenous activity. Examination of boron-deficient nodules showed dramatic changes in cell walls and in both peri-bacteroid and infection thread membranes, suggesting a role for boron in the stability of these structures. These results indicate that boron is a requirement for normal nodule development and functionality. Boron is required for infection thread development and nodule cell invasion, probably due to a B-mediated inhibition of the binding of infection thread matrix material to the cell surface of *Rhizobium* that promotes endocytosis of bacteria (Bolanos *et al.*, 1996). Boron nutrition also affected glycosylation and targeting of glycoprotein during differentiation of endophytic bacteria to N₂-fixing bacteroid and symbiosomal development (Bolanos *et al.*, 1996). Lesser use of organic manures and boron fertilizers has resulted in deficiency of boron in soils which limits the growth, yield and nodulation of various legume crops including pea, indicating the need of its application.

MATERIAL AND METHODS

Present experiment was carried out at the Bahadari farm, College of Horticulture, Mandsaur, (M.P.). The soil of the experimental field was medium black (Vertisol) clay loam in texture with uniform topography. Twenty treatment combinations comprised of four varieties (V₁-Arkel, V₂-Kashi Nandini, V₃-Pusa Pragati and V₄-Kashi Samarth) of pea and five doses (B₁-0 kg/ha, B₂-1.0 kg/ha, B₃-1.5 kg/ha, B₄-2.0 kg/ha and

B₅-2.5 kg/ha) of boron were laid in factorial randomized block design with three replications. Pea seed was sown at a spacing of 30 cm row to row and 10 cm plant to plant at a depth of 3-4 cm. Before sowing, seeds were treated first with 2g mancozeb 75% WP + 1g carbendazim 50% WP @ per kg seed, thereafter with 5g PSB and 3g *Rhizobium, leguminosarum* culture per kg seed. Nitrogen, phosphorus and potash was applied at the rate of 45 kg/ha, 90 kg/ha and 60 kg/ha, respectively. The difference in percentage between total sugars and reducing sugar was taken as the estimate of non-reducing sugar. Crude protein content in green pea (g/100g) was determined with estimating total nitrogen with micro-Kjeldahl method and multiplying the nitrogen content with factor 6.25 as described by Thimmaiah (1999). The potassium content in plant was estimated by flame photometer as described by Black (1965).

RESULTS AND DISCUSSION

Effect on growth parameters

The findings pertaining to growth parameters *viz.*, plant height, number of primary branches, fresh weight of plant and plant dry weight indicated significant influence of different varieties and boron doses. The maximum plant height was found with variety V₄ (Kashi Samarth) at 30, 45 and 60 DAS. It was followed by V₃ (Pusa Pragati) and V₂ (Kashi Nandini) in descending order at all the stages under study. The minimum plant height was recorded in case of V₁ (Arkel) at all the stages under study. Though at 30 DAS there was non-significant difference in plant height of pea varieties. Differences in plant height among varieties might be attributed to their genetic diversity. Singh *et al.* (2015b) also reported significant influence of varieties on plant height. Variety V₄ (Kashi Samarth) recorded the maximum number of

primary branches per plant at 30, 45 and 60 DAS. It was followed by V₃ (Pusa Pragati) and V₂ (Kashi Nandini) at all the stages under study. The minimum number of primary branches were found with V₁ (Arkel) at all the stages i.e. at 30, 45 and 60 DAS. These findings are in accordance to those obtained by Gupta and Singh (2007). Variety V₄ (Kashi Samarth) registered highest fresh weight of plant at all the stages under the study. It was followed by V₂ (Kashi Nandini) at 30 and 45 DAS, but at 60 DAS by V₃. The lowest fresh weight of plant was recorded with V₁ (Arkel) at all the growth stages under study. Boron doses exerted significant effect on plant height at all the three growth stages. Application of boron B₅ recorded the maximum plant height at 30, 45 and 60 DAS followed by B₄ > B₃ > B₂ in descending order at all the growth stages. The minimum plant height was measured with application of boron dose B₁ at 30, 45 and 60 DAS. Boron is essential for cell wall synthesis, cell differentiation ribonucleic acid (RNA) metabolism thereby its increased availability might have enhanced the plant height. These results are in agreement to the findings obtained by Singh *et al.* (2012a), and Sharma and Sharma (2016).

Effect on SPAD value, nodulation and phenological parameters

The findings pertaining to number of nodules per plant, SPAD value in leaves, days taken to 50% flowering and number of days taken to first picking indicated significant influence of different varieties and boron doses.

The maximum SPAD value in leaves was noted with variety V₄ (Kashi Samarth) at 30, 45 and 60 DAS. It was followed by V₃ (Pusa Pragati) and V₂ (Kashi Nandini) at all the stages under study. The difference between V₄ and V₃ was non-significant. The lowest SPAD value was observed under V₁ (Arkel) at all the

stages i.e. at 30, 45 and 60 DAS. The maximum number of nodules per plant were recorded with variety V₄ (Kashi Samarth) at all the stages under the study. It was followed by V₂ (Kashi Nandini) at 30 and 45 DAS and by V₃ (Pusa Pragati) at 60 DAS under this study. The minimum number of nodules per plant were observed with V₁ (Arkel) at all the stages i.e. 30, 45 and 60 DAS. Variety V₄ (Kashi Samarth) had taken the maximum days to 50% flowering. It was followed by V₃ (Pusa Pragati) and V₂ (Kashi Nandini) in descending order. The minimum days to 50% flowering were taken by variety V₁ (Arkel). Application of boron indicated significant effect on SPAD values in leaves at all the three growth stages. Boron dose B₅ recorded the maximum SPAD values at 30, 45 and 60 DAS followed by B₄ > B₃ > B₂ in descending order at all the growth stages. Application of boron caused significant influence on days to 50% flowering. Each higher dose of boron delayed flowering. Boron dose B₅ recorded the maximum days to 50% flowering followed by B₄ > B₃ > B₂ in descending order. Earliest 50% flowering was commenced under boron dose B₁. Under lower boron application there was lesser availability of nitrogen thereby lesser growth which might have caused to early flowering in plants. There was significant increase in days taken to first picking with each increasing boron dose. Application of B₅ recorded the highest days taken to first picking which was followed by B₄ > B₃ > B₂. The minimum days taken to first picking were noted in case of B₁ dose of boron.

Yield parameters and yield

The highest number of pods per plant was found with variety V₄ (Kashi Samarth) which was followed by V₂ (Kashi Nandini) and V₃ (Pusa Pragati). The lowest number of pods was observed in case of variety V₁ (Arkel). Differences in number of pods among varieties may be due to their genetic potential. The

longest pod was found in variety V₃ (Pusa Pragati) which was followed by V₁ (Arkel) and V₄ (Kashi Samarth). Smallest pod was observed in case of variety V₂ (Kashi Nandini). The highest number of seed per pod was noted with variety V₃ (Pusa Pragati) which was followed by V₁ (Arkel) and V₄ (Kashi Samarth). The lowest number of seed per pod was counted in case of variety V₂ (Kashi Nandini). The maximum weight of 10 pods was found with variety V₃ (Pusa Pragati) which was followed by V₁ (Arkel) and V₄ (Kashi Samarth).

Application of boron had exerted significant effect on pod length, number of seed per pod, 10 pods weight and green pod yield. Each increase in boron doses resulted in consequent increase in all these parameters. Use of B₅ recorded the maximum pod length, number of seed per pod, 10 pods weight and green pod yield which was followed by B₄ > B₃ > B₂. The minimum pod length, number of seed per pod, 10 pods weight and green pod yield were observed in case of B₁ dose of boron. Boron is essential for cell division which increased the growth parameters as well as yield parameters.

The higher growth attribute and yield attributes consequently lead to higher yield with higher dose of boron. There was improvement in shelling (%) with each increase in boron dose. The highest shelling percentage was found under B₅. It was followed by B₄ > B₃ > B₂. The lowest shelling percentage was recorded under B₁. Similar observations have also been reported by Hossain *et al.* (2011), and Sharma and Sharma (2016)

Effect on quality parameters

Quality parameters *viz.*, TSS (°Brix), sugar (%), as well as protein content in green pea indicated significant effect of varieties and boron doses. The highest TSS was found with

variety V₁ (Arkel) which was followed by V₃ (Pusa Pragati) and V₂ (Kashi Nandini) with significant difference. The lowest TSS was observed in case of variety V₄ (Kashi Samarth). Gupta and Singh (2007) also noted significant differences in TSS content among pea genotypes.

Effect on nutrient content in plant

The highest nitrogen, phosphorus and potassium content were found with variety V₄ (Kashi Samarth) which was followed by V₂ (Kashi Nandini) and V₃ (Pusa Pragati). The lowest nitrogen, phosphorus and potassium content were observed in case of variety V₁ (Arkel). These results are in agreement to the findings obtained by Khattab *et al.* (2016) and Kumari *et al.* (2017).

Effect on available nutrients in soil

After last picking of green pods, plants were uprooted and soil samples were collected from each plot to determine the available NPK and boron content in soil.

The highest available nitrogen, phosphorus and potassium in soil was found with variety V₁ (Arkel) which was followed by V₂ (Kashi Nandini) and V₃ (Pusa Pragati). The lowest nitrogen, phosphorus and potassium content in soil was determined in case of variety V₄ (Kashi Samarth). The highest available phosphorus content was recorded under B₁. It was followed by B₂ > B₃ > B₄. The lowest available phosphorus content was determined under B₅ which was at par to B₄. Higher production with use of boron might have resulted in more depletion of available phosphorus from the soil. Similar observations have been reported by Chatterjee and Bandyopadhyay (2015). Boron doses exerted significant effect on available potassium content in soil. Application of B₁ recorded the maximum potassium content followed by B₂ > B₃ > B₄. The minimum

available potassium content was determined under boron dose B₅. Lesser available potassium in soil with increasing boron doses may be attributed to higher up take by the plants for fulfilling its higher yielding demands. These findings are in agreement of those reported by Chatterjee and Bandyopadhyay (2015).

Effect on economics

Among the varieties, V₄ (Kashi Samarth) recorded the maximum gross income, net income and B: C ratio. It was followed by V₃ (Pusa Pragati) and V₂ (Kashi Nandini) in

descending order. The minimum gross income, net income and B: C ratio were found with variety V₁ (Arkel). Higher yield due to genetic potential consequently resulted in more economic returns. Application of boron doses caused significant influence on gross income, net income and B: C ratio. Boron dose B₅ recorded the maximum gross income, net income and B: C ratio followed by B₄ > B₃ > B₂ in descending order. The minimum gross income, net income and B: C ratio was obtained with boron dose B₁. Application of boron enhanced the pod yield which ultimately resulted in higher economic returns.

Table 1. Effect of varieties and boron doses on growth parameters in pea

Treatment	Plant height (cm)			No. of primary branches	Fresh weight of plant (g)			Dry weight of plant (g)		
	30DAS	45DAS	60DAS		30DAS	45DAS	60DAS	30DAS	45DAS	60DAS
Varieties										
V ₁	19.40	29.37	49.51	3.22	5.70	29.24	77.91	0.68	3.80	10.12
V ₂	19.85	29.94	50.95	3.43	6.08	31.69	81.69	0.74	4.41	10.62
V ₃	19.97	30.41	51.75	3.46	5.95	30.48	81.93	0.70	4.16	10.91
V ₄	20.66	31.47	56.40	3.69	6.30	34.46	85.59	0.79	4.68	11.50
S.Em±	0.47	0.93	1.53	0.09	0.15	0.72	1.72	0.02	0.10	0.22
CD _{5%}	NS	2.64	4.38	0.26	0.41	2.04	4.92	0.05	0.27	0.62
Boron doses										
B ₁	18.65	28.52	46.95	3.13	5.12	26.44	74.09	0.65	3.31	9.12
rsid13959421B ₂	19.48	29.73	50.82	3.37	5.59	28.47	79.30	0.68	3.76	10.14
B ₃	20.20	30.94	52.40	3.48	6.19	31.35	82.34	0.73	4.44	10.96
B ₄	20.53	32.13	54.30	3.53	6.52	34.76	84.60	0.79	4.86	11.53
B ₅	20.98	32.68	56.28	3.73	6.62	36.33	88.57	0.80	4.93	12.17
S.Em±	0.52	1.04	1.71	0.10	0.16	0.80	1.92	0.02	0.11	0.24
CD _{5%}	1.48	2.96	4.89	0.29	0.46	2.28	5.50	0.05	0.30	0.69

Evaluation of Boron Doses on Different Varieties of Pea (Pisum Sativum L.)

Table 2. Effect of varieties and boron doses on SPAD values, nodulation and phenological parameters in pea

Treatment	SPAD Value in leaves			Number of nodules per plant			Phenological parameters	
	30DAS	45DAS	60DAS	30DAS	45DAS	60DAS	Days to 50% Flowering	Days to first Picking
Varieties								
V ₁	40.83	42.69	43.06	21.34	31.01	14.67	37.96	67.75
V ₂	43.46	44.28	44.93	23.98	33.84	15.39	43.89	73.45
V ₃	44.66	45.17	45.67	21.99	34.24	15.79	56.05	91.36
V ₄	46.53	47.17	46.83	25.62	37.48	18.11	59.84	94.71
S.Em±	1.40	1.09	0.93	0.52	0.81	0.40	1.27	1.42
CD _{5%}	4.00	3.12	2.67	1.48	2.31	1.13	3.63	4.07
Boron doses								
B ₁	38.84	41.12	41.07	19.89	30.22	12.59	42.89	75.76
B ₂	41.63	43.13	43.71	21.24	31.34	14.13	47.65	81.42
B ₃	44.35	45.13	45.92	22.98	33.66	15.89	50.58	82.13
B ₄	46.94	46.92	46.88	24.65	36.46	17.62	52.30	83.10
B ₅	47.59	47.86	48.05	27.42	39.05	19.72	53.75	86.68
S.Em±	1.56	1.22	1.04	0.58	0.91	0.44	1.42	1.59
CD _{5%}	4.47	3.49	2.98	1.65	2.58	1.26	4.06	4.55

Table 3. Effect of varieties and boron doses on yield parameters and yield in pea

Treatment	Number of pod per plant	Pod length (cm)	No. of seed per pod	Ten pod weight (g)	Green pod yield (q/ha)	Shelling %
Varieties						
V ₁	18.84	8.77	8.13	40.40	64.28	43.43
V ₂	24.79	7.78	7.67	38.17	70.80	45.70
V ₃	20.59	9.13	8.47	42.97	74.53	42.67
V ₄	25.48	8.16	8.07	39.50	80.76	47.33
S.Em±	0.90	0.18	0.19	1.10	2.03	1.21
CD _{5%}	2.56	0.53	0.53	3.13	5.80	3.45
Boron doses						
B ₁	17.80	7.95	7.08	36.04	62.23	41.21
B ₂	19.80	8.12	7.58	38.63	69.96	43.42
B ₃	23.05	8.34	8.17	40.21	72.88	45.58
B ₄	25.02	8.75	8.42	42.46	77.16	46.33
B ₅	26.46	9.15	9.17	43.96	80.74	47.38
S.Em±	1.00	0.21	0.21	1.23	2.27	1.35
CD _{5%}	2.86	0.59	0.59	3.50	6.48	3.87

Table 4. Effect of varieties and boron doses on quality in green pea

Treatment	TSS (°Brix)	Total sugar (%)	Reducing sugar (%)	Non reducing (%)	Protein content (%)
Varieties					
V ₁	10.91	10.53	8.02	2.51	19.99
V ₂	9.99	9.28	5.62	3.64	20.69
V ₃	10.28	10.09	7.49	2.60	19.73
V ₄	9.52	8.93	5.30	3.61	21.63
S.Em±	0.18	0.18	0.10	0.06	0.30
CD _{5%}	0.51	0.50	0.28	0.15	0.86
Boron doses					
B ₁	9.28	8.91	5.93	2.78	18.37
B ₂	9.78	9.20	6.21	2.92	19.49
B ₃	10.19	9.72	6.59	3.08	21.07
B ₄	10.44	10.03	6.96	3.25	21.48
faautoB ₅	11.19	10.67	7.35	3.41	22.15
S.Em±	0.20	0.15	0.11	0.06	0.34
CD _{5%}	0.57	0.43	0.31	0.17	0.96

Table 5. Effect of varieties and boron doses on nutrients content in pea plant

Treatment	Nitrogen content (%) in plant	Phosphorus content (%) in plant	Potassium content(%) in plant	Boron content in plant (ppm)
Varieties				
V ₁	2.35	0.26	0.68	27.94
V ₂	2.44	0.35	0.93	30.98
V ₃	2.39	0.29	0.75	28.87
V ₄	2.50	0.42	0.94	32.07
S.Em±	0.04	0.01	0.02	0.50
CD _{5%}	0.11	0.03	0.04	1.42
Boron doses				
B ₁	2.16	0.25	0.79	25.56
B ₂	2.30	0.30	0.81	28.78
B ₃	2.47	0.34	0.83	29.75
B ₄	2.55	0.37	0.84	31.39
B ₅	2.63	0.40	0.86	34.35
S.Em ±	0.05	0.01	0.02	0.56
CD _{5%}	0.12	0.03	0.05	1.59

Table 6. Effect of varieties and boron doses on available nutrients in soil

Treatment	Nitrogen content in soil (kg/ha)	Phosphorus content in soil (kg/ha)	Potassium content in soil (kg/ha)	Boron content in soil (ppm)
Varieties				
V ₁	210.40	11.54	373.39	1.19
V ₂	209.40	11.40	365.04	1.14
V ₃	204.27	11.20	359.97	1.08
V ₄	200.73	10.54	338.48	1.08
S.Em±	2.56	0.20	6.20	0.02
CD _{5%}	7.32	0.57	17.74	0.05
Boron doses				
B ₁	198.83	12.09	388.31	1.01
B ₂	210.58	11.54	367.88	1.09
B ₃	210.00	11.19	357.19	1.12
B ₄	207.00	10.79	346.65	1.17
B ₅	203.58	10.24	336.06	1.22
S.Em ±	2.86	0.23	6.93	0.02
CD _{5%}	8.18	0.64	19.84	0.06

Table 7. Economics of different varieties and boron doses in pea

Treatment	Gross income(Rs/ha)	Expenditure (Rs/ha)	Net income(Rs/ha)	B:C ratio
Varieties				
V ₁	64278.67	32168	32377.33	1.00
V ₂	70800.00	32168	38632.00	1.20
V ₃	74528.67	32168	42360.67	1.31
spalphaV ₄	80760.67	32168	48592.67	1.50
S.Em±	2023.91	-	2019.84	0.03
CD _{5%}	5794.31	-	5782.64	0.06
Boron doses				
B ₁	62226.67	28668	33558.67	1.17
B ₂	69959.17	31168	38791.17	1.24
B ₃	72879.17	32418	40794.50	1.26
B ₄	77156.67	33668	43488.67	1.29
B ₅	80738.33	34918	45820.33	1.31
S.Em±	2262.80	-	2258.25	0.03
CD _{5%}	6478.23	-	6465.19	0.07

CONCLUSIONS

The experiment demonstrated that variety Kashi Samarth outperformed other pea varieties in terms of green pod yield, pod number, and overall quality, making it the most promising cultivar for cultivation under

the given conditions. Among the boron treatments with 2.5 kg/ha, proved to be the most effective, significantly enhancing growth, yield parameters, and quality traits such as TSS, reducing sugar, and total sugar content. Therefore, the combination of Kashi

Samarthwith 2.5 kg/ha Boron can be recommended for achieving higher productivity and better economic returns in pea cultivation at Mandasaur and similar agro-climatic regions.

REFERENCES

- Amjad, M. and Anjum, M. (2002). Performance of nine pea cultivars under Faisalabad conditions. *Pak. J. Agri. Sci.* **39**: 16-19.
- Black, C. A. (1965). *Methods of Soil Analysis*. American Society of Agronomy, Publisher Madison, Wisconsin, USA. 15: 720.
- Bolanos, L.; Brewin, N. J. and Bonilla, I. (1996). Effects of boron on rhizobium-legume cell-surface interactions and nodule development. *Plant Physiol.*, **110**:1249-1256.
- Chatterjee, R. and Bandyopadhyay, S. (2015). Effect of boron, molybdenum and biofertilizers on growth and yield of cowpea (*Vigna unguiculata* L. Walp.) in acid soil of eastern Himalayan region. *J. Saudi. Soci. Agric. Sci.*, <http://dx.doi.org/10.1016/j.jssas.2015.11.001>.
- Gupta, A. J. and Singh, Y. V. (2007). Evaluation of garden pea (*Pisum sativum* L.) genotypes for earliness, yield and quality attributes. *Haryana J. hortic. Sci.*, **36**(1&2): 106-110.
- Hossain, A.; Sarker, M. A. Z.; Hakim, M. A.; Islam, Mst.T. and Ali, M.E. (2011). Effect of lime, magnesium and boron on wheat (*Triticum aestivum* L.) and their residual effects on mungbean (*Vigna radiata* L.). *Int. J. Agril. Res. Innov. & Tech.*, **1**(1&2): 9-15.
- Khatab, E. A.; Badr, E. A. and Afifi, M. H. (2016). Response of some varieties of faba bean (*Vicia faba* L.) to boron and potassium. *Int. J. Chem Tech Res.*, **9**(8): 98-103.
- Kumari, M.; Verma, S. C.; and Bhardwaj, S. K.; (2017). Impact of elevated CO₂ and temperature on quality and biochemical parameters of pea (*Pisum sativum* L.). *Indian J. Agri. Sci.*, **87**(8): 1035-1040.
- Sharma, A. and Sharma, R. P. (2016). Effects of boron and lime on productivity of garden pea under acidic soils in northwestern Himalayas. *Communications Soil Sci. Plant Analysis*, **47**(3): 291–297.
- Singh, D. K.; Singh, A. K.; Singh, M.; Bordoloi, L.J. and Srivastava, O. P. (2012a). Production potential and nutrient uptake efficiency of pea (*Pisum sativum* L.) as influenced by different fertility levels and micronutrients. *J. Indian Society Soil Sci.*, **60**(2): 150–155.
- Singh, V.; Shah, K. H. N. and Rana, D.K. (2015b). Performance of pea (*Pisum sativum* L.) genotypes under valley condition of Garhwal Himalayan region. *HortFlora. Res. Spectrum*, **4**(2): 164-167.
- Thimmaiah, S.K. (1999). *Standard Methods of Biochemical Analysis*. Kalyani Publishers, Ludhiana, India, p545.

EVALUATION OF PHYSICO-CHEMICAL PROPERTIES OF CUCUMBER CHIPS FRIED IN DIFFERENT EDIBLE OILS

AWADHESH KUMAR YADAV¹, SURESH CHANDRA¹, B.R. SINGH¹, JAIVIR SINGH¹, NEELASH CHAUHAN¹, DEEPAK K. MISHRA¹, TARUN KUMAR¹ AND S.P. SINGH²

¹*Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh*

²*ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut (UP)*

Corresponding author's email: manishforestry@gmail.com

ABSTRACT

The study was carried out to evaluate the Physico-chemical properties of cucumber chips fried in different vegetable oils. The mustard, sunflower, groundnut, and canola oils were used to deep fry ready-to-eat cucumber chips at temperatures of 180°C for 15 to 45 seconds. The physio-chemical characteristics of cucumber chips, such as their moisture content, ash content, pH level, acidity, color (L*, a*, and b*), and whiteness index, were significantly affected by the various types of oils used in the deep-frying process. The color, texture, taste, crispiness, and acceptability of the cucumber chips were analyzed after frying in various oils. After frying in mustard oil, the cucumber chips' ash content ranged between (1.65-8.23 %). As a consequence, treatment with Calcium Chloride (CaCl₂) 1% and Sodium Chloride (NaCl) 1% had the highest ash concentration (8.23%), whereas treatment with Sodium Chloride, 1% (1.65%) had the lowest ash content.

Key words: Cucumber chips, Edible oil, Deep frying, Physio-chemical properties.

Cucumber (*Cucumis sativus* L.) is one of the most popular vegetables in many countries. Cucumber is considered as fourth most important vegetable crop after tomato, cabbage and onion. It constitutes moisture (96.3g), protein (0.4g), fat (0.1g), minerals (0.3g), fiber (0.4g), carbohydrate (2.5g), calcium (10mg), phosphorus (25mg), iron (1.5mg). Chips making is one of the popular techniques for preservation of many fruits and vegetables. It involves pushing or forcing a thin, sharp knife to shear through the material intended to be sliced (Owolarafe *et al.*, 2007). Deep frying is one of the most common methods used for the preparation of food. Due to failures in harvesting techniques and poor quality of post-harvest technologies,

about 30% of this produce is wasted. If vegetables are made into snacks of different tastes, textures, and flavors, using different drying and processing methods, their acceptability often increases. Frying is a process of immersing food in hot oil with a contact among oil, air, and food at a high temperature of 150 to 190 °C. Frying oil acts as a heat transfer medium and contributes to the texture and flavour of fried food (Mudawi *et al.*, 2014). Fried foods have desirable flavour, colour and crispy texture, which make deep-fat fried foods very popular and acceptable to consumers. This paper discusses the effect of different frying oils and pretreatments on the quality of cucumber chips.

MATERIALS AND METHODS

Preparation of Cucumber Chips

Cleaning and trimming of procured fresh cucumber were done manually. The Cucumbers were peeled and cut into 2mm thin with help of vegetable slicer. The Cucumber slices were blanched into boiling water (90°C) for 5 minutes. The samples were then cooled under running tap water to prevent over cooking and discoloration. Blanched and cooled slices were treated for 5 min. by at different levels (i) Control (T₁); (ii) Sodium Chloride, 1% (T₂); (iii) Potassium metabisulphite (0.5% KMS) and Sodium Chloride (1%, NaCl) (T₃); (iv) Potassium metabisulphite (0.5%, KMS) and Sodium Chloride (1%, NaCl) and Citric acid, 0.5 % (T₄) and (v) Calcium Chloride (CaCl₂) 1% and Sodium Chloride (NaCl) 1% (T₅). After 5 minutes, treatment solution was drained, and slices were spread in trays for tray drying at 60°C for 4 hours. The dried slices of 250g per batch were deep-fried at 180°C. The fried-Cucumber chips were spread on paper to remove excess oil. The Cucumber chips products were packaged (40 g per batch) in HDPE pouches for further analysis.

Proximate Composition: The deep-fried cucumber chips were analyzed for moisture (AOAC, 2002), ash (AOAC, 2000), Acidity and pH by using the procedures of Ranganna (2010).

Sensory evaluation: The sensory attributes in terms of color, texture, taste, crispiness and overall acceptability, were evaluated using a 9-point scale for likeness where 9=Like extremely, 8=Like very much, 7=Like moderately, 6=Like slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much, 1=Dislike extremely. The cucumber chips were deep fried in Mustard oil, Sunflower oil, Groundnut oil, Canola oil and served warm to a

semi-trained panel of judges. The coded samples were served to the panelists in random order. The nature of experiments was explained to the panelists without disclosing the identity of samples. Water was provided to rinse the mouth between the samples. The panelists judged the samples for color, texture, taste, crispiness and overall acceptability.

Color analysis of chips (L, a*, b* values)*

Color analysis of deep-fried cucumber chips was done by using a colorimeter (3nH Colour meter, China) after calibration with a white reference plate. Reading was displaced as L*, a*, and b* color parameters. The a* value ranged from +100 (redness) to -100 (greenness), the b* values ranged from +100 (yellowness) to -100 (blueness) while as L* value indicating the measure of lightness, ranged from 0 (black) to 100 (white). The whiteness index was measured by the whiteness meter.

RESULTS AND DISCUSSION

Proximate analysis of cucumber chips

Moisture content: Table 1 shows the percentage of moisture in fresh cucumber chips as T1 (91.25), T2 (95.22), T3 (95.87), T4 (95.81), and T5 (96.01). 91.25-96.01% was the range of the moisture content. The treatment with the highest moisture content was T5, and the one with the lowest was T1. It suggests the outcome was the product of several treatments, which led to various moisture contents. There will be less moisture content to be found in treatment T1 because it was a control treatment. Treatment T5 involved treating the sample with 1% CaCl₂+ 1% NaCl at 90°C for 5 minutes to increase the moisture content. Table 2 shows the range of moisture content (2.69-3.65%) of the cucumber chips after frying in mustard oil. T5 had the lowest moisture level (2.69 %) and treatment T1 had the greatest moisture content (3.65%).

According to this outcome, there was a greater moisture loss after frying the cucumber chips in mustard oil. Less moisture was lost in treatments T5 and higher in T1. After being fried in sunflower oil, the cucumber chips' moisture content ranged from 1.38 to 2.78 (Table 3). Treatment T5 had the highest moisture content (2.78%), and T2 had the lowest moisture content (1.38%). The outcome indicates that after being compressed between two batches of mustard oil frying cucumber chips, there was low moisture content in the chips (Table 4). The range of moisture percentage of the fried cucumber chips (2.07-2.76%) was recorded with the groundnut oil. Treatment T5 (2.76%) had the highest moisture content, while T3 had the lowest moisture content (2.07%). Cucumber chips with moisture content of between 1.94% and 4.76% were the outcome, as shown in Table 5. Chemical treatment with 0.5%KMS+ 1%NaCl+ 0.5% CA at 90°C for 5 minutes had a greater impact on this result of treatment T4.

Ash content: Table 1 shows that the ash content of fresh cucumber chips ranged from (4.06-7.87%). Treatment T5 had the highest ash concentration (7.87), whereas T3 had the lowest (4.06). Treatment T3 (Blanching with 0.5% KMS+1% NaCl at 90°C for 5 minutes) had an impact on the ash content result. Treatment T5 (1% CaCl₂+ 1% NaCl at 90°C for 5 minutes) had the greatest impact on ash content (Table 2). After frying in mustard oil, the cucumber chips' ash content ranged between (1.65-8.23%). As a consequence, treatment T5 (8.23%) had the highest ash concentration, whereas treatment T1 (1.65%) had the lowest ash content. As a result, the cucumber chips from treatment T5 were more adversely affected, and greater ash content was recorded (Table 3). The amount of ash in cucumber chips after they have been fried in sunflower oil. The range of the ash content was (1.51-6.54%). Treatment T5 had the

greatest ash content value, whereas T1 had the lowest value. The effects of treatment T5 were greater and those of treatment T1 were less. Table 4 shows the range of ash concentration for the fried cucumber chips in groundnut oil (2.93-6.90). The treatments with the greatest and lowest ash contents, respectively, were 6.90 (T5) and 2.93 (T1). As a result, treatment T5 had a higher ash content, which indicates that the chemical was more negatively impacted by this treatment. Except for blanching at 90°C for 5 minutes, T1's resulted in less ash content. The canola oil fried cucumber chips showed the ash contents ranging from 1.94 to 8.35 (Table 5). The treatments with the greatest and lowest ash contents, respectively, were T5 (8.35) and T1 (1.94), respectively.

pH: Results for the treatments T1, T2, T3, T4, and T5 for the pH of the cucumber chips were 7.36, 7.32, 7.03, and 6.36 respectively (Table 1). Table 2 shows the pH range (6.44-6.87) of cucumber chips that have been fried in mustard oil. The pH values that were greatest and lowest, respectively, were in treatment T2 (6.87) and T5 (6.44). Table 3 lists the pH range (5.28–6.88) for the frying of cucumber chips in sunflower oil. The cucumber chips' highest pH value (6.68) and lowest pH value (5.28) were in treatment T2 and T1, respectively. As a result, the pH scale showed that the greatest pH indicated mild acidity and the lowest pH indicated strong acidity. Consequently, compared to low acidity products, high acidity products were more preservative. Table 4 shows the results, which included a range of cucumber chips (5.31–7.27) frying in groundnut oil. The pH values in treatment T2 were the greatest (7.27) and lowest (5.31), respectively. The method T5 for frying cucumber chips in groundnut oil produced the best results. Table 5 showed the pH range (5.14-6.84) for cucumber chips fried in canola oil. Treatment

T2 had the greatest pH (6.84), while T1 had the lowest pH (5.14). The treatment T1 that cooks the cucumber chips in canola oil came out on top. Only blanching was used during treatment; there were no chemical processes.

Acidity: The % acidity values of each pretreated cucumber chip are given in Table 1. For different treatments it was as T1 (0.05), T2 (0.06), T3 (0.09), T4 (0.10), and T5 (0.07). Treatment T4 (0.10) had the highest acidity, while T1 (0.05) had the lowest. Treatment T4 (blanching with 1% NaCl+0.5% KMS+0.5%CA at 90°C for 5 minutes) had a greater impact since the treatment T4 was more acidic. Only blanching was used in treatment T1; no chemical processes were used. Table 2 shows that the cucumber chips' range of acidity after frying in mustard oil was 0.07–0.12. Treatment T4 had the greatest (0.12) and lowest (0.07) acidities of the frying cucumber chips. Products with higher levels of acidity require more preservatives than those with lower levels of acidity. This outcome was largely influenced by the KMS and CA treatments of the cucumber chips. Table 3 shows that the cucumber chips fried in sunflower oil ranged in acidity from 0.07 to 0.12. Treatment T5 had the highest acidity reading (0.12), while T1 had the lowest reading (0.07). It implies that the outcome was that calcium chloride and sodium chloride had a greater impact on the treatment T5. The acidity range of cucumber chips fries in groundnut oil was 0.07 to 0.15, as shown in Table 4. T1 treatment had the highest acidic value (0.15), while T3 had the lowest acidic value (0.07). The T1 outcome, which involved frying cucumber chips in groundnut oil, was the best. The outcome was a variety of canola oil-fried, acidic (0.06-0.12) cucumber chips. The treatments T1 and T2 and T4 had the greatest and lowest acidic values, respectively (0.12 and 0.06). In comparison to the alternative treatment, which involved

deep-frying cucumber chips in canola oil, T1's results were the best (Table 5).

Color: L* (lightness), a* (red-green), and b* (yellow-blue) are the three parameters that determine the color. The a* and b* parameters have a range of -128 to 127, while the L* parameter has a range of 0 (lightness) to 100 (black). L* values for treatments T1 (40.00), T2, 39.19, T3, 75.46, T4, and T5 (61.09). The results showed that treatment T2 had the highest L* (75.46) value and treatment T3 had the lowest L* (39.19), meaning that treatment T2 had the highest lightness color of cucumber chips and treatment T3 had the lowest lightness color of fresh cucumber chips. The a* value for treatments T1 (-5.07), T2 (-4.80), T3, -3.50, T4, and T5 (-6.44). Table 1 displays the findings. Lowest a* value in the treatment T3 (-7.14) and highest a* value in T5 (-3.50). With a higher a* value in T3, the green color is more pronounced, and a lower a* in T5, the green color is less pronounced. The b* value for treatments T1 (12.69), T2, T3, T4, T5, and T5 (13.97, 14.71, and 17.02). Table 1 displays the findings. Both the lowest b* value in treatment T2 (10.96) and the greatest b* value in treatment T5 (17.02) were obtained. This outcome has more yellow color in T5 where the b* value is greater and less yellow color in T2 where the b* value is lower. Table 2 shows the value's color after the cucumber chips were fried in mustard oil. The L* value ranged between (27.43 and 46.53). The L* had the highest value in treatment T1 (46.53) and the lowest value in treatment T3 (27.43). This resulted in the cucumber chips in treatment T3 being fried in mustard oil more lightly and those in treatment T1 being fried in less lightly. While there was only blanching in treatment T1 and no chemical treatment, there was also blanching in treatment T3. The 0.5% KMS+1% NaCl with 90°C blanching in 5 minutes treatment T3 had a greater impact on the outcome. The range of the a* value is (-1.57

to +4.64). The highest a^* value in treatment T3 (+4.64) and the lowest a^* value in treatment T1 (-1.57). The treatment T3 value of the a^* had more red color as a result, whereas the treatment T1 value had more green color. The range of the cucumber chip's b^* value (7.15–14.05). The highest b^* value in treatment T1 (14.05) and the lowest b^* value in treatment T5 (7.15). The outcome indicated that treatment T1 produced the most yellow-colored frying cucumber chips, whereas treatment T5 produced the least yellow-colored chips. Table 3 displays the Lightness L^* (27.86-46.06) color value range for the fried cucumber chips in sunflower oil. The T5 (46.06) treatment had the greatest and lowest brightness color values, respectively, while the T2 (27.86) had the lowest. Cucumber chips that were frying in sunflower oil had a lighter color as a result of treatment T2, which had a greater impact. (0.57-7.70) is the color value of a^* . The treatment T3 (7.70) had a greater a^* value as a result, whereas the T5 (0.57) had a lower value. As a result, the treatment T3's red color was higher and the treatment T5's red color was lower. The b^* value of the fried cucumber chips in sunflower oil was (11.84-16.81). The treatment with the highest b^* value was T4 (16.81), and the one with the lowest b^* value was T2 (11.84). The T4 treatment produced the most yellow, and the T2 treatment produced the least yellow. Table 4. The L^* color spectrum of the fried groundnut oil-based cucumber chips (25.38–44.89). The treatment T3 had the lowest L^* value (25.38) and treatment T2 had the greatest L^* value (44.89) for the cucumber chips. The treatment with the highest level of lightness, T3, and the one with the lowest level of lightness, T2, were the outcomes. The range of the cucumber chips' a^* colors is 7.06–13.79. The treatment T2 had a a^* value of 13.79, and the therapy T3 had an a^* value of 7.06. As a result, treatment T2 was redder in color than

the other treatments. The cucumber chip color groundnut (11.90–30.66) in b^* . The treatment T2 had the highest b^* value (30.66), while the therapy T3 had the lowest b^* value (11.90). As a result, treatment T2 had a more yellowish color, whereas treatment T3 had a less yellowish color. Table 5. The L^* color gamut of the canola oil-fried cucumber chips (38.84–52.03). The treatment T5 had the highest L^* value (52.03) while the treatment T3 had the lowest L^* value (38.84). The outcome was the lowest L^* value for color lightness and the greatest L^* value for black color. Results showed that treatment T3 had more color lightness and that treatment T5 had less color lightness when compared to other treatments. The cucumber chips cooked in canola oil had a a^* color range of (0.07-8.62). The treatment T2 (0.07) had the lowest a^* value and the treatment T4 (8.62) had the greatest a^* value for the cucumber chip treatment. In the end, cucumber chips from treatment T4 had the red color while those from treatment T2 had the least red color. Cucumber chips in treatment T4 were more negatively impacted. The cucumber chips' b^* color range (6.40–27.61) was determined using canola oil. Lowest b^* value for treatment T2 (6.40) and highest b^* value for treatment T5 (27.61). The outcome indicated that the treatment T5 cucumber chips had the highest yellow color and the treatment T2 had the lowest yellow color. Treatment T5 had a greater impact on the cucumber chips, which had a more yellowish color.

Whiteness Index: The whiteness indices for the treatments for fresh cucumber chips are shown in Table 1 as follows: T1 (29.70), T2 (31.30), T3 (40.10), T4 (29.70), and T5 (22.00). The highest (40.10) and lowest (22.00) whiteness indices were found in T3 and T5, respectively. Treatments T3 and T5 appeared more and less white, respectively, when light from a spectrophotometer of different

wavelengths was absorbed. Table 2 shows that the cucumber chips' whiteness index ranged from 37.90 to 69.50. Treatment T3 had the whitest cucumber chips (whiteness index: 69.50), while treatment T4 had the whitest cucumber chips (whiteness index: 37.90). Cucumber chips cooked in mustard oil with the treatment T3 produced a whiter product, while the treatment T4 produced chips with a lower whiteness index. The impact of the product's chemical processing was greater in treatment T4. Table 3 shows the range of the whiteness index for the fried cucumber chips in sunflower oil (16.60-35.60). Treatment T3 had the greatest and lowest whiteness indices, respectively (35.60 and 16.60). The outcome indicated that treatment T3 produced more white cucumber chips, while treatment T2 produced the least amount of whiteness. Table

4 shows the whiteness index range of the groundnut oil-fried cucumber chips (26.40–58.40). Treatment T3 had the highest whiteness index (58.40), whereas T5 had the lowest (26.40). More whiteness index in treatment T3 and less in treatment T5 as a result. The groundnut oil-fried cucumber chips that were part of Treatment T3 were more negatively impacted. Table 5 shows the range (18.70–38.30) of the whiteness index for the fried cucumber chips in canola oil. Treatment T2 had the highest whiteness index (38.70), whereas treatment T3 had the lowest (18.70). Cucumber chips cooked in canola oil were found to be more negatively impacted by treatment T2. The treatment T2 had a higher whiteness index than the other treatments.

Table 1. Effect on proximate analysis of fresh cucumber chips

Treatment	Moisture	Ash	pH	Acidity	Color			W.I.
	%	%		%	L*	a*	b*	
T1	91.25±0.15	4.34±0.01	7.36±0.01	0.05±0.01	40.00	-5.07	12.69	29.70
T2	95.22±0.06	4.50±0.02	7.32±0.02	0.06±0.00	39.19	-4.80	10.96	31.30
T3	95.87±0.13	4.06±0.00	7.03±0.02	0.09±0.01	75.46	-3.50	13.97	40.10
T4	95.81±0.10	5.36±0.38	6.36±0.00	0.10±0.01	67.04	-6.44	14.71	29.70
T5	96.01±0.02	7.87±0.43	6.59±0.00	0.07±0.00	61.09	-7.14	17.02	22.00

Table 2. Effect on proximate analysis of cucumber chips fried in mustard oil

Treatment	Moisture	Ash	pH	Acidity	Color			W.I.
	%	%		%	L*	a*	b*	
T1	3.65±0.06	1.65±0.00	6.45±0.02	0.07±0.01	46.53	-1.57	14.05	50.50
T2	2.72±0.11	4.68±0.14	6.87±0.00	0.09±0.01	29.16	0.44	8.43	47.30
T3	2.85±0.10	2.78±0.01	6.49±0.02	0.08±0.00	27.43	4.64	10.63	69.50
T4	2.96±0.08	4.69±0.03	6.57±0.01	0.12±0.02	38.01	1.18	12.74	37.90
T5	2.69±0.08	8.23±0.11	6.44±0.01	0.09±0.00	33.19	-1.19	7.15	55.10

Table 3. Effect on proximate analysis of cucumber chips fried in sunflower oil

Treatment	Moisture	Ash	pH	Acidity	Color			W.I.
	%	%		%	L*	a*	b*	
T1	1.84±0.02	1.51±0.00	5.28±0.02	0.07±0.02	32.45	3.50	13.65	21.70
T2	1.38±0.02	3.92±0.01	6.88±0.00	0.08±0.01	27.86	3.01	11.84	16.60
T3	1.39±0.04	2.16±0.05	5.37±0.02	0.07±0.01	29.32	7.70	15.46	35.60
T4	2.15±0.03	3.34±0.04	6.80±0.01	0.11±0.01	37.21	2.91	16.81	22.60
T5	2.78±0.02	6.54±0.05	5.30±0.02	0.12±0.01	46.06	0.57	15.13	21.70

Table 4. Effect on proximate analysis of cucumber chips fried in groundnut oil

Treatment	Moisture	Ash	pH	Acidity	Color			W.I.
	%	%		%	L*	a*	b*	
T1	2.43±0.05	2.93±0.00	5.50±0.01	0.15±0.03	27.48	9.36	16.02	28.30
T2	2.26±0.02	4.50±0.10	7.27±0.03	0.09±0.01	44.89	13.79	30.66	33.30
T3	2.07±0.01	4.31±0.02	5.39±0.02	0.14±0.00	25.38	7.06	11.90	58.40
T4	2.61±0.10	4.34±0.01	6.69±0.01	0.07±0.00	36.24	9.36	26.01	32.50
T5	2.76±0.02	6.90±0.07	5.31±0.01	0.12±0.02	39.76	11.32	24.50	26.40

Table 5: Effect on proximate analysis of cucumber chips fried in canola oil

Treatment	Moisture	Ash	pH	Acidity	Color			W.I.
	%	%		%	L*	a*	b*	
T1	3.42±0.03	1.94±0.04	5.14±0.00	0.12±0.02	46.06	0.57	15.13	34.60
T2	2.84±0.05	4.19±0.02	6.84±0.01	0.06±0.00	41.60	0.07	6.40	38.30
T3	3.45±0.10	3.25±0.05	5.38±0.04	0.10±0.00	38.84	4.68	16.95	18.70
T4	1.94±0.02	4.56±0.03	6.80±0.01	0.06±0.00	44.85	8.62	26.03	24.60
T5	4.76±0.06	8.35±0.05	6.80±0.01	0.10±0.01	52.03	7.91	27.61	35.10

Sensory Evaluation

The sensory information for fresh cucumber chips that have been cooked in mustard oil and sunflower oil is displayed in Table 6 and 7. It includes color, texture, taste, crispiness, and overall acceptability scores. After being fried in mustard oil, cucumber chips had a color rating between 7.12 and 8.50. Treatment T1 had the lowest color value (7.12) and T4 had the greatest color value (8.50). The effects of the T4 treatment were more pronounced on the cucumber chips. The variety in texture of the fried cucumber chips in mustard oil (6.75-8.12). Treatment T4 had the greatest texture rating of the cucumber

chips (8.12), while treatment T5 had the lowest rating (6.75). Generally, textural attributes are a function of starch composition of the product as well as processing factors such as time of frying, temperature of frying oil, type of oil and size of fries. The treatment T4 had results that were extremely comparable to cucumber chips in terms of both color and texture, which were both more affected by the treatment.

The taste of the fried cucumber chips in mustard oil (6.62–7.25). The taste treatment T4 had a taste value of 7.25, while treatment T2 had a taste value of 6.62. Color, texture, and taste of the cucumber chips were more

significantly impacted by treatment T₄. The degree of crispness (6.50–7.75). In mustard oil, treatment T₁ produced the crispiest cucumber chips (6.75), whereas treatment T₅ produced the least amount (6.50). The range of the overall acceptability of fried mustard oil cucumber chips (6.87–7.87). Treatment T₅ had the lowest score (6.87), whereas T₄ had the greatest value (7.87). The outcome was that treatment T₄ of the cucumber chips frying in mustard oil was rated as having a moderate overall acceptability by the panel, while treatment T₅ had the lowest rating, rating it as having a slight overall acceptability. Cucumber chips that had been fried in sunflower oil had a color score range of (6.25-7.62). The treatment with the highest color value was T₄ (7.62), while the one with the lowest color value was T₁ (6.25). The effects of the T₄treatment were more pronounced on the cucumber chips. The thickness range of the sunflower oil-fried cucumber chips (6.50–7.25). Treatment T₄ had the greatest texture rating of the cucumber chips (7.25), and Treatment T₁ had the lowest rating (6.50). Similar color and texture were present, and both were more impacted by the treatment T₄, which had results that were somewhat akin to cucumber chips. The flavor of the fried cucumber chips in sunflower oil ranged between 6.12–7.25. With treatment T₄ having the highest taste value (7.25), and T₁ having the lowest taste value (6.12), respectively. The color, texture, and taste of the cucumber chips were more significantly impacted by treatment T₄. 6 to 7 to 50 is the range of crispness. Cucumber chips cooked in sunflower oil had a crispness value of T₄ (7.50) that was the highest, and T₅ (6.12), the lowest. The range of the cucumber chips' general acceptability when frying them in sunflower oil (6.31–7.40). T₁ had the lowest score (6.31) while T₄ had the highest value (7.40). Overall acceptance by the panel

indicated that the outcome was satisfactory. The cucumber chips in sunflower oil in treatment T₄ were like moderately, while T₁'s lowest overall acceptably value was like somewhat. The sensory information for the fresh cucumber chips' color, texture, taste, crispiness, and overall acceptability scores after being fried in canola oil and groundnut oil is shown in Table 7. Cucumber chips that had been fried in groundnut oil had a color score range of (6.25-7.50). The treatment with the highest color value was T₄ (7.50), and the one with the lowest color value was T₂ (6.25).

The cucumber chips were more impacted by the T₄ treatment. Cucumber chips that were fried in groundnut oil ranged in texture from 6.37 to 6.87. The cucumber chip treatments with the greatest and lowest texture values, respectively, were T₅ (6.87) and T₂, (6.37). When fried in groundnut oil, the texture of the cucumber chips was more significantly impacted by the T₅ additive. The taste of the fried groundnut oil-fried cucumber chips (6.25-8.62). The taste treatment T₄ scored the highest (6.62) and the lowest (6.25), respectively. The color and taste of the cucumber chips are more impacted by treatment T₄. 6.12 to 6.37 is the range of crispiness. Cucumber chips treated with T₃ in groundnut oil had a crispiness value of 6.37, whereas T₂ and T₅ had a crispiness value of 6.12. The range of the overall acceptability of groundnut oil-fried cucumber chips (6.31-6.71). Treatment T₂ had the lowest value (6.31) and Treatment T₄ had the highest value (6.71).

Overall acceptance by the panel indicated that the outcome was satisfactory. The lowest overall acceptably value of treatment T₂ and T₄ were like the fried cucumber chips in groundnut oil. Cucumber chips that had been fried in canola oil had a color rating between 6.00 and 7.50. Treatment T₄ (7.50) had the highest color value, while T₃ (6.00) had the

lowest color value. The cucumber chip chips were more impacted by the T₄ treatment. Cucumber chips that were fried in canola oil had a range of textures (6.1–7.12). The T₄ and T₅ treatments had the highest and lowest values, respectively, for the texture of the cucumber chips. The treatment T₄ had results that were somewhat akin to cucumber chips in terms of color and texture, and both were more affected by the therapy. The taste of the canola oil-fried cucumber chips (6.25–6.62). The taste treatment T₄ had the highest taste rating (6.62), while treatments T₃ and T₅ had the lowest taste rating (6.25). Taste attributes were described as perceived by only the tongue which included the four basic taste sensations (sweet, sour, bitter, salt) and umami while flavor attributes were described to include aroma through the nasal cavity as well as through the mouth. Sweet potato is generally a sweet crop due to its ability to easily

breakdown starch to maltose as a result of amylase activity and to the presence of other sugars. The color, texture, and taste of the cucumber chips have been more adversely affected by treatment T₄. The crispness scale (6.12–7.50). Cucumber chips treated T₄ in canola oil had the highest crispiness value (7.50), whereas T₁ had the lowest (6.12). Crispness and/or crunchiness have frequently been cited as the most important criteria for determining acceptability. The range of cucumber chips' overall acceptability when frying them in canola oil (6.31–7.18). Treatment T₄ had the highest score (7.18), and T₁ had the lowest value (6.31). The outcome showed that treatment T₁ had the lowest overall acceptability value and treatment T₄ had the highest overall acceptability value for the canola oil-fried cucumber chips.

Table 6. Sensory evaluation of Cucumber chips after fryingin Mustard oil and Sunflower

Treat ment	Mustard oil					Sunflower oil				
	Color	Texture	Taste	Crispiness	Overall Acceptability	Color	Texture	Taste	Crispiness	Overall Acceptability
T1	7.12	7.00	7.12	6.75	6.99±0.15	6.25	6.50	6.12	6.37	6.31±0.14
T2	7.50	7.12	6.62	7.00	7.06±0.31	7.00	7.12	6.62	6.50	6.81±0.25
T3	8.00	7.50	7.00	7.12	7.40±0.38	6.87	6.62	7.00	6.25	6.68±0.28
T4	8.50	8.12	7.25	7.62	7.87±0.47	7.62	7.25	7.25	7.50	7.40±0.16
T5	7.37	6.75	6.87	6.50	6.87±0.31	6.37	6.75	6.25	6.12	6.37±0.23

Table 7. Sensory evaluation of Cucumber chips after fryingin Groundnut oil and Canola oil

Treat ment	Groundnut oil					Canola oil				
	Color	Texture	Taste	Crispiness	Overall Acceptability	Color	Texture	Taste	Crispiness	Overall Acceptability
T1	6.75	6.50	6.37	6.25	6.46±0.18	6.50	6.25	6.37	6.12	6.31±0.14
T2	6.25	6.37	6.50	6.12	6.31±0.14	6.25	7.00	6.50	7.12	6.71±0.35
T3	6.62	6.75	6.25	6.37	6.49±0.19	6.00	6.50	6.25	6.37	6.28±0.18
T4	7.50	6.50	6.62	6.25	6.71±0.47	7.50	7.12	6.62	7.50	7.18±0.36
T5	6.37	6.87	6.25	6.12	6.40±0.28	6.37	6.12	6.25	6.87	6.40±0.28

CONCLUSION

The physicochemical properties of the cucumber chips before frying increases

(Moisture content, ash content, acidity) only pH value decreases due to the effect of treatment. Increases in moisture content

result in an increase in green and yellow color and a decrease in light color and brightness index of the cucumber chips. Only in treatment T₅ does the moisture content enhance the pH; all other treatments decrease the pH and raise the acidity level. Red color drops and yellow color increases as the moisture content rises. Increases in cucumber chip moisture content also result in an increase in the whiteness index after canola oil frying.

ACKNOWLEDGMENT

I empathetically extend my heartfelt gratitude, appreciation and venerable thanks to the RKVY, funded “Establishment of Agro Processing Centre (CoPHT&FP) and Principal Investigator to provide the experimental facilities for the entire study is acknowledged.

REFERENCES

- AOAC 2000: Official Methods of Analysis of the Association of Official Agricultural Chemists, 14th ed. Washington, D.C.
- Mudawi AH, Elhassan MSM, Sulieman AME 2014. Effect of Frying Process on Physicochemical Characteristics of Corn and Sunflower Oils. *Food and Public Health*, 4(4):181-184. DOI: 10.5923/j.fph.20140404.01
- Owolarafe, OK; Muritala, OA and Ogunsina, BS 2007. Development of an Okro Slicing Device. *Journal of Food Science and Technology*, 44(4): 426-429.
- Ranganna, S. 2010. Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill Publishing Company Limited, New Delhi, India, Pp. 1-30.

SOCIO-ECONOMIC DYNAMICS IN RURAL MEGHALAYA: A COMPARATIVE STUDY OF SELECTED VILLAGES OF EAST KHASI HILLS AND WEST JAINTIA HILLS DISTRICTS

ANDREANA TARIANG, LASARA CHYNNAMSUTING, MANISH KUMAR*, PRABHAKAR MANORI,
SANDHYA GOSWAMI AND VIKASPAL SINGH

Dolphin (PG) Institute of Biomedical & Natural Sciences, Dehradun
Corresponding author's email: manishforestry@gmail.com

ABSTRACT

The primary purpose of this study is to explore the socioeconomic dynamics of selected villages in the East Khasi Hills and West Jaintia Hills regions of the Indian state of Meghalaya. It aims to understand the variations and similarities in the socioeconomic conditions of these rural communities by comparing the villages of Trangblang and Satpator in West Jaintia Hills with those of Riwai and Kongthong in East Khasi Hills. The study examines variables that influence residents' livelihoods, sources of income, and overall well-being, including geographic location, climate, cultural norms, and government interventions. The findings contribute to a deeper understanding of socioeconomic conditions in rural Meghalaya and provide valuable insights for development professionals and policymakers designing targeted regional development initiatives.

Key words: Socio-economic dynamics, Meghalaya, East Khasi Hills, West Jaintia Hills

The primary objective of a socioeconomic survey is to understand the intricate relationships between social and economic factors and provide insights into the overall growth and well-being of the population it surveys through the comprehensive and systematic collection, analysis, and interpretation of data on various topics such as population well-being, economic development, and social structures. In a rapidly changing world, a thorough understanding of socioeconomic variables is crucial for formulating policy, promoting equitable growth, and addressing societal challenges (Mishenko, 2010). The scope of a socioeconomic survey extends far beyond data

and graphs, as it seeks to grasp the complexities of human existence and offers a comprehensive understanding of how different factors interact to shape the standard of living (Pillai et al., 2023). These surveys, which closely examine income disparities, employment trends, and educational attainment gaps, enable policymakers, scholars, and organizations to identify the key drivers of inequality and social exclusion and to take necessary action. Exploring the scope and usefulness of socioeconomic surveys has wide-ranging applications in research, policy-making, and societal development.

MATERIALS AND METHOD

The study was conducted in 2023 across four villages in two districts of Meghalaya. In East Khasi Hills district, the villages of Riwai and Kongthong were selected for the study. Riwai, known for its stunning living root bridges ancient marvels created by local tribes enjoys pleasant weather year-round and is located approximately 80 km from Meghalaya's capital, Shillong. Kongthong village, situated 60 km from Shillong, is famous for its unique tradition of using whistling as a means of communication among villagers, earning it the nickname "the whistling village" (MOSPI, 2023).

In West Jaintia Hills district, Trangblang village is located at a latitude of 25.2019°N and a longitude of 92.2069°E, while Satpator lies between 25.1984°N and 92.2062°E. To the east of both villages, there is a peak known as "*Lum Bah Bo Bah Kong*," standing 3,367 feet above sea level, which has a distinctive shape resembling a human carrying two others on their back. Trangblang and Satpator are situated 106.4 km from the state capital, Shillong. The temperature in these villages ranges between 27°C and 28°C in summer and 14°C to 15°C in winter. The villages are inhabited by the War-Jaintia, a sub-tribe of the Jaintia or Pnar community.

This study incorporates both primary and secondary data, sourced from published and unpublished materials. Data collection from the entire locality was conducted using random sampling, the questionnaire method, and the observation method. Secondary data related to the village's history, population, and governing body were gathered through interactions with the Headman and villagers. Primary data were collected through door-to-door personal interviews and observations conducted in the villages. A wide range of information regarding the social and

economic status of villagers across all castes and economic groups was gathered. Communication with villagers was conducted in the Khasi language in East Khasi Hills District and Pnar in West Jaintia Hills. The data was analyzed for both quantitative and qualitative study (Bakkegaard, 2016 & Liswanti *et al.*, 2012).

RESULTS AND DISCUSSION

The demographic study revealed that in East Khasi Hills, the female population was higher than the male population, whereas the opposite trend was observed in West Jaintia Hills (Table 1). Age-wise population distribution showed that the largest age group in all the villages was between 21-40 years. The population above 60 years ranged from only 2.27% to 11% (Table 1), suggesting that life expectancy in the study area is generally up to 60 years. The literacy rates recorded in the villages were 65.90% in Riwai, 57.14% in Kongthong, 87% in Trangblang, and 54% in Satpator. Except for Trangblang, the literacy rates in the other villages were below the state's average literacy rate of 75.48%. Each village in the study had 2-3 primary schools, while secondary schools were present only in Kongthong and Trangblang villages.

Table 1: Demography (%) of East Khasi and West Jaintia Hills.

Particulars (Gender, Age)	East Khasi Hills	West Jaintia Hills		
	Riwai	Kongthong	Trangblang	Satpator
Male	48	43	57	53
Female	52	57	43	47
0-20	34.09	23.80	20	20
21-40	40.81	38.09	36	34
41-60	20.55	26.19	29	29
61-80	2.27	7.14	11	07
81-100	2.27	4.76	04	10

In both districts, farming was the primary source of income for the majority of households

(Fig. 1). In East Khasi Hills District, tourism was the second most important source of income, whereas in West Jaintia Hills, no tourism-related income was recorded. In Trangblang, 22% of households were employed in government jobs, while only 4% of households in Satpator had government employment (Fig. 1).

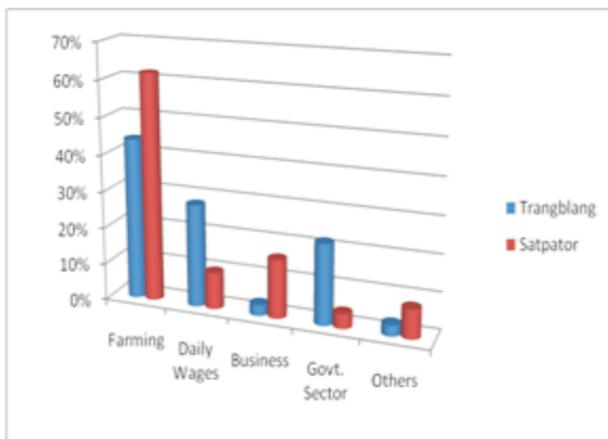
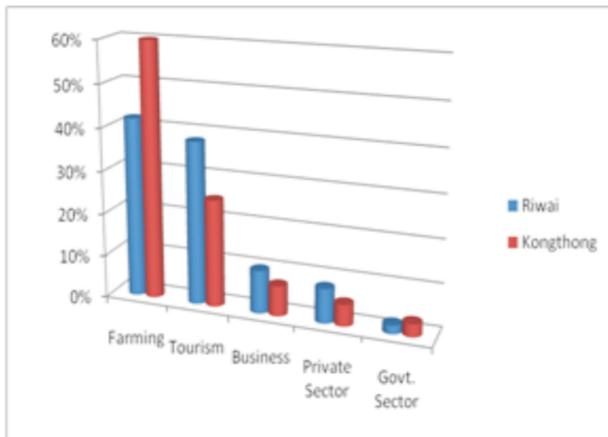


Fig 1. Income source, a) Riwai& Kongthong Village (East Khasi Hills); b)Trangblang&Satpator (West Jaintia Hills).

The various occupations in the surveyed areas yielded different incomes, and wages varied from village to village. However, villagers working in government services earned a higher annual income compared to farmers, laborers, and those in other occupations. Expenditure was primarily allocated to food, education, transport,

healthcare, clothing, and festivals. Data revealed that 39-47% of household income in all four villages was spent on food. In Trangblang and Kongthong, 27% of income was spent on education, whereas spending on education was lower in the other two villages. It was also noted that medical expenses were higher in West Jaintia Hills compared to East Khasi Hills (Fig. 2).

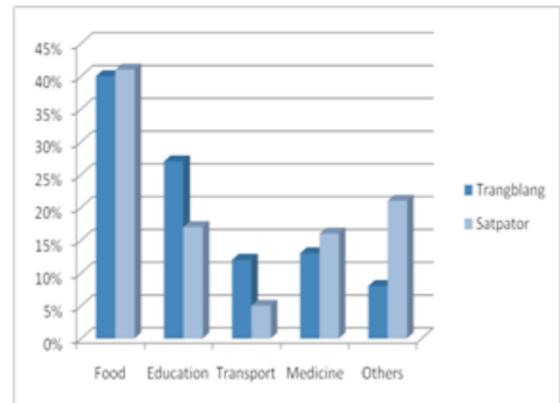
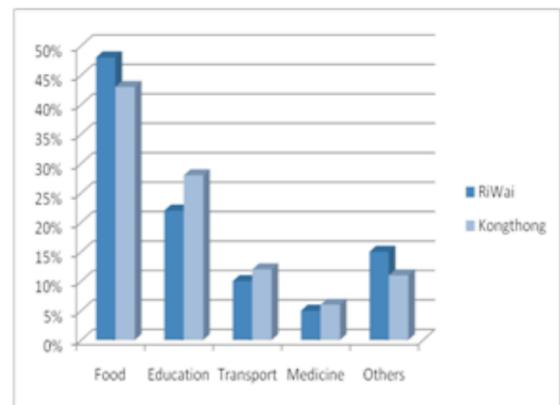


Fig 2. Household Expenditure, a) Riwai& Kongthong Village (East Khasi Hills); b)Trangblang&Satpator (West Jaintia Hills).

Semi-pucca houses were the dominant housing category in the study area. Trangblang village had the highest percentage of pucca houses at 45%, and the lowest percentage of kuccha houses at 7%. In contrast, Satpator village had the highest number of kuccha houses, accounting for 42%. The study also revealed poor medical facilities

across the area. Only Kongthong village had a primary healthcare center, while the other villages had either a dispensary or a dispensary sub-center. In East Khasi Hills, villagers primarily relied on fuelwood for cooking and heating, whereas in West Jaintia Hills, LPG and electricity were the main energy sources. This difference is largely due to restrictions on wood extraction from community reserves and sacred groves (Table 2).

Table 2 :Amenities in East Khasi and West Jaintia Hills.

Amenity	East Khasi Hills		West Jaintia Hills		
	Riwai	Kongthong	Trangblang	Satpator	
Pucca House	17	29	45	21	
Semi Pucca House	58	50	48	37	
Kuccha House	25	21	07	42	
LPG	19	4	58	37	
Fuelwood	58	62	5	5	
Electricity	12	7	20	22	
LPG & Fuelwood	00	13	7	20	
LPG, Fuelwood & Electricity	20	14	10	16	
Dispensary	01	00	00	00	
Dispensary Sub-centre	00	01	01	01	
PHC (Primary Healthcare Center)	00	01	00	00	

In Riwai village, East Khasi Hills the majority of landholdings are dominated by agroforestry. *Areca catechu* is cultivated alongside other crops and vegetables in a mixed cropping system. In Kongthong village, the land use system is primarily characterized

by both orchard and agroforestry systems, with pure agriculture not observed. Whereas in West Jaintia Hills Agriculture was the dominant land use system in both villages, followed by an agrisilviculture system (Table 3).

Table 3: Landuse systems and average landholding (acres) in East Khasi and West Jaintia Hills.

S. No.	Landuse System	West Jaintia Hills			
		East Khasi Hills Riwai	Kongthong	Trangblang	Satpator
1	Pure Agriculture	Nil	Nil	1.7	1.8
2	Home Garden	0.3	0.6	0.02	0.04
3	Orchard	Nil	1.4	0.08	0.09
4	Agri + Fruit Tree	Nil	0.5	0.05	0.07
5	Agri + Silvi Tree	0.5	1.5	1.2	0.8
6	Agri + Mixed Tree	2.2	1.4	0.03	0.05

Areca catechu (areca nut) is the predominant woody perennial in the agroforestry fields, with *Citrus sinensis* (orange) also present in some areas. Broom grass cultivation was primarily recorded, as this crop meets market demand and generates good revenue for the people. It can grow well in both hilly terrains and plain areas. Other crops grown include black pepper, sweet potato, ladyfinger, ginger, red rice, peas, and betel leaves (Tables 4 & 5). Farmers typically sell their agricultural produce in the market while reserving some for personal use. The prices of the produce vary across villages based on availability.

Table 4: Crop production in East Khasi Hills

S.No.	Crop	Cropping Period	Riwai	Kongthong		
			Produce (kg/Acre)	Price (Rs/Kg)	Produce (kg/Acre)	Price (Rs/Kg)
1.	Broom grass	January- March	22,000	70-100	12,000kg	70
2.	Ladyfinger	June-August	20	30	-	-
3.	Sweet potato	March-June	200	30	130 kg	40
4.	Pea	October-November	-	-	30 kg	60
5.	Ginger	December-January	250	60	-	-
6.	Black pepper	January-April	140	800	140 kg	800
7.	Chilly	April-September	50	70	-	-
8.	Bay leaf	November-January	105	25	-	-
9.	Betel leaf	October-January	4 bundle	60	—	
10.	Turmeric	December-February	-	-	200 kg	60
11.	Mustard leaves	September-October	-	-	35 kg	20

Table 5: Crop production in West Jaintia Hills District

S.No	Crop	Cropping Period	Trangblang	Satpator	Produce (kg/Acre)	Price (Rs/Kg)
			Produce (kg/Acre)	Price (Rs/Kg)		
1.	Broom grass	February-April	5400	75	1700 kg	250
2.	Sweet potato	March -June	-	-	270 kg	50
3.	Black pepper	January-March	350	270	-	-
4.	Bay leaf	October-November	-	-	700 kg	150
5.	Betel leaf	February-April	2500	250	2100 kg	270
6.	Red rice	June-August	500	50	-	-
7.	White yam	May-June	450	150	-	-

CONCLUSION

Villagers in Riwai experience crop damage from hail and wind, along with issues of land scarcity. Residents of Kongthong face crop losses due to changing climatic conditions. In Trangblang and Satpator villages, farmers encounter several major constraints, including labor shortages, unproductive land, crop damage from insects and animals, excessive rainfall, livestock diseases, and challenges related to marketing. The village attachment survey provides a comprehensive overview of rural life in these areas, encompassing livelihoods, land use, traditional farming practices, and the effects of climate change. The highest literacy rate

was recorded in Trangblang village, positively influencing employment opportunities in government jobs, with residents showing a preference for LPG over other cooking fuels. While most villages in the eastern part of the country rely on agriculture and unsustainable *jhum* cultivation, there is promising evidence of an increasing area under tree-based systems. Additionally, successful forest restoration efforts and the potential for tourism highlighted by initiatives such as reserve forests, sacred groves, bamboo treks, and eco-cafes offer new avenues for economic growth. Village livelihoods are heavily dependent on forests, agriculture, and livestock. Women play a crucial role in

farming, while both genders contribute to food production. Forest products, including timber and non-timber items, enhance income and employment opportunities for the community.

REFERENCES

- Bakkegaard, R.Y., Agrawal, A., Animon, I., Hogarth, N.J., Miller, D.C., Persha, L., Rametsteiner, E, Wunder, S., Zezza, A. 2016. National socioeconomic surveys in forestry: Guidance and survey modules for measuring the multiple roles of forests in household welfare and livelihoods. FAO Forestry Paper No. 179. Rome, Italy: FAO, CIFOR, IFRI, World Bank.
- Liswanti, N., Shantiko, B., Fripp, E., Mwangi, E., Laumonier, Y. 2012. Practical guide for socio-economic livelihood, land tenure and rights surveys for use in collaborative ecosystem-based land use planning Bogor, Indonesia: Center for International Forestry Research (CIFOR). <http://dx.doi.org/10.17528/cifor/004030>
- Mishenko, I.V. 2010. The main factors of sustainable development of rural areas Available at: <http://izvestia.asu.ru/2010/2-1/econ/TheNewsOfASU-2010-2-1-econ-12.pdf>
- Pillai,Ashwini, Panicker, Ashwin, Kumar, Manish, Goswami,Sandhya, and Chamoli, Rashmi, 2023. The scope and relevance of a socio-economic survey-A case study in sustainable development of selected localities in village. International Journal of Research Publication and reviews. 4(7):2247-2254.
- MOSPI. 2023. Annual Report, [ww.mospi.gov.in/sites/default/files/reports_and_publication/statistical_publication/social_statistics/Chapter_3.pdf](http://www.mospi.gov.in/sites/default/files/reports_and_publication/statistical_publication/social_statistics/Chapter_3.pdf)

PLANTS USED IN TRADITIONAL MEDICINE BY RAI COMMUNITY OF EAST SIKKIM, INDIA

NISHA RAI, SANDHYA GOSWAMI*, SAS BISWAS, MANISH KUMAR AND VIKASPAL SINGH

*Dolphin (PG) Institute of Biomedical & Natural Sciences, Dehradun
Corresponding author's email: sandhya.goswami@gmail.com*

ABSTRACT

An ethnobotanical study was conducted in Rolep, East Sikkim to document indigenous knowledge on traditional medicines used by herbal-healers to treat human ailments. A total of 30 medicinal plants from 23 families were identified. Out of 30 identified plant species, 53% were herbs, 20% were shrubs and share of trees and climbers was 13% each. The result of this study revealed that most of traditional medicinal plants were collected from wild and the local community rely only on plant-based remedies for common health problems. With traditional medicine system around 17 health issues were addressed including diabetes, tuberculosis, typhoid and kidney related ailments using different forms of herbal medicine preparations. The elderly natives possess a great knowledge of indigenous herbal medicine. The younger generation shows little interest, leading to a gradual decline in the use of medicinal plants in local health traditions, compounded by minimal conservation efforts. To address this, public awareness and community-based management initiatives are necessary to conserve both the medicinal plants and the indigenous knowledge associated with them. Proper documentation of these plants and the knowledge surrounding them could aid in the conservation of both the species and the traditional herbal medicinal practices.

Key words: Rai community, Traditional medicine, Ethnobotany and East Sikkim

According to World Health Organization (WHO), 60% of the world's population relies on herbal medicine and about 80% of the population in developing countries depends on it for their primary health care needs (Khan & Ahmad, 2019). In many societies, traditional and modern system of medicines are used independently. India has 2.4% of world's area with 8% of global bio-diversity. It is one of the 12 mega-diversity hot-spot regions of the world (Chitale *et al.*, 2014). India has one of the richest plant based medical treatment traditions in the world. In terms distribution

of India's medicinal plants diversity, it is estimated that 90% are found in forests and only 10% are cultivated (Roy *et al.*, 2016). Around 25,000 effective plant-based formulations are used in folk medicine and known only to rural communities in India (Wakdikar, 2004). The Shanghai Declaration 2016 and WHO Traditional Medicine Strategy highlight the significance of Indigenous Knowledge (IK) and Traditional Medicine (TM) in advancing health goals. There is a growing concord for decolonization & expansion of the restrictive idea of IK/TM to

include in traditional medicine and health systems (Patwardhan *et al.*, 2023). Medicinal plants are considered as a rich resource of phytochemicals which can be used in drug development for allopathic treatment. Eastern Himalaya is one of the world's 18 biodiversity hotspots. Eastern state Sikkim represents a unique eco-system rich in medicinal plant with more than 424 species reported with strong traditional system in the state. Medicinal plants ought to be given the status of a "National Resources" because their sustained availability is essential to sustain one of the world's oldest medicinal traditions, a priceless legacy of the Indian people (Sikkim Gov.). Since there is growing worldwide demand for natural medicines, conservation and development of the country's medicinal flora will serve national & global needs. The ethnobotanical information serve as a base for study on new compounds for pharmacological and clinical research (Hussain and Hore, 2007). The influence of modernization resulting in cultural changes, deforestation, exploitation of resources and lack of interests by the younger generations are some factors that impose a serious threat of depletion of these species and loss of knowledge. Hence in-situ as well as ex-situ conservation of plants and traditional knowledge is advocated (Panda, 2012; Reang *et al.*, 2016, Napagoda *et al.*, 2018; Sangma *et al.*, 2022).

MATERIAL AND METHODS

The study was carried out in Rolep village of East Sikkim District of Indian State Sikkim. Rolep village is in 27.14575°N latitude and 88.4254°E longitude and 1219.20 meter above mean sea level. The study area was dominated by Rai community which is the largest ethnic group in Sikkim (13.4%), India with Nepali and Hindi as their primary dialects. They are Tibeto-Burman people with

rich cultural heritage. Traditionally, they were farmers and hunters, living in close harmony with nature. The ethnobotanical survey was conducted between months of February to April. Traditional herbal healers (*Ojha*) were interviewed using structured questionnaires on traditional medicinal plants and their uses. Plant specimen with flowers and roots were collected, wherever possible for identification.

RESULTS AND DISCUSSION

30 plant species belonging to 23 family were reported for treating 17 human ailments (Table 1 & 2). Most being herbs (16) followed by shrubs (6), trees (4) and climbers (4). Whole or part of the plants were being used for local medicine either individually or in combinations. Underground part is used in most cases followed by leaves and whole plant (Table 2). The medicine is used in the form of powder, decoction, juice or paste of various parts of plant for the treatment of ailments. The method of medicine application for various ailment's treatment is varied as per the plant used.

Plants used for ethnomedicinal practice, Rolep, Sikkim;

Aloe barbadensis miller: The leaf sap is applied on skin burns and leucoderma conditions.

Ampelocissus latifolia (Roxb.) Planch.: To cure eye inflammation, 2 – 4 drops of fluid obtained from cut ends of stem is used as an eye drop every morning and evening.

Artemisia vulgaris L.: Leaf extract used on cuts to stop bleeding mostly in nose bleeding and also used as cleansing agent. Young stems are eaten daily in the morning in empty stomach for curing diabetes.

Buddleja asiatica Lour.: Leaves decoction is used in the treatment of inflammation, skin diseases and malaria.

Chlorophytum comosum: Leaves extract can be applied on skin to treat common skin diseases.

Cissus quadrangularis L.: Fresh root paste is applied for the treatment of bone fracture.

Clematis buchananiana DC.: Root juice and powder is taken against food poisoning and sinusitis. Whole plant paste is used in gout and cuts and wounds.

Combretum decandrum: The root decoction is used as a medicine to cure jaundice. The raw leaves are eaten to relieve diarrhoea and gastric troubles. The seed oil of this medicinal plant is used in treating eczema.

Commelina benghalensis L.: Root extract is taken against pneumonia.

Curcuma caesia Roxb.: Decoction of fresh rhizomes is used for the treatment of diarrhoea and to get relief from stomach ache. Crushed rhizome paste is applied against cut or injury to control bleeding and quick healing.

Daphne bholua Buch. -Ham.ex D.Don: The root juice is taken to treat food poisoning and intestinal disorder. The decoction of root bark is given to children to remove intestinal worms.

Drymaria cordata (L.) Willd. Ex Schult.: Above ground parts is used to cure sinusitis and nasal blockade. The leaves and stems are rolled in a bigger leaf and introduced to glowing cinder, taking care not to burn it. The content while hot is transferred into a thin cotton cloth and the emanating vapour is smelled immediately.

Drymaria spp.: Roots decoction is used for curing gastric problems, jaundice. It is also used as an appetizer.

Eupatorium adenophorum Spreng.: Leaf extract work as antiseptic agent. It is applied on cuts to stop bleeding and leaf paste is applied on wounds.

Evodia fraxinifolia (Hook.) Benth. Fruits are used in the treatment of thyphoid and they help in digestion too. Decoction of Khanakpa and Chimping tonic is used to treat cough and cold.

Fraxinus floribunda Wall. The bark extracted from Lakuri and the roots of Khokim are crushed and boiled. Then the decoction is mixed with milk and honey and is consumed in liquid form to heal internal injury.

Heracleum wallichii Dc.: The decoction of roots is taken as tonic in tuberculosis. Fruits are taken against stomach disorders, cough, cold and body ache. Fruits can also be eaten as chutney.

Litsea citrata Bl. Mejangkori: The fruits are used dried or fresh against stomach disorder. Fruits paste mixing with mustard oil is applied to relieve back pain and leg pain. Fruits can also be eaten in the form of chutney.

Lygodium japonicum (Thunb.) Sw.: The leaves are used to control bleeding in deep cut wounds. Also the leaves of this plant are mixed with Kali jhar leaves to form a paste so as to apply on the wound. The purpose of Kali jhar is to avoid infections.

Nasturtium officinale W.T. Aiton: Decoction of the plant is given as a blood purifier, vermifuge and diuretic. It is consumed as a vegetable to improve appetite and is effective against high blood pressure.

Nephrolepis cardifolia (L.) C.Presl: Juice of root tubers taken for bowel and urinary problems.

Oxalis stricta L.: Whole plant extract is rubbed on the wound area and also help to cure skin allergies.

Plantago major Huds.: The plant is rubbed in the hands and thereafter heated. Then it is applied on skin to cure rashes and burns.

Smallanthus sonchifolius (Poepp.) H. Rob.: Root is cut into small pieces and taken daily for the treatment of kidney related problems.

It also helps to reduce the concentration of glucose in the blood.

Swertia chirayita (Roxb.) H.Karst. Whole plant's decoction is used in cough, constipation and fever.

Tupistra nutans Wall. ex Lindl. Flower decoction is taken to control diabetes, high blood pressure and used as appetizer.

Urtica dioica L.: Root's dried or fresh paste is applied on minor fractures. To control high blood pressure, tender shoots or leaves are cooked as vegetable.

Viscum articulatum Burm. f.: The paste of whole plant is used for the treatment of bone fracture, muscular pain and injuries.

Viscum spp.: Paste of roots is applied for the treatment of muscular pain, injuries, fracture.

Zanthoxylum acanthopodium DC.: It's bark is chewed to cure toothache. The bark and seeds are used as a tonic to treat fever and bowel complaints.

CONCLUSION

The study revealed that most traditional medicinal plants are harvested from the wild, and people commonly rely on plant-based remedies for health issues such as cuts, eye inflammation, gastric problems, bone fractures, diarrhea, indigestion, stomach aches, and diabetes. The local community possesses significant knowledge of herbal medicine, though this knowledge is primarily held by elders and traditional healers. However, factors such as the younger generation's lack of interest, development activities, deforestation for agriculture, population growth, and other human-induced impacts are contributing to the decline in the use of medicinal plants in local health practices. To preserve these valuable plants, raising public awareness and promoting community-based management is essential.

Table 1: Plants used by traditional healers in Rolep, East Sikkim.

S. No.	Scientific name	Vernacular name	Family	Life form	Wild (W) or Cultivated (C)
1.	<i>Aloe barbadensis</i> miller	Ghiu Kumari	Liliaceae	Herb	W & C
2.	<i>Ampelocissus latifolia</i> (Roxb.) Planch.	Panilahara	Vitaceae	Climber	W
3.	<i>Artemisia vulgaris</i> L.	Titaypati	Asteraceae	Herb	W
4.	<i>Buddleja asiatica</i> Lour.	Bhimsenpate	Scrophulariaceae	Shrub	W
5.	<i>Chlorophytum comosum</i>	Dubi Jhar	Asparagaceae	Herb	W & C
6.	<i>Cissus quadrangularis</i> L.	Harjora	Vitaceae	Climber	W
7.	<i>Clematis buchananiana</i> DC.	Pinasey	Ranunculaceae	Climber	W
8.	<i>Combretum decandrum</i> Roxb.	Kali	Combretaceae	Climber	W
9.	<i>Commelina benghalensis</i> L.	Aakhlay jhar	Commelinaceae	Herb	W
10.	<i>Curcuma caesia</i> Roxb.	Kalo	Zingiberaceae	Herb	W & C
11.	<i>Daphne bhoolua</i> Buch. -Ham.ex D.Don	Kalo Kagati	Thymelaeaceae	Shrub	W
12.	<i>Drymaria cordata</i> (L.) Willd. Ex Schult.	Abhijal	Caryophyllaceae	Herb	W
13.	<i>Drymaria</i> spp.	Tharo Abhijal	Caryophyllaceae	Shrub	W
14.	<i>Eupatorium adenophorum</i> Spreng.	Kali Jhar	Asteraceae	Herb	W
15.	<i>Evodia fraxinifolia</i> (Hook.) Benth.	Khanakpa	Rutaceae	Tree	W

Plants Used in Traditional Medicine by Rai Community of East Sikkim, India

16.	<i>Fraxinus floribunda</i> Wall.	Lakuri	Oleaceae	Tree	W
17.	<i>Heracleum wallichii</i> Dc.	Chimping	Apiaceae	Shrub	W
18.	<i>Litsea citrata</i> Bl. Mejangkori	Sil Timbur	Lauraceae	Tree	W
19.	<i>Lygodium japonicum</i> (Thunb.) Sw.	Nasay jhar	Ligodiaceae	Herb	W
20.	<i>Nasturtium officinale</i> W.T. Aiton	Simrayo	Brassicaceae	Herb	W
21.	<i>Nephrolepis cardifolia</i> (L.) C.Presl	Pani amala	Nephrolepidaceae	Herb	W
22.	<i>Oxalis stricta</i> L.	Amilo Jhar/ Amilo Abijal	Oxalidaceae	Herb	W
23.	<i>Plantago major</i> Huds.	Chiplay Jhar/ Juslay Jhar	Plantaginaceae	Herb	W
24.	<i>Smallanthus sonchifolius</i> (Poepp.) H. Rob	Yacon	Asteraceae	Herb	W
25.	<i>Swertia chirayita</i> (Roxb.) H.Karst.	Chirouto	Gentianaceae	Herb	W
26.	<i>Tupistra nutans</i> Wall. ex Lindl.	Nakima	Liliaceae	Herb	W & C
27.	<i>Urtica dioica</i> L.	Sisno	Urticaceae	Herb	W
28.	<i>Viscum articulatum</i> Burm. f.	Rukh	Viscaceae	Shrub	W
29.	<i>Viscum</i> spp.	Bhiu	Viscaceae	Shrub	W
30.	<i>Zanthoxylum acanthopodium</i> DC.	Bokey Timbur	Rutaceae	Tree	W

Table 2: Diseases, Medicinal plants and plant parts used for treatment.

S.No.	Diseases	Plant	Plant part used				
1.	Diabetes	<i>Artemisia vulgaris</i>	Young stem	7.	Pneumonia	<i>Commelina benghalensis</i>	Root
		<i>Nasturtium officinale</i>	Leaves	8.	Stomach disorder	<i>Litsea citrata</i>	Fruit
		<i>Tupistra nutans</i>	Flower			<i>Heracleum wallichii</i>	Fruit
		<i>Urtica dioica</i>	Leaves			<i>Nephrolepis cardifolia</i>	Tuber
2.	Jaundice	<i>Combretum decandrum</i>	Root			<i>Daphne bholua</i>	Root
		<i>Drymaria</i> spp.	Root			<i>Swertia chirayita</i>	Whole plant
3.	Sinusitis	<i>Clematis buchananiana</i>	Root			<i>Curcuma caesia</i>	Rhizome
		<i>Drymaria cordata</i>	Whole plant	9.	Gastric	<i>Clematis buchananiana</i>	Root
4.	Fever, malaria, cough and cold	<i>Buddleja asiatica</i>	Leaves			<i>Drymaria</i> spp.	Root
		<i>Evodia fraxinifolia</i>	Fruits			<i>Combretum decandrum</i>	Root
		<i>Heracleum wallichii</i>	Fruits	10.	Eczema	<i>Combretum decandrum</i>	Seed
		<i>Swertia chirata</i>	Whole plant	11.	Kidney problem	<i>Smallanthus sonchifolius</i>	Root
		<i>Zanthoxylum acanthopodium</i>	Bark and seeds	12.	Burns, cuts and wounds	<i>Aloe barbadensis</i>	Whole plant
5.	Tuberculosis	<i>Heracleum wallichii</i>	Root			<i>Clematis buchananiana</i>	Root
6.	Thyphoid	<i>Evodia fraxinifolia</i>	Fruits			<i>Curcuma caesia</i>	Rhizome

	<i>Eupatorium adenophorum</i>	Leaves
	<i>Lygodium japonicum</i>	Leaves
	<i>Plantago major</i>	Whole plant
13. Bone fracture	<i>Cissus quadrangularis</i>	Root
	<i>Urtica dioica</i>	Root
	<i>Viscum articulatum</i>	Whole plant
	<i>Viscum spp.</i>	Root
14. Internal injury	<i>Fraxinus floribunda</i>	Bark
15. Skin Inflammation	<i>Buddleja asiatica</i>	Leaves
16. Eye inflammation	<i>Ampelocissus latifolia</i>	Stem
17. Nose bleeding	<i>Artemisia vulgaris</i>	Leaf

REFERENCES

- Ahmad Khan, M. S., and Ahmad, I. 2019. Herbal Medicine: Current Trends and Future Prospects. *New Look to Phytomedicine*, 3-13. <https://doi.org/10.1016/B978-0-12-814619-4.0001-X>
- Alexiades M. 1996. Collecting ethnobotanical data: An introduction to basic concepts and techniques. *In: Selected Guidelines for Ethnobotanical Research: A Field Manual*. 53-94. New York Botanical Gardens Press.
- Chitale, V.S., Behera, M.D., and Roy, P.S. 2014. Future of Endemic Flora of Biodiversity Hotspots in India. *PLoS ONE*, 9(12). <https://doi.org/10.1371/journal.pone.0115264>
- Sikkim Govt. (2024). <https://sikkim.gov.in/departments/forest-environment-and-wildlife-department/biodiversity>
- Hussain, S. and Hore, DK. 2007. Collection and conservation of major medicinal plants of Darjeeling and Sikkim Himalayas. *Indian Journal*, 6 (2): 352-357.
- Martin G. J. 2004. *Ethnobotany. A Method Manual*. Earthscan Publications, London.
- Napagoda, M.T., Sundarapperuma, T., Fonseka, D., Amarasiri and Gunaratnas 2018. An Ethnobotanical study of the medicinal plants used as Anti Inflammatory Remedies in Gampha district, Western Provinces, Sri Lanka. *Scientifica*. 8 (1). DOI:10.1155/2018/9395052.
- Panda, A.K. 2012. Medicinal plants use and Primary health care in Sikkim. *International journal of Ayurvedic and Herbal medicine*. 2 (2) 253-259.
- Reang, I., Goswami, S., Pala, N. A., Kumar, M. & Bussmann, R.W. 2016. Ethnoveterinary Applications of Medicinal Plants by Traditional Herbal healers in Reang Tribe of South District Tripura, India. *Med Aromatic Plants*. 5 (2):1000234 doi.org/10.4172/2167-0412.1000234
- Roy, Aniruddha, Das, Shaon, Tripathi, Anil, Singh, Nongmaithem and Man, H. K. 2015. Biodiversity in North east India and their conservation. *Progressive Agriculture- An International Journal*. 15 182-189.
- Sangma, Bonnyesh Ch, Goswami, Sandhya, Chamoli, Rashmi T., Singh, Vikaspal, Uniyal, Anil Kumar and Kumar, Manish. 2022. Indigenous Traditional Medicine Application by Traditional Healers in Garo Hills, Meghalaya, India. *Biodiversity: In the service of mankind*, pp 222, Manju Rani (Eds.), Walnut Publication USA/India/UK.
- Wakdikar, S. 2004. Global health care challenge: Indian experiences and new prescriptions. *Electronic Journal of Biotechnology*, 7 (3).
- Patwardhan, Bhushan, Wieland, L. Susan, Obijiofor, Aginam, Anchalee, Chuthaputti, Ricardo, Ghelman, Roshanak, Ghods, Goh, Cheng Soon, Motlalepula, G. Matsabisa, Georg, Seifert, Sione, Tu'itahi, Kim, Sung Chol, Shyama, Kuruvilla, Kathi, Kemper, Holger, Cramer, Nagendra, H. R., Thakar, Anup, Nesari, Tanuja, Sharma, Sanjeev, Srikanth, Narayanam, Acharya Rabinarayan. 2023. Evidence-based traditional medicine for transforming global health and well-being. *Journal of Ayurveda and Integrative Medicine*, 14 (4) 100790 <https://doi.org/10.1016/j.jaim.2023.100790>.

IMPACT OF INTENSIVE CULTIVATION ON PHYSICO-CHEMICAL PROPERTIES OF SOIL OF BULANDSHAHR

SIDDHANT TOMAR¹, SATENDRA KUMAR¹, B.P. DHYANI¹, YOGESH KUMAR¹, P.K. SINGH¹
AND LALIT KUMAR²

¹*Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh)*

²*Indian Institute of Farming System Research, Modipuram, 250110*

Corresponding author's email- siddhanttomar678@gmail.com

ABSTRACT

For closely monitoring the present health status of KVK Bulandshahr soil, the present investigation has been undertaken during 2022-23 with major impetus to manage the physico-chemical health of soil so that soil fertility in this region could be restored. The soil samples taken from the depths of 0-15 and 15-30cm were analyzed for their certain physico-chemical properties. The soil of the KVK categorized under loam, sandy clay loam and sandy loam textural classes with neutral to slightly alkaline in reaction. Bulk and particle densities were recorded respectively in range of 1.37-1.57 and 2.51-2.72 Mg m⁻³ and the values for both increased with depth. Porosity in surface and sub-surface soil varied respectively between 39.92-46.95 and 36.29-40.82%. According to the calculated nutrient index, soil classified as low in available N, medium in available P and low in available K. Among the secondary macronutrient, available Ca and Mg classified as high and available S classified as medium. All DTPA extractable micronutrient *i.e.*, Zn, Fe, Cu and Mn classified as high as per the calculated nutrient index values. A highly significant and positive correlation of OC with available N, P and S was observed.

Key words: Intensive cultivation, Nutrient index, integrated nutrient management and Crop rotation.

More than 60% of the India's total population resides in rural areas and their livelihood survival mainly relies on agriculture and allied activities. Therefore, in this sense, agriculture is not only back bone of rural economy but also contributes a lot in foundation of the Indian economy. Bulandshahr is an agriculturally important district located in the Meerut region of western part of Indo-Gangetic plain (zone-5) of Uttar Pradesh and it is also a part of national capital region of India. Present study confined to the KVK Bulandshahr which is situated 72

km away from the national capital (New Delhi) of the country at NH-91 (Delhi-Kanpur). This region falls under the sub-tropical climate zone with average annual rainfall and relative humidity of 782 mm and 32 to 80%, respectively. Sandy loam, sandy loam to loam and loam to clay loam are the three major soil type found in this region. Sugarcane-ratoon-wheat, Paddy-wheat, Maize-wheat are the major cropping system adopted by the farmers of this region. However, Paddy-Wheat, Arhar-Wheat, Sugarcane-Ratoon-Wheat are the major

cropping system adopted at KVK research farm which are almost same as adopted by the farmers of this region. Owing to be of high cropping intensity (157%) and high level of nutrient exhaustive nature of crops, recently a declined trend in soil fertility and productivity being recognized in this area. Therefore, to maintain the productivity, farmers of this region are exercising a heavy dose blanket application of nitrogenous and phosphatic fertilizers and neglecting the application of potassium, sulphure and other micronutrient fertilizers that further aggravated the fertility and productivity declining tendency of the soil. The assessment of soil's potentials and limitations for various land uses serves as the foundation for developing appropriate management strategies that address specific management issues in order to optimize crop output, soil and water conservation. A comprehensive analysis of the soils could provide this information. However, inappreciable work has been done to maintain the fertility of the KVK, Bulandshahr soil, and the data on soil fertility status accessible locally is insufficient. The productivity of the KVK, Bulandshahr soil is diminishing as a result of soil *sickness*. So, present study has been carried out to analyse the soil for various physical and chemical parameters to determine the soil health and an attempt was also made to derive correlation among different parameters.

MATERIAL AND METHODS

SOIL SAMPLING AND ANALYSIS

From the experimental sites, 12 numbers of plots of 0.5ha size were chosen and the soil samples from each one of the plots were collected from various locations in three replicates and from two depths i.e. 0-15 cm and 15-30 cm. Collected samples were mixed together by hand on a piece of cloth or

polythene sheet and further reduced to an amount of nearly 500 g by following quartering process. The samples collected so was dried in shade and then crushed, sieved and filled in clean and dry polythene bags and analyzed for their certain physical properties *viz.*, bulk density, particle density and soil texture by following respective methodologies suggested by Piper (1966), Blake and Hartge (1986) and Bouyoucos (1962). The porosity of soil was determined by using the formula $(1-BD/PD) \times 100$. The collected samples were also analyzed for their chemical properties. Soil pH and electrical conductivity was measured in 1:2.5 soil water suspensions by using respectively the pH and EC meters. Easily oxidizable organic carbon (OC) was determined by following the wet digestion method as suggested by Walkley and Black, 1934. Available nitrogen, phosphorus, potassium and sulphur were determined by following respective methodologies of Subbiah and Asija (1956), Olsen *et al.*, (1954), Hanway and Heidel (1952) and Williams and Steinbergs (1954). DTPA- extractable iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) was determined by adopting the methodology of Lindsay and Norvell (1978).

STATISTICAL ANALYSIS

Correlation coefficient between different physical and chemical properties was determined by using the formula given below:

Correlation coefficient (X, Y) =

Where,

= values of the x-variable in a sample

= mean of the values of the x-variable

= values of the y-variable in a sample

= mean of the values of the y-variable

RESULTS AND DISCUSSION

Physical properties: The soil of experimental site belongs to Sandy clay loam

and Sandy loam type category. The sand, silt and clay contents in samples of experimental plots were found to vary between 46 to 56, 25 to 30 and 19 to 28%, respectively. Data on various physical parameters are given in table 1. Particle density of surface and sub-surface soil varied respectively between 2.51-2.72 and 2.61-2.79 Mg m^{-3} whereas, bulk density of surface and sub-surface soil varied respectively between 1.37-1.57 and 1.58-1.72 Mg m^{-3} . Porosity in surface and sub-surface soil varied respectively between 39.92-46.95 and 36.29-40.82%. Particle density followed the increasing trend with increasing depth, which may be due to decrease in organic matter content and increase in heavy elements like iron, manganese etc. with depth. Sub-surface layers have lesser organic matter content, lesser aggregation and root penetration leads to low porosity which caused bulk density to increase in lower depth.

Chemical Properties: collected samples were observed neutral to slightly alkaline in reaction nearly 83.0% of surface soil samples were found in neutral range with pH values ranging from 6.6-7.3 and rest of 17% samples were found in slightly alkaline range with pH values ranging from 7.4-7.8 (Table-1). However, in case of sub-surface soil samples, nearly 58 % soil samples were found neutral in reaction and rest 42% of soil samples were observed slightly alkaline in reaction (Table-1). High base saturation may result in neutral to slightly alkaline pH. Kumar and Babel (2011), Sharma *et al.*, (2013), Nigam *et al.*, (2014), Singh *et al.* (2012) also observed similar results. EC values of surface soil (0-15cm) and sub-surface soil samples varied

respectively between 0.10-0.12 and 0.10-0.13 dS m^{-1} (Table-1). On the basis of limits suggested by Muhr *et al.*, (1965), the observed EC values of our samples are in slight lower range, this may be due to the leaching of soluble salts to lower horizons by rainfall or flood irrigation. As EC was low, present environment may not be conducive for buildup of salts. Findings are confirmatory with the results of Pandiaraj *et al.*, 2017.

Organic carbon (%) of surface soil *i.e.* in samples of 0-15cm depth were found to ranged between 0.55- 0.86 %. Based on the observed carbon content values of samples nearly 67% of soil samples can be categorized to medium category of organic carbon and rest 33% belonged to high organic carbon content category. However, in case of sub-surface soil samples (15-30cm depth), soil organic carbon content were observed to ranged between 0.43-0.78 %, where 17% of soil samples are low 58.% are moderate and 25% are high in organic carbon content (Table-1). Luxuriant availability of organic matter and its slow seasonal decomposition might have resulted in high organic carbon content (Kavitha and Sujatha, 2015 and Pandiaraj *et al.*, 2017). Low organic carbon might be the result of rapid decomposition of organic matter due to high temperature prevailing in the environment (Sharma *et al.*, 2013) and continuous utilization by plants for the uptake of nutrients. Soil organic carbon followed a decreasing trend with increasing depth might be due to organic matter addition in upper horizons because of crop residues accumulation. Similar results reported by Sethy (2014).

Table 1: Status of some selected physico-chemical properties of KVK, Bulandshahr

Plot No.	Depth (cm)	P.D. (Mg m ⁻³)	B.D. (Mg m ⁻³)	Porosity (%)	pH	EC (dS m ⁻¹)	SOC (%)	Available Nutrients in (Kg ha ⁻³)		
								N	P	K
1	0-15	2.58	1.41	45.34	7.13	0.10	0.76	198.59	19.80	129.89
	15-30	2.70	1.62	40.00	7.30	0.14	0.62	164.19	18.24	133.07
2	0-15	2.59	1.44	44.40	7.11	0.11	0.71	175.41	17.46	138.86
	15-30	2.75	1.64	40.36	7.28	0.12	0.60	143.58	16.62	138.03
3	0-15	2.57	1.43	44.36	7.10	0.12	0.56	162.03	18.44	136.42
	15-30	2.70	1.72	36.29	7.25	0.13	0.28	94.19	8.88	122.49
4	0-15	2.54	1.37	46.06	7.29	0.12	0.69	181.26	19.64	127.86
	15-30	2.65	1.66	37.35	7.34	0.16	0.61	125.70	19.39	132.12
5	0-15	2.55	1.38	45.88	7.04	0.11	0.86	232.67	22.31	135.53
	15-30	2.73	1.68	38.46	7.12	0.11	0.78	182.34	19.98	136.43
6	0-15	2.62	1.39	46.95	7.20	0.12	0.81	229.28	22.41	159.27
	15-30	2.72	1.64	39.70	7.19	0.14	0.74	187.16	18.22	161.48
7	0-15	2.58	1.38	46.51	7.12	0.11	0.83	212.73	21.10	152.37
	15-30	2.73	1.66	39.19	7.14	0.13	0.77	186.43	18.22	154.13
8	0-15	2.56	1.40	45.31	7.10	0.11	0.68	184.07	19.88	124.13
	15-30	2.67	1.58	40.82	7.15	0.13	0.57	129.88	20.53	126.53
9	0-15	2.51	1.45	42.23	7.29	0.12	0.65	176.85	19.24	132.91
	15-30	2.64	1.67	36.74	7.35	0.14	0.56	154.85	16.12	135.95
10	0-15	2.53	1.52	39.92	7.53	0.11	0.58	164.57	19.56	151.93
	15-30	2.61	1.62	37.93	7.62	0.16	0.60	147.03	16.86	151.80
11	0-15	2.55	1.46	42.74	7.53	0.11	0.55	174.45	17.41	110.05
	15-30	2.68	1.66	38.05	7.64	0.16	0.43	137.21	15.67	112.04
12	0-15	2.72	1.57	42.27	7.30	0.11	0.59	166.89	16.53	115.48
	15-30	2.79	1.72	38.35	7.38	0.13	0.48	101.44	15.97	117.44

Table 2: Depth wise status of secondary and micronutrients in KVK, Bulandshahr Soil

Plot No.	Depth (cm)	Ca (cmol (p+) kg ⁻¹)	Mg (cmol (p+) kg ⁻¹)	S (Kg ha ⁻¹)	Available form in (ppm)			
					Fe	Zn	Cu	Mn
1	0-15	2.42	1.52	27.90	39.84	1.54	1.16	11.33
	15-30	2.15	1.36	25.51	47.96	1.44	1.59	10.14
2	0-15	2.01	1.37	28.82	35.98	1.10	1.05	11.06
	15-30	1.89	1.26	26.91	46.42	1.00	1.41	10.15
3	0-15	1.82	1.25	25.99	41.74	0.58	1.47	9.09
	15-30	1.96	1.20	17.54	49.85	0.54	0.80	8.68
4	0-15	2.23	1.50	25.96	37.65	0.75	1.18	9.99
	15-30	2.01	1.28	23.48	39.06	0.72	1.39	8.83
5	0-15	1.73	1.58	30.42	42.96	1.81	0.92	10.49
	15-30	1.55	1.35	28.13	46.02	1.62	0.91	9.56

Impact of Intensive Cultivation on Physico-Chemical Properties of Kvk Bulandshahr Soil

6	0-15	2.12	1.59	33.20	42.35	1.61	0.96	11.47
	15-30	2.18	1.43	29.53	48.92	1.31	1.35	10.52
7	0-15	2.74	1.33	33.56	35.39	1.68	0.95	11.19
	15-30	2.58	1.07	30.59	30.79	1.43	0.95	9.65
8	0-15	2.79	1.48	28.11	28.70	1.60	1.04	11.92
	15-30	2.52	1.28	26.27	33.50	1.42	0.87	10.51
9	0-15	2.61	1.66	29.41	36.06	1.49	1.21	11.54
	15-30	2.62	1.50	26.11	41.38	1.28	0.86	10.42
10	0-15	2.83	1.32	29.15	31.34	1.52	1.27	11.09
	15-30	2.80	1.14	27.03	40.86	1.21	0.95	10.97
11	0-15	2.87	1.49	27.44	33.46	1.63	1.42	9.43
	15-30	2.63	1.28	25.15	38.90	1.48	1.00	9.71
12	0-15	2.26	1.38	26.16	26.02	0.79	0.94	9.17
	15-30	2.48	1.12	23.95	20.39	0.63	0.76	8.38

Table 3: Soil fertility status of KVK, Bulandshahr with respect to soil nutrient index

Nutrient	Surface soil		Sub- surface soil	
	Nutrient index	Category	Nutrient Index	Category
Organic Carbon	2.33	Medium	2.08	Medium
Nitrogen	1	Low	1	Low
Phosphorus	2	Medium	2	Medium
Potassium	1.5	Low	1.58	Low
in0Calcium	3	High	3	High
Magnesium	3	High	3	High
Sulphur	2	Medium	2	Medium
Zinc	2.66	High	2.66	High
Iron	3	High	3	High
Manganese	3	High	3	High
Zinc	3	High	3	High

Nitrogen content of surface and sub-surface soil varied respectively between 162.03-232.67 and 117.53-187.16 kg ha⁻¹ (Table-1). All the collected samples of experimental field were found low in available nitrogen. Since the area is under intensive cultivation thereby organic carbon content goes down continuously hence this might be a reason for low N content. It might also be the result of high temperature and uncertain rainfall which has major impact on availability of nitrogen (Verma *et al.*, 2005 and

Singh *et al.*, 2012). Irrespective of all the plots, soil available nitrogen followed the decreasing trend with increasing depth; it might be due to decline in organic carbon content with depth. Similar findings were reported by Pattanayak (2016). Soil should be well supplied with FYM and other organic sources along with inorganic nitrogenous fertilizers.

Available phosphorus content of surface soil (0-15cm) and sub-surface soil (15-30cm) varied respectively between 16.53-22.41 and 15.67-20.53 kg ha⁻¹ (Table 1). 100% soil

samples were reported as medium in available phosphorus content in both surface and sub-surface soil. It may be the result of proper phosphorus fertilization and presence of phosphorus bearing minerals. Results are in close conformity with Meena *et al.*, (2006) and Bharteey *et al.*, (2017). Soil available phosphorus followed the decreasing trend with increasing depth; because of decline in organic carbon content with depth as a major fraction of available phosphorus exist in organic form (Sethy, 2014).

Available potassium content of surface and sub-surface soil varied respectively between 110.05-159.27 and 112.04-161.48 kg ha⁻¹ (Table 1). 50% soil samples were found in low range and 50% in medium range in available potassium content in the surface soil, whereas 41.66% samples were found in low range and 58.33% were found in medium range in sub-surface soil. Low available potassium content may be attributed to highly exhaustive cropping pattern with neglecting potassium fertilization. Medium range of available potassium may be attributed to presence of micaceous minerals. Similar results were reported by Pattanayak (2016). Available potassium found to increase with increase in soil depth in almost all plots; it may be attributed to illuviation of clay, as a major part of available potassium exists in exchangeable form (Choudhury *et al.*, 2021).

Available sulphur in surface and sub-surface soil varied respectively between 25.96-33.56 and 23.20-30.59 kg ha⁻¹ (Table-2). 100% soil samples were found as medium in available sulphur content in both surface and sub-surface soil. It may be due to the presence of sulphur bearing minerals and continuous application of sulphur containing fertilizers (Ramana *et al.*, 2016 and Bharteey *et al.*, 2017). Decreasing trend in available sulphur in subsurface samples might be attributed to

decrease in organic carbon content with depth (Choudhury *et al.*, 2021).

Zn concentration in surface and sub-surface soil varied respectively between 0.65-1.81 and 0.63-1.62 mg kg⁻¹ (Table-2). In both surface and sub-surface soil samples, nearly 67 % soil samples were found high and rest 33% soil samples were found medium in Zn concentration in DTPA-extractable zinc. Continuous application of zinc containing fertilizer might have resulted increased level of zinc in these soils. Similar results were reported by Kavitha and Sujatha (2015) and Patil *et al.*, (2017). Zinc fertilization may likely to have good response in terms of crop yield and quality. Cu concentration in surface and sub-surface soil samples varied respectively, between 0.92 to 1.47 and 0.76 to 1.39 mg kg⁻¹ (Table-2). 100% samples in both surface and subsurface soils were reported in high category for DTPA extractable Cu. Although soil under investigation observed neutral to slightly alkaline in reaction, but Cu being a fungicide ingredient, its levels might have increased as a result of frequent application of fungicide either to soil or crops. Results are in accordance with Patil *et al.*, (2017). Fe concentration in surface and sub-surface soil respectively varied between 26.02 to 42.96 and 20.39 to 49.85 mg kg⁻¹ (Table-2). 100% samples in both surface and sub-surface soils were recorded as high in DTPA extractable iron. This might be the result of iron containing minerals and medium to high level of organic carbon in the respective soil, which acts as chelating agent to protect the iron from oxidation and precipitation, thus increases iron availability as a result. Results are in conformity with Patil *et al.*, (2017). It might also be due to continuous rice-wheat cropping system, as submerged condition in rice reduces the ferric form (plant unavailable) to ferrous form (plant available). Mn concentration in surface and sub-surface soil

varied respectively between 9.09 to 11.92 and 8.38 to 10.97 mg kg⁻¹ (Table-2). 100% samples in both surface and subsurface soils were reported in high category for DTPA extractable Mn. Similar to Fe, the increased level of Mn is related to its chelation by organic compounds generated during the decomposition of organic matter as the area under investigation recorded as medium to high in organic carbon content. These observations are similar to the findings of Verma *et al.*, (2007).

Correlation among different physical and chemical properties:- For surface soil, porosity showed highly significant and positive correlation with clay ($r=0.840$) and non-significant positive correlation with silt ($r=0.166$) and highly significant negative correlation with sand ($r=-0.947$). Similar results were reported by Chaudhari *et al.*, (2013). For the surface soil bulk density showed highly significant and positive correlation with sand ($r=0.840$), whereas negative and highly significant correlation with porosity ($r=-0.860$) and clay ($r=-0.776$). Similar results were reported by Chaudhari *et al.*, (2013). Organic carbon in surface soil showed highly significant and positive correlation ($r=0.923$) ($r=0.801$) ($r=0.723$) respectively with nitrogen, phosphorus and sulphur. Nitrogen showed highly significant and positive correlation with phosphorus ($r=0.864$), sulphur ($r=0.751$) in the surface soil. Potassium in the surface soil was founded in a significant and positive correlation with phosphorus ($r=0.650$), sulphur ($r=0.749$). Similar results were reported by Khan *et al.*, (2017).

CONCLUSION

Based on the soil analysis data, it can be concluded that soil of KVK, Bulandshahr can be categorized under loam, sandy clay loam and sandy loam textural classes with neutral

to slightly alkaline in reaction. Bulk and particle densities were recorded respectively in range of 1.37-1.57 and 2.51-2.72 Mg m⁻³ and increased with depth. Porosity in surface and sub-surface soil varied respectively between 39.92-46.95 and 36.29-40.82%. Based on above mentioned analytical parameter there is a requirement of nitrogen and potassium application more than the recommended dose. To avoid further decline of phosphorus and sulphur contents, application of crop based recommended dose of the nutrients must be ensured as per the crop need; however, its response may not be as high as in case of nitrogenous fertilizers. To maintain Zn content its application must also be ensured. Crop residues should be incorporated and green manure should also be included in rotation to maintain and improve organic carbon levels. Theme of integrated nutrient management should be adopted by complimentary use of bio-fertilizers, organic manures in suitable combination of chemical fertilizers, which will not only help to overcome the effect of chemical cultivation but will also improve the soil health that in turn will ensure an efficient and sustained crop production.

ACKNOWLEDGEMENT

The authors are highly thankful to the department of soil science and agricultural chemistry of SVPUAT, Meerut for providing the facilities to conduct the research.

REFERENCE

- Blake, G.R. and Hartge, K.H. 1986 Particle density. Methods of soil analysis, part 1. Rev. Physical and Mineralogical Methods. *American Society of Agronomy Monograph 9*.
- Bouyoucos, G.J. (1962) Hydrometer method improved for making particle size analysis of soils. *Agronomy Journal* 54, 464-465.

- Bharteey, Dr, Singh, Y.V., Sukirtee, Kumar, Maneesh&Rai, Avinash 2017, Available Macro Nutrient Status and their Relationship with Soil Physico-Chemical Properties of Mirzapur District of Uttar- Pradesh, India. *International Journal of Current Microbiology and Applied Sciences* 6, 2829-2837.
- Chaudhari, P, R., Ahire, D.V., Ahire, V, D., Chkravarty, M. and Maity, S. 2013, Soil bulk density as related to soil texture, Organic matter content and available total nutrients of Coimbatore soil. *International Journal of scientific and research publication* 3 (2), 1-8.
- Choudhury, Debasish, Thomas, Tarence and Kumar, Tarun. 2021, Fertility Status and Evaluation of Nutrient Index Using Available Nitrogen, Phosphorous and Potassium of Soils of Deomali Hill-Range Valley Zone, Odisha 10, 121-126.
- Kavitha, C. and Sujatha, M.P. 2015, Evaluation of soil fertility status in various agro ecosystems of Thrissur district, Kerala, India. *Internat. J. Agric. Crop Sci.* 8 (3) 328-338.
- Khan, A.I., N.L. Uranw, R.N. Yadav, Y.V. Singh, Durgawati Patel and RenuYadav 2017, Evaluation of Soil Fertility Status from Kanchanpur district, Far-Western Development Region of Nepal. *Int.J.Curr. Microbiol.App.Sci.* 6 (3), 961-968.
- Kumar, M. and A.L. Babel. 2011, Available Micronutrient Status and Their Relationship with Soil Properties of Jhunjhunu Tehsil, District Jhunjhunu, Rajasthan, India *J.Agric. Sci.* 3 (2) 97-106.
- Lindsay, W.L. and Norvell, W.A. 1978, Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* 42, 421-428.
- Meena, H.B., Sharma, R.P. and Rawat, U.S. 2006. Status of macro and micro nutrient in some soils of Tonk district of Rajasthan. *Journal of the Indian Society of Soil Science* 54, 508-512.
- Muhr, G.R., Datta, N.P., Subramany, N.S. Dever, F., Leczy, V.K. and Donahue, R.R. 1965, Soil testing in India, *USDA Publication*, 120.
- Nigam, G.K., Pandey, V.K., Tripathi, M.P. and Sinha, Jitendra. 2014, Assessment of macro and micronutrients of soil in a small Agricultural watershed. *International Journal of Chem. Tech. Research* 6 (7), 3658-3664.
- Pandiaraj, T. Pandiaraj, Srivastava, P, Das, Susmita and Sinha, Ajit .2017, Evaluation of Soil Fertility Status for Soil Health Card in Various Tasar Growing Fields of Bihar and Jharkhand States, India. *International Journal of Current Microbiology and Applied Sciences* 6 (4), 1685-1693.
- Patil, Sidharam, Kumar, Anil, Kokkuvayil and Srinivasamurthy, C.A. 2017, Soil fertility status and nutrient index for primary nutrients in Western Ghats and Coastal Karnataka under different Agro-ecological systems. *An Asian Journal of Soil Science* 12, 314-319.
- Pattnayak T. 2016, Preparation of GPS based soil Fertility maps and identification of soil related crop production Constraints for Dhenkanal District, Odisha, Ph.D. Thesis, Department of Chemistry, Institute of Technical Education and Research Siksha 'O' Anusandhan University, Bhubaneswar, Odisha, India
- Piper, 1966, Soil and Plant analysis. *Hans Publishers Bombay*, 135-136.
- Ramana, Singh, Y, Jat, Lokesh, Meena, Santosh, Singh, Lakhapati, Jatav, Hanuman and Paul, Alpana, 2016, Available Macro Nutrient Status and their Relationship with Soil Physico-Chemical Properties of Sri Ganganagar District of Rajasthan, India 9, 2887-2894.
- Sethy SK. 2014, Preparation of GPS and GIS based soil fertility maps of Deogarh District, KVK Deogarh and identification of soil related crop production constraints. M.Sc. Thesis. Dept. of Soil Science and Agril. Chemistry,

- Orissa University of Agriculture and Technology, Bhubaneswar.
- Sharma, R.P., Yadava, R.B., Lama, T.D., Bahadur, A. and Singh, K.P. 2013, Status of secondary nutrients vis-a-vis soil site-characteristics of vegetable growing soils of Varanasi. *Vegetable Sciences* 40 (1), 65-68.
- Singh, R. P. and Mishra, S. K. 2012. Available macro nutrients (N, P, K and S) in the soils of Chiraigaon block of district Varanasi (UP) in relation to soil characteristics. *Indian Journal of Scientific Research* 3 (1), 97-100.
- Subbiah, BV and Asija, GL, 1956, A rapid procedure for estimation of available N in Soil. *Curr. Sci.* 25, 259-260.
- Verma, V.K., Patel, L.B., Toor, G.S. and Sharma, P.K. 2005, Spatial Distribution of Macronutrients in Soils of arid tract of Punjab, Indian. *Journal of Agriculture & Biology* 7 (2), 370-372.
- Verma, V.K., Setia, R.K., Sharma, P.K., Khurana, M.P.S. and Kang, G.S. 2007, Pedosheric distribution of micronutrient cations in soils developed on various landforms in north-east Punjab. *Journal of the Indian Society of Soil Science* 55 (4), 515-520.
- Walkley, A. and Black, C.A. 1934, An examination of the Degt. Joneff method for determining of soil organic matter and proposed modification of the chromic acid titration. *Soil Science* 37, 29-38.

IDENTIFICATION OF SUITABLE MUSTARD VARIETIES FOR ORGANIC PRODUCTION SYSTEM

D. KUMAR, L. R. MEENA, S. MALIK AND ANUJ KUMAR

ICAR-Indian Institute of Farming Systems Research, Modipuram-250110

Corresponding author's email-dkiisr6@gmail.com

ABSTRACT

Twenty mustard varieties of different origin were evaluated in RBD for two crop seasons (2021-22 and 2022-2023) under purely organic environment against locally adapted variety RH 749. Organic package and practices was employed to raise the experimental crop. In first year evaluation the varieties namely Maya, RB 50 and Varuna over took RH 749 in terms of seed yield, while oil content was recorded higher in Azad Mahak, Maya and RH 761. However, second year evaluation revealed that RH 9301, Maya, Azad Mahak, Varuna and RB 50 registered numerical superiority over standard check (RH749) in terms of seed yield, whereas Azad Mahak, RB 50 and Maya found surpassing to RH 749 for oil content.

Key words: Genetic base, Mustard, Organic genome and Oil Content

Mustard belongs to family of *Cruciferae* and popularly used in Indian cooking. Rapeseed- mustard is the third most important oilseed crop in India after Soybean and Groundnut. It accounts for nearly 20 -22% of the total oilseeds produced in the country. Indian mustard is mainly used for extraction of edible oil, while the black and yellow mustard are mainly used as spices. White mustard is used as fodder crop or as a green manure. Rapeseed-mustard group broadly include Indian mustard, yellow sarson, brown sarson, raya and toria crops. Indian mustard (*Brassica juncea*) is predominantly cultivated in Rajasthan, U.P., Haryana, M.P. and Gujarat. It is also grown under some non-traditional areas of South India including Karnataka, Tamil Nadu and Andhra Pradesh. The total oilseed production has been hovering around 30 million tons during last few years. The area, production and yield of inorganic

rapeseed mustard in India during 2022-23 were 8.80 million hectare, 12.49 million tons, and 1419 kg/ha, respectively.

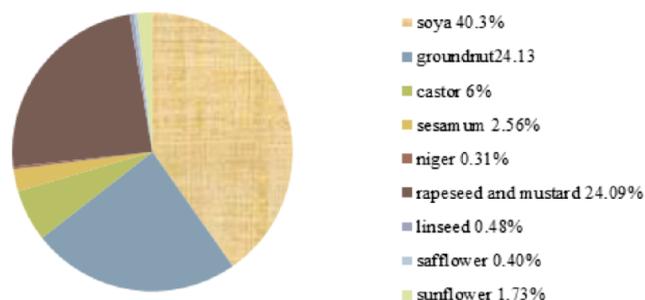


Fig.1 A :A rough picture of oilseed crops contribution towards India's total Oil seed production

Rajasthan has shown the highest growth rate in terms of production and area, while decline in the area has been observed in U. P. and Punjab (Singh, 2015). However, despite all efforts, the import of edible oil has increased up to 10.09 million tons during 2023-2024. These figures and facts pertaining

to area, production and yield of rapeseed - mustard have been reported from the area where the crop was grown either in integrated management or traditional method or in inorganic management across the states in the country. In fact, four oil seed crops *viz.* soybean, sesame, castor and mustard are being grown in organic farming on mere 0.5 million hectare with the production of 0.23 million tons however, around 56% organic oil is being exported. Therefore, in order to bridge the wide gap in area and production of mustard between organic and inorganic cultivation there is an urgent need to develop high yielding mustard varieties coupled with quality oil to cater to varietal need of organic production system in the country. As many as, 191 countries across the globe are promoting organic farming in order to protect human being, livestock, water, soil and environment from the hazardous effects of chemicals and synthetics.

India accounts for only 4% area under organic cultivation where suitable varieties for organic farming is one of the major thrust areas to move forward in organic production, since evolution and testing of newly developed varieties are being carried out in high input environment (chemical environment) consequently, when these varieties are put in low input organic environment, they generally do not respond up to the mark which makes a wide gap (around 20 to 30% yield reduction in organic cultivation) in production of crops between chemical farming and organic farming. Indeed, this gap can be bridged by deployment of organic crop varieties in production system or by identifying suitable varieties of crops for organic farming. The varieties those either have broad genetic base

or organic genome make a guaranty to respond better under organic environment.

MATERIALS AND METHODS

Twenty varieties of mustard of different origin were evaluated in RBD with three replications against locally adapted variety RH 749 for two consecutive crop seasons (2021-22 and 2022-23) under organic environment to find out their superiority and suitability for organic production system. The varieties includes Rohini, Maya, Azad Mahak, Ashirvad, Urvashi, Vaibhav; Basanti, Vardan, Varuna, Pitambari, RH 749, RB 50, RH 9801, RH 0119, RH 9304, RH 8812, RH 761, RH 725, RH 406, and RH 30. The experiments in both the years were laid in second fortnight of October, 2021 and 2022. Sowing was done manually in which 45 cm distance between rows was kept maintaining plant to plant spacing of 15cm. Organic manure's as basal dose (FYM @ 50.0 q/ha or Vermicompost@ 18q/ha + Neem cake / Mustard cake @5.0 q/ha) were applied one week before sowing. Weeding between rows and within plants was carried out after 20 -25 days of sowing. First irrigation after 40 days of sowing and second irrigation was done after 80 days of sowing or after siliqua formations in the crop. The observations were recorded on central 4 rows in each plot having 9 m² size, however net plots were of 4 rows with 5.0 meter in length having 0.45 meter in spacing between rows. Analysis of variance of the characters was computed as per the method of Panse and Sukhatme (1985).

RESULT AND DISCUSSION

Twenty varieties of Indian mustard were evaluated in organic environment for two years of 2021-22 and 2022-23 including

standard check (RH 749) for 16 physiological and seed yield contributing traits. Significant variation among the varieties of mustard in terms of flower was observed however, Pitambari, Varuna and Azad Mahak were flowered ahead of the standard check Table 1. In fact, Pitambari was the earliest maturing variety among all. It is in the agreement of the findings of Bhagirath *et al.*, 2021. Plant height is desirable trait which determines primary and secondary branches on the plant. Pitambari was found to carry higher number of primary branches followed by Vardan while, higher secondary branches were registered by Varuna and Rohini Table 1. Siliqua per plant was recorded highest in RH 406, RB 50 and Ashirwad. Main shoot length was recorded highest in Maya, Basanti and Urvashi Table 1. Number of seed per siliqua is an important character which ultimately determines seed yield of a variety as also reported by IFOAM, 2017. Pitambari, RB 50 and Maya registered higher number of seed per siliqua over RH 749 Table 2. Biological yield per plot was recorded highest in Maya and Varuna whereas, seed yield per plot was registered highest with Maya and RB 50. This finding is in the agreement of You *et al.*, 1995. Although, in terms of seed yield q/ha Maya was among the top of varieties (24.20 q/ha) while, RB 50 was ascertained (22.89 q/ha) numerically superior over RH-749 in 2021-22 crop season Table 2. The highest biological yield per hectare was also recorded with Maya (79.63 q/ha) while, Varuna and Basanti were on same pedestal having biological yield (59.50 q/ha as also suggested by Lammerts van Bueren *et al.*, 1999, Wolfe *et al.*, 2008. Harvest index reflects source and sink relationship in the plant as Pitambari recorded highest harvest index (62.78%) which reflected higher seed yield than straw yield. Oil content is one of the most important millable criteria for accepting a variety in the market Table 2. Azad Mahak

recorded highest (44.06) oil content while, RH 725 and Maya stood on second and third pedestal, respectively. Straw yield of mustard crop is used as fuel in brick kiln which fetch better remunerative prices for the farmers. Maya (55.43 q/ha) recorded highest straw yield, while Varuna and Basanti had equal superiority for straw yield over RH 749 Table 2.

The experiment comprising of same varieties was repeated in 2022-23 to ascertain their suitability for organic production system. Significant variation among the varieties for flowering behavior was also observed. The earliest flowering was noticed in Vaibhav (51.66 days) followed by Ashirwad, Rohani and Maya Table 3.

Earliest maturing variety was Pitambari among them. However, none of the varieties could mature before standard check RH 749. The varieties *Viz*; Basanti, Ashirwad and RH 761 surpassed over standard check in terms of plant height. Pitambari and RH 0119 had higher equal primary branches to RH 749. Highest secondary branches were observed in Maya, Ashirwad and Varuna while, siliqua per plant was recorded highest with Ashirwad, Urvashi Azad Mahak and Basanti etc. However, main shoot which had significant role in bearing primary and secondary branches on the plant was recorded highest in Maya, Basanti and Urvashi Table 3. Number of seeds per siliqua was significant higher in Pitambari and RH 761 over standard check. RB 50 was the only variety which had significantly highest length of siliqua Table 4. Seed yield q/ha was non-significant, but numerical superiority for seed yield was registered over standard check by RH 9304, Maya, Azad Mahak, Varuna and RB50, while biological yield q/ha was found highest in Varuna, Vardan, Urvashi, RH9304, RB 50 etc. This is in accordance with the finding of Shekhawat *et al.*, 2012. Highest harvest index

was recorded in Pitambari, whereas Azad Mahak was equal with standard check in terms of harvest index too. Two Varieties namely Azad Mahak (45.34) and RB 50 were ascertained numerically superior for oil content over RH 749. Straw yield q/ha was also computed as it is being used in paper industry as a raw material and also in brick kiln as a fuel. Four varieties Viz; Vardan Varuna RH 9304 and RB50 were numerically superior over standard check in terms of straw yield Table 4. The varieties showed higher seed yield in organic environment which were developed 30-40 year ago taking the parental lines from wider gene pool as advocated by FAO 2020. Indeed, these varieties can be utilized in breeding programme owing to have

diverse genetic base and origin Bhatnagar and Karmaker 1995 and Karmaker 2001.

Graphical representation of the varieties for oil content Fig.1 indicated that Azad Mahak is highest oil producer while Maya and RH 761 were on equal pedestal. Seed yield fig.2 revealed that the varieties Viz; RH 9304, Maya, Azad Mahak, RB50 and Varuna were found to be numerically superior over standard check under organic environment. The performance of these varieties in organic environment corroborated the fact that the varieties which had broad genetic base performed beyond expectation over RH-749. This is in accordance with the finding of Chung and Singh (2008).

Table 1: Performance of mustard varieties under organic environment (2021-22)

Varieties	Days to flower (100%)	Physiological maturity (days)	Plant height (cm)	Primary Branches/plant	Secondary branches/plant	Siliqua/plant	Main shoot length (cm)
Rohani	52.33	137.66	165.00	5.00	14.66	368.00	112.66
Maya	53.66	138.33	197.66	5.33	12.33	263.33	147.33
Azad Mahak	52.33	138.66	169.66	4.00	13.33	367.66	135.66
Ashirwad	53.66	141.00	175.00	4.33	12.00	418.00	113.66
Urvasi	53.33	140.00	137.00	4.66	11.66	428.33	141.00
apdefaultVaibhav	53.33	136.66	170.00	4.66	12.00	154.00	110.66
Basanti	53.00	136.66	172.66	5.33	13.00	347.66	144.33
Vardan	53.66	136.33	172.66	5.66	12.00	302.00	121.00
Varuna	52.00	137.66	170.00	5.00	15.00	285.33	134.66
Pitambari	51.00	121.66	88.33	6.66	4.66	118.33	77.66
RH 749	57.00	137.33	147.00	5.66	12.33	292.00	130.66
RB 50	58.00	140.66	178.33	4.33	14.00	441.66	142.33
RH 9801	55.33	137.33	131.00	4.66	11.00	376.66	143.66
RH 0119	55.66	137.33	156.00	4.33	12.66	435.00	133.33
RH 9304	54.00	137.00	145.00	3.66	10.66	281.66	126.66
RH 8812	55.33	139.00	149.66	5.00	15.00	285.00	130.33
RH 761	56.00	139.00	143.66	3.66	13.33	344.00	105.00
RH 725	55.33	137.66	146.66	4.33	13.66	242.33	130.00
RH 406	54.33	137.00	122.66	4.33	13.33	470.66	105.33
RH 30	55.66	137.00	124.33	4.33	13.66	284.66	121.00
CD(0.05)	2.09	1.92	13.69	1.20	2.22	47.47	13.07
CV (%)	2.32	0.84	5.39	15.26	10.70	8.79	6.28

Table 2: Performance of mustard varieties under organic environment (2021-22)

Variety	Number. of seeds per (5 siliqua)	Length of siliquae (cm)	Biological yield (kg/plot)	Seed yield (kg / plot)	Seed yield (q/ha)	Biological yield (q/ha)	Harvest index (%)	Oil Content (%)	Straw yield (q/ha)
Rohani	58.00	5.00	7.28	1.99	14.74	53.99.	27.31	42.08	39.24
Maya	59.33	5.33	10.74	3.26	24.20	79.63.	30.44	43.54	55.43
Azad Mahak	53.33	4.66	6.40	1.78	13.24	47.48.	27.97	44.06	34.23
Ashirwad	49.00	4.33	6.00	1.93	14.31	44.53	32.17	41.76	30.21
Urvasi	57.66	4.66	5.63	1.88	13.95	41.78	33.44	42.84	27.82
Vaibhav	42.66	4.33	4.70	1.56	11.57	34.89	32.98	42.62	23.31
Basanti	55.66	5.00	7.96	2.48	18.43	59.05	31.15	42.62	40.61
Vardan	41.66	4.66	5.31	1.49	10.88	39.36	28.32	41.02	28.47
Varuna	49.00	4.00	8.02	2.62	19.48	59.50	32.74	41.32	40.02
Pitambari	87.66	5.00	3.53	2.21	16.41	26.17	62.78	42.02	9.76
RH 749	57.33	5.00	4.89	2.47	18.42	36.26	30.07	41.59	25.35
RB 50	73.66	6.40	5.54	2.78	22.89	41.07	34.99	42.62	26.70
RH 9801	51.33	4.00	3.75	1.21	8.99	27.85	32.27	42.62	18.85
RH 0119	52.00	5.66	4.77	1.49	11.04	35.36	31.16	41.02	24.31
RH 9304	66.33	6.33	3.91	1.39	10.35	29.59	34.99	42.62	19.23
RH 8812	53.00	5.66	3.62	1.22	9.04	26.00	33.72	42.62	16.96
RH 761	53.33	6.00	3.50	1.31	9.73	25.95	37.56	43.54	16.21
RH 725	61.33	5.66	4.74	1.39	10.13	35.17	28.81	44.06	25.03
RH 406	60.33	6.66	3.65	1.29	9.61	27.08	35.55	41.76	17.47
RH 30	59.33	6.00	3.77	1.40	10.40	27.99	37.11	42.84	17.58
CD(0.05)	9.01	1.30	0.56	0.25	1.89	4.13	4.03	1.51	3.51
CV(%)	9.51	15.10	6.28	8.80	8.70	6.24	7.20	2.15	7.89

Tae 3: Performance of mustard varieties under organic environment (2022-23)

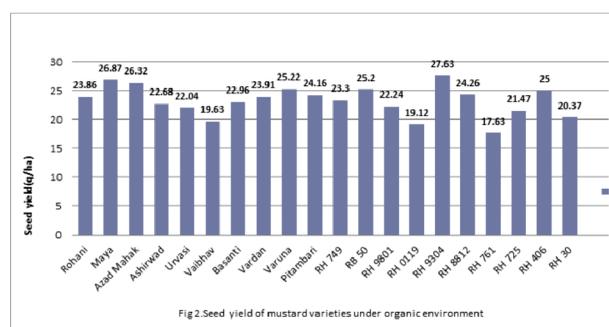
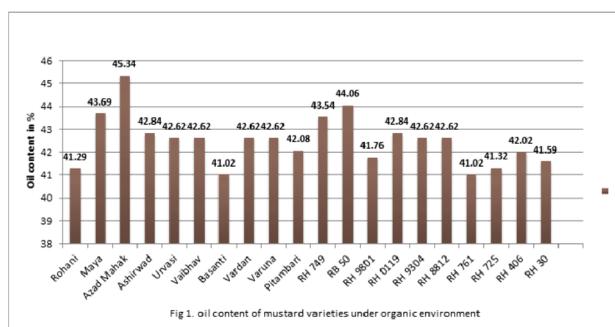
Varieties	Days to flower (100%)	Physiological maturity (Days)	Plant height (cm)	Primary Branches/ plant	Secondary branches/ plant	Siliqua/ plant	Main shoot length (cm)
Rohani	52.00	140.66	192.66	4.66	13.33	536.33	116.33
Maya	53.66	139.00	188.66	4.66	17.00	420.33	150.00
Azad Mahak	53.00	138.33	183.00	4.33	14.33	813.66	141.00
Ashirwad	52.00	139.66	201.33	6.66	15.66	826.00	121.00
Urvasi	53.00	139.66	193.00	5.00	13.33	819.00	144.00
Vaibhav	51.66	134.00	187.66	4.33	13.00	766.33	114.66
Basanti	54.66	134.66	202.00	4.66	12.33	774.33	150.66
Vardan	54.66	137.00	196.66	6.33	12.33	520.33	127.66
Varuna	52.33	139.33	186.66	5.33	15.33	517.66	138.66
Pitambari	52.66	124.33	92.00	7.00	4.00	356.00	82.00
RH 749	57.33	129.33	192.66	7.00	13.66	456.66	131.00
RB 50	57.00	137.00	188.66	5.00	11.66	491.66	145.33
RH 9801	55.33	138.66	183.00	6.00	12.00	479.00	147.66
RH 0119	56.66	136.00	201.33	7.00	14.00	428.66	138.66
RH 9304	55.00	137.667	193.00	5.66	12.00	462.66	131.66

Identification of Suitable Mustard Varieties for Organic Production System

RH 8812	56.00	138.00	187.66	5.66	13.00	505.00	140.33
RH 761	58.00	134.33	200.00	6.00	13.33	491.66	107.00
RH 725	55.66	134.00	196.66	5.66	13.00	501.00	137.33
RH 406	56.66	137.00	186.66	4.66	13.00	532.33	107.33
RH 30	59.00	137.00	120.00	5.33	13.00	411.00	125.33
CD (0.05%)	1.98	3.81	10.26	1.22	1.44	72.93	9.74
CV (%)	2.18	1.68	3.36	13.25	6.72	7.91	4.52

Table 4: Performance of mustard varieties under organic environment (2022-23)

Varieties	Number of seeds per (5 siliquae)	Length of siliquae (cm)	Biological yield (kg/plot)	Seed yield (kg / plot)	Seed yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Rohani	58.00	4.66	8.83	2.15	23.86	98.05	28.04
Maya	58.00	4.00	7.63	2.89	26.87	84.73	27.50
mrgAzad Mahak	79.33	4.66	7.58	2.87	26.32	84.17	30.58
Ashirwad	65.00	4.00	6.83	2.04	22.68	75.85	29.65
Urvasi	68.00	4.33	8.51	2.25	22.04	94.35	27.09
Vaibhav	55.00	4.00	6.33	1.76	19.63	70.30	27.40
Basanti	76.00	5.00	7.63	2.06	22.96	84.73	26.81
Vardan	65.33	4.00	9.00	2.37	23.91	99.90	27.74
Varuna	71.00	4.00	9.00	2.69	25.22	99.90	23.80
Pitambari	90.00	5.00	4.90	2.67	24.16	54.46	54.29
RH 749	74.33	5.00	8.00	2.40	23.30	88.80	30.10
RB 50	72.00	6.00	8.50	2.68	25.20	94.35	26.66
RH 9801	73.33	4.00	7.33	2.00	22.24	81.40	27.35
RH 0119	67.33	5.00	6.50	1.72	19.12	72.15	25.80
RH 9304	75.33	4.33	8.83	2.97	27.63	98.05	28.14
RH 8812	74.66	4.66	8.33	2.18	24.26	92.50	26.29
RH 761	82.00	5.33	6.00	1.58	17.63	66.60	26.11
RH 725	80.00	5.00	6.98	1.93	21.47	77.48	27.71
RH 406	77.33	4.33	8.09	2.25	25.00	89.80	27.85
RH 30	59.33	5.00	6.63	1.83	20.37	73.59	27.68
CD (0.05)	6.31	0.85	N/A	0.64	N/A	N/A	5.07
CV (%)	5.28	11.18	19.71	17.82	16.58	19.70	10.59



REFERENCES

- Bhatnagar PS and Karmaker P.K. 1995. Achievement and prospects of breeding research in soybean (*Glycine max* L.) in India. *Indian journal of Agricultural Sciences* 65: 1-9
- Bhagirath Ram, Priyamedha, M.S, Sujith kumar, H.K.Sharma. Reema Rani, K,H,Singh, V.V. Singh, Vinod Kumar and P.K. Rai 2021. Development and evaluation of early maturing and thermo-tolerant Indian mustard (*Brassica juncea* L) genotypes for cultivation in semi-arid region of India. *Electronic Journal of Plant Breeding* .Vol. 12 (1) : 200-206.
- Chung G and Singh RJ. 2008. Broadening the genetic base of soybean: A multidisciplinary approach. *Critical Reviews in Plant Sciences* 27:295-341.
- FAO.2020. Commission on Genetic Resources for food and Agriculture. Plant Genetic Resource. Food and Agriculture Organization of the United Nations. [http; www.fao.org](http://www.fao.org).
- Ifoam, 2017. The most important characteristics of organic breeding program and all breeding steps. *International position paper on organic breeding*, Nov, 2017.
- Karmaker PG, 2001. Speeding up the development of new soybean varieties, In: Proceeding of India Soy Forum, Indore, PP:65-9.
- Lammerts van Bueren ET, Hulscher M, Jongerden J, Ruivenkamp GTP, Haring M, van Mansvelt JD, Den NIJS, AMP, 1999. Sustainable organic plant breeding-A vision, Choices, Consequences and steps. Louis Bolk Institute: Driebergen, The Netherlands.
- Panase, V.G. and Sukhatme, P.V. 1985. Statistical method for agriculture workers. Indian Council of Agricultural Research, New Delhi, 155.
- Shekhawat, Kapila;Rathore, S.S., Premi, O.P., Kandpal, B.K. and Chauhan, J.S, 2012. Advances in agronomic management of Indian mustard(*Brassica jancea* (L.): an overview. *International Journal of Agronomy*.P.1-14.
- Singh Dhiraj. 2015-16. Project coordinator's report presented in 23rd Annual AICRP (R&M) Group meeting held at DUVA SU, Mathara form August 5-7, 2016.
- Wolfe M S, Baresel JP, Desclaux D, Goldringer I, Hoad S, Kovacs G, Loschenberger F, Miedaner T, Stergard H, Lammerts van Bueren E T, 2008. Development in breeding of cereals for organic agriculture. *Euphytica* 163:323-346.
- You M, Zhao T and Gai J. 1995. Performance and inheritance of short petiole trait of a new soybean mutant. *Soybean Genetics News letter* 22: 71-5.

STUDIES OF DIRECT AND INDIRECT EFFECTS OF YIELD AND YIELD ATTRIBUTING CHARACTERS IN URDBEAN (*VIGNA MUNGO* (L.) HEPPER)

H. VANLALHMULIANA¹, C. RACHAEL¹, LALTHASANGI¹ AND MEENAKSHI MALIK²

Institute of Agricultural Sciences Bundelkhand University, Jhansi (U.P.)

Corresponding author's email-maahiseeds@gmail.com

ABSTRACT

A set of twelve genotypes of urd bean were evaluated for studying of “Studies on direct and indirect effects of yield and yield Attributing Characters in Urdbean (*Vigna mungo* (L.) Hepper).” The experiment was conducted in a randomized block design with three replications during the *Kharif* season, 2023-24 at Rainfed Agriculture Research Farm, Narayanbagh, Institute of Agricultural Sciences, Bundelkhand University, and Jhansi. From the present investigation it is concluded that among 12 genotypes of urdbean based on mean performance 3 genotypes *viz.* PU-30 followed by PDU-103 and PLLU-302 indicating that these genotypes can be used in hybridization programme to achieve higher yield. Significant variation recorded among different genotypes for all characters studied indicating presence of good amount of variability among the genotypes. Phenotypic differences might be considered genotypic variations among the genotypes for selection. PCV values were highest for number of clusters per plant, seed yield per plant and days to 50% germination whereas, GCV higher for number of clusters per plant only indicating that these characteristics may be improved by selection. Correlation coefficient analysis revealed that seed yield per plant exhibited significant and positive association with all characters except for seed yield per plant showed negative and significant correlation with days to first flowering, days to 50% flowering and days to maturity at both genotypic and phenotypic level.

Key words: Urdbean, GCV, PCV, Variability, Heritability, Correlation and Path analysis.

Black gram generally known as urd bean, is an important self-pollinated crop and belong to the family Fabaceae and sub family Papilionaceae. Black gram is extensively used as a nutritious pulse. India is the largest producer of pulses in the world, accounting for about 25% global share. Black gram is the fourth important pulse crop in India which holds about 12% of the total pulse area and contributing about 10% to the total pulse

production. Its cultivation is spread over three different seasons namely the rainy seasons (*kharif*), dry (*rabi*), and summer (*zaid*). Black gram is one of the most important pulse crops of rained areas, grown throughout the country. Urd bean production in the country is largely concentrated in five states *viz.* Uttar Pradesh (UP), Andhra Pradesh, Maharashtra, Madhya Pradesh and Tamil Nadu. These five states together contribute for about 65% of

total urd production in the country. U.P. and Andhra Pradesh occupy the first two positions, contributing over 40%. Maharashtra contributes about 14% respectively of total production in the country. Black gram is a highly priced pulse, rich in protein (24%), carbohydrates (56%), fat (2%), minerals (4%), Vitamins (0.4%) and phosphoric acid. Correlation coefficient studies provide an opportunity to study the magnitude and direction of association of yield with its components and also among various components. Path coefficient analysis is an efficient statistical technique specially designed to quantify the interrelationship of different components and their direct and indirect effects on seed yield. Lack of stable varieties giving higher yield, because of technological stagnations is the major bottleneck for growing of this crop to serve as a commercial crop. The plant type should be determinate, photo insensitive, early maturing with high harvest index and should have reasonable seed yield.

The present study was undertaken to estimate association between yield contributing characters along with path analysis for developing suitable selection criterion for black gram improvement. Knowledge of inter-relationships existing among yield components is essential when selection for improvement is to be effective. Path analysis identifies the yield components which directly and indirectly influence the yield. Hence, the present research work was carried out to study the correlation coefficients and path coefficients in order to formulate selection criteria for evolving high yielding genotypes of black gram.

MATERIALS AND METHODS

The experimental materials consisted of 12 black gram genotypes obtained from NBPGR, New Delhi, raised in Randomized Block

Design with three replications at the Rainfed Agriculture Research Farm, Narayanbag, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.), during *Kharif* season 2023-24. The genotypes were raised following spacing of 20 X 10 cm and other recommended cultural practices. Observations were recorded on five randomly selected plants from each replication for fourteen quantitative traits *viz.*, days to 50% germination, days to initial flowering, days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pod per clusters, number of pods per plant, pod length (cm), number of leaves per plant, number of seeds per pod, seed yield per plant (g), biological yield per plant (g), seed index (g) and harvest index. The genetic association among the traits was estimated according to the formulae described by Johnson *et al.*, (1955). The path coefficient analysis was done according to (Dewey and Lu, 1959) for assessing the direct and indirect effects of each trait on grain yield.

RESULTS AND DISCUSSION

Analysis of Variance

The table 1 the variability exploited in breeding programme is desired from the naturally occurring variants and wild relatives of main crop species as well as from strains and genetic stocks artificially developed by human effort. Through this study, an attempt was made to assess the mean performance of sixty genotypes for fourteen characters. In table 1 the mean square due to genotypes were found significantly differed amongst themselves for 16 characters *viz.*, days to 50% germination, days to initial flowering, days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pod

per clusters, number of pods per plant, pod length (cm), number of leaves per plant, number of seeds per pod, seed yield per plant (g), biological yield per plant (g), seed index (g) and harvest index, which suggested the existence of sufficient variability in the experimental materials and showing an ample scope for selection of promising genotypes

which can be used directly as a variety or as a parent in breeding. The presence of large amount of variability might be due to diverse source of material taken as well as environment affecting the phenotype. These outcomes were comparable with that of (Gupta *et al.*, 2006 and Roshani *et al.*, 2022).

Table 1: Analysis of variance (ANOVA) for yield and its component traits in urd genotypes

Source of variation	Degree of freedom (df)	Mean sum of squares							
		Days to 50% germination	Days to initial flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches/ plant	Number of clusters per plant	Number of pod per clusters
Replications	2	0.5277	1.4444	5.583	5.083	18.860	0.272	1.598	0.044
Genotypes	11	1.3611**	7.5354**	10.431**	17.000**	32.954**	1.665**	124.333**	0.152**
Error	22	0.3762	2.202	1.856	3.174	7.631	0.407	5.785	0.045

** Significant at 1% level; * Significant at 5% level

Source of variation	Degree of freedom (df)	Mean sum of squares							
		Number of pods per plant	Pod length (cm)	Number of leaves per plant	Number of seeds per pod	Seed yield per plant (g)	Biological yield per plant (g)	Seed index (g)	Harvest index (%)
Replications	2	85.30	0.046	29.79	0.137	9.374	161.3	0.014	1.549
Genotypes	11	651.53**	0.354**	1349.65**	0.902**	35.795**	3167.4**	0.564**	2.282*
Error	22	103.97	0.107	383.49	0.148	4.166	977.6	0.058	0.870

** Significant at 1% level; * Significant at 5% level

Table 2: Mean values of 12 genotypes for 16 characters in urd bean

Parameters	DG50	DF50	DM	PH	NPB	NCPP	NPPC
PLLU-302	3.33	41.67	83.33	31.20	4.65	32.75	2.35
IPU-1070	5.33	40.33	75.33	31.70	4.07	35.15	2.21
PLU-144	4.00	41.67	75.33	39.87	4.73	31.27	2.47
NP-16	4.33	39.67	77.00	31.07	5.22	31.13	2.23
PDU-3	3.33	39.67	78.33	27.07	6.45	28.45	2.34
UG-27	4.33	43.67	78.67	32.20	4.99	30.27	2.31
BGP-211D2	4.33	45.33	75.67	31.60	3.90	12.52	2.23
PDU-2E	4.33	42.33	76.00	34.33	4.63	24.75	2.50
PDU-103	3.00	45.00	75.33	28.67	3.66	22.10	2.55
PGRU-9902	4.33	41.00	74.67	34.67	3.99	19.47	2.18
NO-5131	4.00	42.00	76.00	32.73	4.83	26.90	2.27
PU-30	5.00	42.67	76.33	29.07	4.90	30.57	2.99
GM	4.1389	42.0833	76.8333	32.0139	4.6675	27.1114	2.3861
SE	0.3541	0.7866	1.0286	1.5948	0.3686	1.3887	0.1234
C.D. 5%	1.0387	2.3069	3.0169	4.6775	1.0810	4.0729	0.3618
C.D. 1%	1.4117	3.1355	4.1005	6.3576	1.4692	5.5358	0.4918
CV	14.82	3.24	2.32	8.63	13.68	8.87	8.96

Parameter	NPPP	PL	NLP	NSPP	BY	SI	HI	SYPP
PLLU-302	120.66	4.45	193.96	6.52	321.89	3.67	6.43	20.63
IPU-1070	124.58	3.66	193.36	5.21	302.29	3.42	5.07	15.23
PLU-144	118.89	4.13	158.01	5.49	293.80	3.51	5.30	15.67
NP-16	116.42	3.58	192.19	4.70	290.80	3.50	6.88	19.75
PDU-3	106.31	4.34	174.43	4.97	292.52	3.41	6.49	18.95
UG-27	84.87	4.20	157.33	5.77	297.82	3.54	5.13	14.91
BGP-211D2	97.76	4.53	144.67	4.82	257.37	2.45	7.44	18.93
PDU-2E	113.00	4.20	186.36	5.11	270.17	3.38	7.47	20.05
PDU-103	130.99	4.43	157.96	5.25	344.65	3.66	6.58	22.58
PGRU-9902	117.54	4.26	128.40	4.57	235.95	2.93	5.93	13.75
NO-5131	129.55	4.15	152.40	5.63	305.77	3.48	6.19	18.83
PU-30	137.75	4.82	164.81	4.83	347.33	4.28	7.40	25.72
GM	116.5253	4.2289	166.9894	5.2400	296.69	3.4353	6.3586	18.7497
SE	5.8871	0.1896	11.3061	0.2223	18.05	0.1393	0.5387	1.1785
C.D. 5%	17.2663	0.5562	33.1598	0.6520	52.94	0.4086	1.58	3.4564
C.D. 1%	23.4680	0.7559	45.0700	0.8862	71.95	0.5553	2.1475	4.6978
CV	8.75	7.77	11.73	7.35	10.54	7.02	14.67	10.89

Coefficient of variation

Genetic variability parameters

In table 2 an effort was made to estimate the variability and mean performance genotypes for various quantitative attributes. All of the traits under study showed a wide range of variation. The variation was highest for biological yield per plant (235.95 to 347.33 g), number of leaves per plant (152.40 to 193.96), number of pods per plant (84.87 to 137.75), number of clusters per plant (12.52 to 35.15), seed yield per plant (13.75 to 25.72 g), plant height (27.07 to 39.87 cm), days to maturity (74.67 to 83.33 days), days to initial flowering (30.67 to 36.33 days), days to 50% flowering (39.67 to 45.33 days), number of primary branches per plant (3.66 to 6.45), days to 50% germination (3.00 to 5.33 days), pod length (3.58 to 4.82 cm), number of seeds per pod (4.70 to 6.52), harvest index (5.07 to 7.40%), seed index (2.45 to 4.28 g) and number of pod per clusters (2.18 to 2.99). The similar outcomes were also reported by Toppo *et al.*, 2019 and Roshani *et al.*, 2022).

The estimates of PCV in table 3 were somewhat higher than the corresponding estimates of GCV for all the traits considered under study, expressing the existence of interplay between genotypes and environment. High genotypic coefficient of variation were observed for number of clusters per plant where as high phenotypic coefficient of variation for number of clusters per plant, seed yield per plant and days to 50% germination.

Moderate genotypic coefficient of variation were observed for seed yield per plant, no. of primary branches/ plant, days to 50% germination, seed index, number of pods per plant, harvest index and number of leaves per plant while, moderate phenotypic coefficient of variation for no. of primary branches/ plant, harvest index, number of leaves per plant, number of pods per plant, biological yield per plant, seed index, plant height, number of seeds per pod, number of pod per clusters and pod length. The similar outcomes were also

reported by Chauhan *et al.*, (2020). Low genotypic coefficient of variation was observed for number of seeds per pod, biological yield per plant, plant height, number of pod per clusters, pod length, days to 50% flowering, days to initial flowering and days to maturity while, low phenotypic coefficient of variation for days to initial flowering, days to 50% flowering and days to maturity. The similar outcomes were also reported by Gupta *et al.*, (2006).

Heritability

Heritability estimate in broad sense is the ratio of genotypic variance to the phenotypic variance and is expressed in percentage. It is an index of transmission of a character from parents to their off-springs. It helps the plant breeders in the selection of superior genotypes from the genetically variable population. Estimates of heritability value was high for number of clusters per plant, seed index, seed yield per plant, number of pods per plant, number of seeds per pod and days to 50% flowering. However, days to maturity, plant height, no. of primary branches/ plant, days to 50% germination, number of leaves per plant, days to initial flowering, number of pod per clusters, pod length, biological yield per plant and harvest index showed moderate heritability. These results were in consonance with the findings Parameswarappa and Lamani (2005).

Genetic advance as per cent of mean

The estimates of heritability are influenced by various factors such as sample size, sampling methods, effects of linkage, method of estimation and population density etc. and other biotic and a-biotic factors hence their utility will be restricted. Thus, heritability values coupled with genetic advance would be more reliable and useful in formulating selection criteria. Genetic advance is the

product of selection intensity, heritability and phenotypic standard deviation.

Number of clusters per plant, seed yield per plant and seed index showed high value of heritability coupled with high genetic advance as per cent of mean indicating lesser influence environmental factors on the expression of these character and prevalence of additive gene action in their inheritance, hence, are amenable for simple selection. These results were in accordance with the findings of Roshani *et al.*, (2022).

In table 4 and 5 the correlation coefficient is a statistical measure, which is used to find out the degree and direction of relationships between two or more variables. Thus, it measures the mutual relationship between two or more variables. It provides better understanding of yield components, which helps the plant breeder during selection (Johnson *et al.*, 1955). For the selection purpose, phenotypic correlation coefficient is of little practical value unless genetic correlation coefficients between pair of characters were in the same directions when estimated separately. Genotypic correlation coefficients provide a measure of genetic association between characters and were generally used in selection of one character as a means of improving another. Genetic correlation coefficient may be accounted by linkage and pleiotropy. Environmental correlation coefficient indicated non-genetic values and arises due to the fact that several observations are affected by the same amount of environmental factors. Therefore, the knowledge of correlation coefficient is of great significance. Correlation coefficient studies showed that for most of characters' pairs, genotypic and phenotypic associations were in the same direction and the genotypic estimates were higher than the phenotypic ones, indicating an inherited association between the characters.

Table 3. Genetic variability parameters for yield and its attributing traits in urd genotypes.

Variability parameters	DG50	DFP	DF50	DM	PH	NPB	NCPP	NPPC
GCV	13.8437	3.8339	4.0176	2.7941	9.0752	13.8749	23.1865	7.9185
PCV	20.2809	5.7363	5.1596	3.6309	12.5225	19.4824	24.8258	11.9570
ECV	14.8205	4.2669	3.2373	2.3188	8.6286	13.6769	8.8719	8.9552
Heritability (Bs)	0.4659	0.4467	0.6063	0.5922	0.5252	0.5072	0.8723	0.4386
GA	0.8057	1.8358	2.7120	3.4030	4.3374	0.9501	12.0944	0.2578
Genetic Advance as percentage of mean	19.4666	5.2787	6.4444	4.4291	13.5485	20.3557	44.6100	10.8042
Variability parameters	NPPP	PL	NLP	NSPP	BY	SI	HI	SYPP
GCV	11.5940	6.7838	10.7467	9.5668	9.1061	11.9563	10.7875	17.3173
PCV	14.5257	10.3129	15.9064	12.0637	13.9274	13.8661	18.2126	20.4550
ECV	8.7507	7.7668	11.7270	7.3484	10.5366	7.0237	14.6741	10.8866
Heritability (Bs)	0.6371	0.4327	0.4565	0.6289	0.4275	0.7435	0.3508	0.7167
GA	22.2135	0.3887	24.9768	0.8189	36.3892	0.7296	0.8369	5.6627
Genetic Advance as percentage of mean	19.0632	9.1915	14.9571	15.6279	12.2648	21.2385	13.1618	30.2015

Correlation coefficient analysis

Seed yield per plant, the most important economic trait, exhibited significant positive association with harvest index (0.843**), biological yield per plant (0.822**) and seed index (0.628*) at both phenotypic and genotypic level. These results suggested that the characters harvest index, biological yield per plant and seed index were positively correlated with seed yield. These results indicated that simultaneous improvement in seed yield through these traits could be achieved within a short period by simple selection procedures and also among themselves indicating their utility in selection programme for improving yield potential of population. These results were in consonance with the finding of Shivade *et al.*, (2011).

Path coefficient analysis

Path coefficient analysis is an efficient statistical technique specially designed to quantify the inter-relationships of different components and their direct and indirect effects on the seed yield. Through this technique, yield-contributing components can be ranked and specific traits producing a given correlation coefficient can be revealed. These will in turn impair the true association

existing between a component and seed yield and a change in any one component were likely to disturb the whole network of cause and effect.

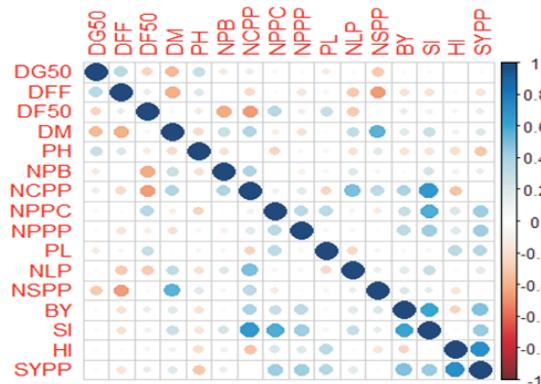


Fig 1 . Diagrammatic representation of genotypic correlation for grain yield/ plant.

As the result of this study, it revealed that harvest index (0.646), seed index (0.466) and biological yield per plant (0.463) registered very high and positive direct effects on yield. Whereas, days to 50% germination (0.13), plant height (0.112), number of primary branches per plant (0.110), number of pods per plant (0.034), days to maturity (0.020) and number of seeds per pod (0.010) registered the low and positive direct effect on yield.

Therefore, a true relationship exists between seed yield per plant with harvest index, seed index and biological yield per plant. These results were in agreement with the findings of Jamil *et al.*, (2022) and Yadav *et al.*, (2023).

Table 4. Genotypic correlation coefficient among different traits in urd genotypes

Characters	DG50	DF50	DM	PH	NPB	NCPP	NPPC
DG50	1 **	0.6842 *	-0.1108 NS	-0.4157 NS	0.1657 NS	-0.1723 NS	0.2224 NS
DF50	0.6842 *	1 **	0.0829 NS	-0.9713 **	0.4402 NS	0.0884 NS	-0.3897 NS
DM	-0.1108 NS	0.0829 NS	1 **	-0.2063 NS	-0.0022 NS	-0.7248 **	-0.6695 *
PH	-0.4157 NS	-0.9713 **	-0.2063 NS	1 **	-0.3227 NS	0.4965 NS	0.4241 NS
NPB	0.1657 NS	0.4402 NS	-0.0022 NS	-0.3227 NS	1 **	-0.3153 NS	0.0118 NS
NCPP	-0.1723 NS	0.0884 NS	-0.7248 **	0.4965 NS	-0.3153 NS	1 **	0.4817 NS
NPPC	0.2224 NS	-0.3897 NS	-0.6695 *	0.4241 NS	0.0118 NS	0.4817 NS	1 **
NPPP	0.1506 NS	0.3292 NS	0.2374 NS	0.0151 NS	-0.1503 NS	0.0911 NS	0.2335 NS
PL	0.0252 NS	-0.4867 NS	-0.2248 NS	-0.2558 NS	-0.1075 NS	-0.3452 NS	0.3021 NS
NLP	-0.4534 NS	0.0515 NS	0.8578 **	0.3248 NS	-0.4941 NS	-0.0747 NS	-0.5337 NS
NSPP	0.1073 NS	-0.5305 NS	-0.6143 *	0.6417 *	-0.2717 NS	0.4535 NS	0.841 **
SYPP	-0.4153 NS	-0.8518 **	0.1402 NS	0.8449 **	0.1065 NS	0.0114 NS	0.5151 NS
BY	-0.3068 NS	-0.3932 NS	0.3479 NS	0.174 NS	-0.7157 **	0.072 NS	-0.013 NS
SI	-0.3791 NS	-0.8418 **	0.18 NS	0.3917 NS	-0.7346 **	0.1426 NS	0.6285 *
HI	0.038 NS	-0.3859 NS	-0.2458 NS	0.2778 NS	-0.2902 NS	0.3816 NS	0.7556 **
	-0.1552 NS	0.0947 NS	0.4345 NS	-0.0521 NS	-0.503 NS	-0.0132 NS	-0.6097 *

Characters	NPPP	PL	NLP	NSPP	SYPP	BY	SI	HI
DG50	0.0252 NS	-0.4534 NS	0.1073 NS	-0.4153 NS	-0.3068 NS	-0.3791 NS	0.038 NS	-0.1552 NS
DF50	-0.4867 NS	0.0515 NS	-0.5305 NS	-0.8518 **	-0.3932 NS	-0.8418 **	-0.3859 NS	0.0947 NS
DM	-0.2248 NS	0.8578 **	-0.6143 *	0.1402 NS	0.3479 NS	0.18 NS	-0.2458 NS	0.4345 NS
PH	-0.2558 NS	0.3248 NS	0.6417 *	0.8449 **	0.174 NS	0.3917 NS	0.2778 NS	-0.0521 NS
NPB	-0.1075 NS	-0.4941 NS	-0.2717 NS	0.1065 NS	-0.7157 **	-0.7346 **	-0.2902 NS	-0.503 NS
NCPP	-0.3452 NS	-0.0747 NS	0.4535 NS	0.0114 NS	0.072 NS	0.1426 NS	0.3816 NS	-0.0132 NS
NPPC	0.3021 NS	-0.5337 NS	0.841 **	0.5151 NS	-0.013 NS	0.6285 *	0.7556 **	-0.6097 *
NPPP	0.6006 *	0.9447 **	0.1648 NS	-0.0024 NS	1.014 **	1.0465 **	0.8441 **	0.6015 *
PL	1 **	0.1353 NS	0.2137 NS	-0.104 NS	0.5446 NS	0.7414 **	0.6178 *	0.1165 NS
NLP	0.1353 NS	1 **	-0.6368 *	0.0827 NS	0.6753 *	0.5191 NS	0.2298 NS	0.5749 NS
NSPP	0.2137 NS	-0.6368 *	1 **	0.4686 NS	0.3675 NS	0.5632 NS	0.5171 NS	0.1547 NS
SYPP	-0.104 NS	0.0827 NS	0.4686 NS	1 **	-0.022 NS	0.61 *	0.4123 NS	-0.5618 NS
BY	0.5446 NS	0.6753 *	0.3675 NS	-0.022 NS	1 **	0.8222 **	0.628 *	0.8437 **
SI	0.7414 **	0.5191 NS	0.5632 NS	0.61 *	0.8222 **	1 **	1.0633 **	0.3848 NS
HI	0.6178 *	0.2298 NS	0.5171 NS	0.4123 NS	0.628 *	1.0633 **	1 **	-0.013 NS
	0.1165 NS	0.5749 NS	0.1547 NS	-0.5618 NS	0.8437 **	0.3848 NS	-0.013 NS	1 **

Table 5. phenotypic correlation coefficient among different traits in urd genotype

Characters	DG50	DF50	DF50	DM	PH	NPB	NCPP	NPPC
DG50	1 **	0.377 *	-0.2189 NS	-0.385 *	0.2484 NS	-0.1669 NS	0.138 NS	-0.0137 NS
DF50	0.377 *	1 **	0.1096 NS	-0.4111 *	0.2414 NS	0.0079 NS	-0.2347 NS	-0.0644 NS
DM	-0.2189 NS	0.1096 NS	1 **	-0.0604 NS	-0.0923 NS	-0.3991 *	-0.4898 **	0.3158 NS
PH	-0.385 *	-0.4111 *	-0.0604 NS	1 **	-0.253 NS	0.282 NS	0.3832 *	-0.1087 NS
NPB	0.2484 NS	0.2414 NS	-0.0923 NS	-0.253 NS	1 **	-0.2256 NS	0.009 NS	-0.23 NS
NCPP	-0.1669 NS	0.0079 NS	-0.3991 *	0.282 NS	-0.2256 NS	1 **	0.3923 *	0.0415 NS
NPPC	0.138 NS	-0.2347 NS	-0.4898 **	0.3832 *	0.009 NS	0.3923 *	1 **	0.082 NS
NPPP	-0.0137 NS	-0.0644 NS	0.3158 NS	-0.1087 NS	-0.23 NS	0.0415 NS	0.082 NS	1 **
PL	0.0468 NS	-0.1675 NS	-0.1025 NS	-0.1632 NS	-0.0439 NS	-0.0853 NS	0.1632 NS	0.3495 *
NLP	-0.1278 NS	-0.0553 NS	0.2961 NS	0.0058 NS	-0.042 NS	-0.0468 NS	-0.2556 NS	0.3366 *
NSPP	0.0283 NS	-0.3027 NS	-0.2999 NS	0.3161 NS	-0.2084 NS	0.1958 NS	0.5001 **	-0.0584 NS
SYPP	-0.3352 *	-0.4563 **	0.0843 NS	0.5731 **	0.1399 NS	0.0465 NS	0.3386 *	-0.1061 NS
BY	-0.0734 NS	-0.1441 NS	0.1711 NS	0.1766 NS	-0.3792 *	0.111 NS	0.0112 NS	0.4609 **
SI	-0.0364 NS	-0.1897 NS	0.1421 NS	0.1957 NS	-0.1733 NS	0.0296 NS	0.3925 *	0.2973 NS
HI	-0.053 NS	-0.1799 NS	-0.0736 NS	0.2679 NS	-0.1875 NS	0.2301 NS	0.6657 **	0.5949 **
HI	-0.0656 NS	0.0048 NS	0.1091 NS	0.0486 NS	-0.2906 NS	0.0734 NS	-0.3294 *	0.2494 NS

Characters	NPPP	PL	NLP	NSPP	SYPP	BY	SI	HI
DG50	0.0468 NS	-0.1278 NS	0.0283 NS	-0.3352 *	-0.0734 NS	-0.0364 NS	-0.053 NS	-0.0656 NS
DF50	-0.1675 NS	-0.0553 NS	-0.3027 NS	-0.4563 **	-0.1441 NS	-0.1897 NS	-0.1799 NS	0.0048 NS
DM	-0.1025 NS	0.2961 NS	-0.2999 NS	0.0843 NS	0.1711 NS	0.1421 NS	-0.0736 NS	0.1091 NS
PH	-0.1632 NS	0.0058 NS	0.3161 NS	0.5731 **	0.1766 NS	0.1957 NS	0.2679 NS	0.0486 NS
NPB	-0.0439 NS	-0.042 NS	-0.2084 NS	0.1399 NS	-0.3792 *	-0.1733 NS	-0.1875 NS	-0.2906 NS
NCPP	-0.0853 NS	-0.0468 NS	0.1958 NS	0.0465 NS	0.111 NS	0.0296 NS	0.2301 NS	0.0734 NS
NPPC	0.1632 NS	-0.2556 NS	0.5001 **	0.3386 *	0.0112 NS	0.3925 *	0.6657 **	-0.3294 *
NPPP	0.3495 *	0.3366 *	-0.0584 NS	-0.1061 NS	0.4609 **	0.2973 NS	0.5949 **	0.2494 NS
PL	1 **	0.0427 NS	0.0572 NS	0.0262 NS	0.4526 **	0.3204 NS	0.4338 **	0.215 NS
NLP	0.0427 NS	1 **	-0.2333 NS	0.0745 NS	0.3846 *	0.0393 NS	0.0616 NS	0.3727 *
NSPP	0.0572 NS	-0.2333 NS	1 **	0.124 NS	0.1494 NS	0.1721 NS	0.2901 NS	0.0145 NS
SYPP	0.0262 NS	0.0745 NS	0.124 NS	1 **	-0.0361 NS	0.2027 NS	0.1438 NS	-0.1845 NS
BY	0.4526 **	0.3846 *	0.1494 NS	-0.0361 NS	1 **	0.51 **	0.4288 **	0.6961 **
SI	0.3204 NS	0.0393 NS	0.1721 NS	0.2027 NS	0.51 **	1 **	0.6114 **	-0.2501 NS
HI	0.4338 **	0.0616 NS	0.2901 NS	0.1438 NS	0.4288 **	0.6114 **	1 **	-0.0466 NS
HI	0.215 NS	0.3727 *	0.0145 NS	-0.1845 NS	0.6961 **	-0.2501 NS	-0.0466 NS	1 **

CONCLUSION

The results showed that the analysis of variance revealed highly significant differences among genotypes for all the characters studied indicating the existence of sufficient genetic variability in the

experimental population. The difference between the values of PCV and GCV was minor for almost all of the characters studied, indicating that the environment had little influence on the expression of these traits. This suggests that phenotypic differences

might be considered genotypic variations among the genotypes for selection. PCV values were highest for number of clusters per plant, seed yield per plant and days to 50% germination whereas, GCV higher for number of clusters per plant only indicating that these characteristics may be improved by selection. The highest mean performance for grain yield/ plant was observed for genotype PU-30 followed by PDU-103 and PLLU-302 indicating that these genotypes can be used in hybridization programme to achieve higher yield.

The estimates of heritability value were high for number of clusters per plant, seed index, seed yield per plant, number of pods per plant, number of seeds per pod and days to 50% flowering indicating that direct selection for these traits may be effective since it is most likely due to additive gene effect. Number of clusters per plant, seed yield per plant and seed index showed high value of heritability coupled with high genetic advance as per cent of mean indicating lesser influence environmental factors on the expression of these character and prevalence of additive gene action in their inheritance, hence, are amenable for simple selection. Seed yield per plant, the most important economic trait, exhibited significant positive association with harvest index (0.843**), biological yield per plant (0.822**) and seed index (0.628*) at both phenotypic and genotypic level. These results indicated that simultaneous improvement in seed yield through these traits could be achieved within a short period by simple selection procedures and also among themselves indicating their utility in selection programme for improving yield potential of population.

Path analysis revealed that maximum direct positive effect on grain yield/ plant was observed by harvest index (0.646), seed index (0.466) and biological yield per plant (0.463).

These characters also showed prominent role as indirect effects on grain yield/ plant through most of the component traits therefore, should be given proper emphasis on these traits during selection programmes for the improvement of grain yield/ plant in urdbean.

In conclusion, the present study has revealed valuable information on different yield traits in urd bean improvement. Genotypes PU-30, PDU-103 and PLLU-302 were found to be the promising genotypes for yield and yield contributing traits. Hence these genotypes were found promising for further utilization in urdbean breeding programme.

REFERENCES

- Chauhan, S., Mittal, R. K., Sood, V. K. and Patial, R. 2020. Evaluation of genetic variability, heritability and genetic advance in blackgram [*Vigna mungo* (L.) Hepper]. *Legume Research-An International Journal*, 43 (4): 488-494.
- Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.*, 51: 515-518.
- Gupta P, Semwal BDS and Gupta D. 2006. Genetic variability, heritability and genetic advance for some traits in black gram (*Vigna Mungo* (L.) Hepper). *Progressive Agriculture*, 6: 164-166
- Jamil, S., Ilyas, M., Khan, M. Z., Awan, S. I., Rehman, S., Shafique, S., Hafeez, S., Riaz, M., Ahmad, H.M. Tamkeen, A., Khan, A.G. and Khan, M. M. 2022. Heritability, genetic gain, and path coefficient analyses in black gram at Poonch Rawalakot, Azad Jammu and Kashmir. *SABRAO J. Breed. Genet.*, 54 (3): 537-548.
- Johnson H.W., Robinson H.F. and Comstock R.E. 1955. Estimates of genetics and environment variability in soybean. *Agronomy Journal* 47 (1): 314-318.

- Panse, V.G and Sukhatme, P.V. 1985. Statistical methods for agricultural workers. ICAR Publication, New Delhi. 381.
- Parameswarappa, S.G. and Lamani, K.D. 2005. Genetic estimates, association and path coefficient analysis in black gram. *Karnataka Journal of Agricultural Sciences*, 18: 21-23.
- Roshani, B., Niranjana, P., Nav Raj, A., & Ankur, P. 2022. Genetic variability for growth, yield, and yield-related traits in blackgram (*Vigna mungo* (L.) Hepper) genotypes. *Russian Journal of Agricultural and Socio-economic Sciences*, 4 (124), 2022-04.
- Shivade, H. A., Rewale, A. P., and Patil, S.B. 2011. Correlation and path analysis for yield and yield component in Black gram [*Vigna mungo* (L.) Hepper]. *Legume Research*, 34 (3), 178-183.
- Toppo, N. A., Nair, S. K. and Nanda, H. C. 2019. Genetic variability studies on yield and yield contributing traits in blackgram (*Vigna mungo* L. Hepper). *Journal of Pharmacognosy and Phytochemistry*, 8 (6): 1713-1716.
- Yadav, M., Meena, A. K., Rajput, S. S., Punia, S. S., and Yadav, A. P. 2023. Correlation and path analysis in m4 generation of Blackgram [*Vigna mungo* (L.) Hepper]. *The Pharma Innovation*, 12 (2): 1698-1701.

STUDIES ON INTERCROPPING OF CASH CROPS IN *POPULUS DELTOIDES* PLANTATION

AFREEN MOHSIN

Forest Research Institute; Dehradun (Uttarakhand)

ABSTRACT

The experiment was conducted at farmer's field in Distt. Rampur, U.P. to study the growth and yields of trees and crops, respectively, in pure fields as well as in intercrops. Performance of *Populus deltoides* trees (S7C15) grown as sole and intercropped with *Mentha arvensis* (shivalik), sugarcane (Co Pant 84212) and wheat (PBW 373) had the similar pattern in growth, *i.e.*, diameter and height. Poplar intercropped with sugarcane attained the maximum growth in each year during the study period. Results revealed that an increase in the age of Poplar decreased the yield of sugarcane and wheat but in *Mentha arvensis* it decreased up to 48 months age trees but in 60 months age trees it increased. Yield of sole crops was higher than intercrops with trees. Poplar trees intercropped with sugarcane produced highest quantity of litter with higher amount of NPK contents and also showed that the total addition of nutrients (NPK) through litterfall to the soil followed the same pattern. It was also increased with the age of trees. The available NPK contents of soil under pure stands of poplar was higher than the soil of intercropped stands.

Key words: *Populus deltoides*, Intercropping, Cash crops, Tree-crop interactions, Soil fertility

Agroforestry can improve the economy of the farmers, besides taking care of the natural resources (soil, water and air). But the component plant species in agroforestry system depends on the same reserve of growth resources such as light, water and nutrients and hence there will be influence of one component of a system on the performance of the other components as well as of the system as a whole (Gill, 2002). Some farmers are putting their agricultural land under poplar plantation either in row plantation or block

plantation. The farmers have adopted poplar due to its short duration, ease of regeneration, and its compatibility with agricultural crops. Growing of cash crops in poplar will not only meet the demand of these crops but will also increase the area under forest.

Growing of intercrops under poplar plantations has been widely advocated so that the growers can ensure regular and enhanced income from such plantations (Singh *et.al.*1985).

MATERIALS AND METHODS

A Field experiment was conducted for 60 – months, at farmer's field in Distt. Rampur, U.P. The agroforestry systems were poplar intercropped with improved varieties of *Mentha arvensis* (Shivalik), Wheat (PBW-373) and Sugarcane (Co Pant 84212) S7C15 clone of Poplar were selected to conduct this study. There were seven treatments; three intercrops with trees, three treatments of pure crop components (control) and one treatment of pure tree component. Pure crop (control) was taken in a randomized block design with three replications. The soil of experimental fields was typic Hapludoll derived from alluvium. It is a silty clay loam having pH of 7.0, organic carbon 1.0%, available N, P and K are 272.5, 12.8 and 245.4 kg/ha, respectively. Planting of poplar was done at 5m x 4m spacing, adopted by growers of the area. All the above-mentioned crops were cultivated both as pure and intercropped with poplar. Height and diameter were measured after 60 months. Sample of intercrops were also taken from both the fields to quantify the yields. The annual litter production of the trees in intercropping stands was recorded by collecting all the leaves and twigs, falling to the soil surface in litter traps made by demarcating 100 x 100 cm areas at six places. The litter samples collected were pooled together to represent annual fall.

A represented sample of each annual litterfall were taken, oven dried at 80 c for 36 hrs. and subjected to further chemical analysis for N, P and K, using the modified micro kjeldahl Vanado molybdophosphoric acid yellow colour method and flame photometry, respectively (Jackson, 1967). Soil samples were taken from the site up to a depth of 45 cm, and pits were divided into three horizons, viz., (a) 0-15cm, (b) 15-30cm and (c) 30-45 cm. Available nitrogen in soil was determined by

alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Olsen method (Jackson, 1967) and available potassium was extracted from the soil by neutral normal ammonium acetate as described by Jackson (1967). On the basis of nutrient concentration in the litter, expected quantity of nutrient elements released and periodical addition to the soil was calculated. *Mentha arvensis* were transplanted during the third week of January each year at a row spacing of 60 cm by suckers, during 60 months of study. First harvest of *Mentha* was taken after 120 days of planting and second after 60-65 days of first harvest.

Sowing of wheat was done in the month of November each year, at a row spacing of 20 cm by seed. Wheat was harvested in the month of April each year during the study. Sugarcane was planted in the month of March at a spacing of 75 cm. The crop remained for two years. The recommended practices were adopted for all the three intercrops.

RESULTS AND DISCUSSION

Performance of tree and crop

Intercrop yields in terms of oil yield (kg/ha) and grain yield (q/ha) and the growth of the trees from a 5 years study indicated that dbh and height of the trees were slightly affected by intercrops. The dbh and height were observed maximum in sugarcane intercrop trees. The variation in dbh and height may be due to higher doses of fertilizers and cultural operations in sugarcane. (Table – 1a). Rapid growth of the trees under agroforestry conditions is suggestive of the fact that trees under this system are able to utilize cultural and nutritional status given to intercrop under them. Trees grown as sole obviously could not receive proper tillage and manure requirement resulting thereby in poor performance. (Mohsin and Babu Ram, 2002 and Gill et. al. 2008). The oil yield of

intercropped *Mentha arvensis*, sugarcane and wheat decline as the age of trees increases (Table 1 b). This was due to canopy effect of trees. The yield of crops was higher in sole field than intercropped with trees (Mohsin and Omveer, 2009, Gill et.al. 2004 and Nandal et.al. 1999).

Litter Production

The total annual litter production (t/ha/yr) was lower in the pure plantation in comparison to intercropped stands. The maximum litter was produced by trees, intercropped with sugarcane. This was due higher growth of trees in sugarcane, hence a greater number of branches in these trees. The litter production is increased as the age of tree increases (Table – 2).

Nutrient Concentration in Litter

The concentration (mg/g) of NPK in the litter was found to be higher in the intercropped than that of pure stands at all the ages. The values remained higher in the stands intercropped with sugarcane and minimum in the stands intercropped with *Mentha* of all the ages in comparison to pure plantation of poplar plantation (Table – 3). Concentration of N, P and K in leaf litter is related to stand age and declines with successive growth of the tree.

Addition of nutrients into the soil

Though the concentration of nutrients decreased with increasing age of the stands but their addition to the soil through litterfall

was increased significantly (Table – 4). This was due to significant increase in the total litter production with advancement of the age of the trees in intercropped as well as in pure stands. Variation among stands intercropped with crops is also noticed.

Available nutrient contents of the soil

The available NPK contents (kg/ha) of soil under the pure stands was found to be higher than the soil of the intercropped stands, at various horizons of the soil under the stand (Table -5). It might be due to higher biomass production under agroforestry system than pure stands. Nutrient contents were high in 0-15 cm horizon and decreased with increasing depth of the soil positively due to nutrient cycling and surface enrichment biomass. Trees removed the nutrients from the deeper horizon and considerable amount of nutrients was returned to the soil through litterfall. Most of the N and K contents were found to be maximum in the upper strata (0-15cm) which decreased slowly with increasing depth of the soil. However, most of the P was accumulated in the soil at the depth of 15-30cm. This was due to washing effect of the phosphorus already available in the upper strata (0-15cm) of the soil and the phosphorus added through litterfall. Nye and Greenland (1964), Hazra and Tripathi (1986), Singh et.al. (1989), Mohsin et.al. (1996) and Mohsin and Ram (2002) have also reported enrichment of the soil nutrients under the tree canopy.

Table 1(a): Performance of trees of agroforestry system in 60 - month duration

Treatments	Diameter(cm)					Height (m)				
	Duration (months)									
	12	24	36	48	60	12	24	36	48	60
Poplar S7C15(pure)	4.4	7.7	11.5	15.6	22.6	7.2	9.8	11.5	15.5	21.8
Poplar+ M. arvensis (Shivalik)	5.2	8.4	11.9	16.6	23.8	8.1	10.4	12.4	16.9	22.6
Poplar+ Sugarcane (Co Pant 84212)	6.2	9.4	13.9	18.7	25.7	9.2	12.4	14.5	18.9	24.7
Poplar + Wheat (PBW-373)	5.6	8.9	12.8	17.5	24.6	8.6	11.2	13.7	17.6	23.3

Table 1(b): Performance of crop components of agroforestry system in 60 – month duration

Treatments	Yield (Kg/ha and q/ha)				
	Duration (Months)				
	12	24	36	48	60
Poplar+ M. arvensis (Shivalik)	145.91 (179.22)	135.42 (172.51)	128.55 (165.62)	112.64 (157.51)	131.51 (152.64)
Poplar+ Sugarcane (Co Pant 84212)	631.42 (635.64)	646.44 (665.15)	628.21 (621.25)	635.51 (644.55)	615.25 (585.25)
Poplar + Wheat (PBW-373)	47.5 (49.6)	45.2 (47.1)	41.2 (46.4)	38.6 (45.2)	37.2 (43.2)

Values in parenthesis indicate the yield values of crops without trees

CD (a) at 5% for stand age = 0.082

CD (b) at 5% for species mixture = NS

CD (a x b) at 5% = 0.395

Table 2: Periodical litterfall of Populus deltoids as affected by age and treatments

Treatments	Litterfall (Dry weight/ha)				
	Duration (months)				
	12	24	36	48	60
Poplar S7C15(pure)	0.98	1.44	2.65	3.36	4.35
Poplar+ M. arvensis (Shivalik)	1.63	2.25	3.39	4.27	6.49
Poplar+ Sugarcane (Co Pant 84212)	2.14	2.55	3.79	4.67	7.21
Poplar + Wheat (PBW-373)	1.79	2.43	3.62	4.55	6.82

CD (a) 5% for stand age = 0.077

CD (b) 5% for species mixture = NS

CD (a x b) 5% = 0.269

Table 3: Nutrient Concentration (mg/g) in litterfall of Populus deltoids as affected by age and treatments

Treatments	Duration (months)				
	12	24	36	48	60
	N				
Poplar S7C15 (pure)	1.92	1.62	1.35	0.91	0.62
Poplar+ M. arvensis (Shivalik)	2.85	2.54	2.25	2.09	1.57
Poplar+ Sugarcane (Co Pant 84212)	3.64	3.51	3.38	3.16	2.92
Poplar + Wheat (PBW-373)	3.52	3.46	3.29	2.79	2.16
CD (a) 5% for stand age	= 0.05				
CD (b) 5% for species mixture	= 0.08				
CD (axb) 5%	= NSP				

Studies on Intercropping of Cash Crops in Populus Deltoides Plantation

Poplar S7C15(pure)	0.36	0.27	0.21	0.17	0.12
Poplar+ M. arvensis (Shivalik)	0.42	0.36	0.27	0.21	0.16
Poplar+ Sugarcane (Co Pant 84212)	0.64	0.53	0.41	0.35	0.22
Poplar +	0.57	0.47	0.35	0.26	0.19
Wheat (PBW-373)					
CD (a) 5% for stand age	= 0.09				
CD (b) 5% for species mixture	= NS				
CD (axb) 5%	= NS				

K

Poplar S7C15(pure)	0.72	0.64	0.49	0.42	0.35
Poplar+ M. arvensis (Shivalik)	0.98	0.87	0.78	0.69	0.55
Poplar+ Sugarcane (Co Pant 84212)	1.25	1.18	1.11	0.95	0.72
Poplar + Wheat (PBW-373)	1.12	1.12	0.84	0.78	0.65
CD (a) 5% for stand age	= 0.07				
CD (b) 5% for species mixture	= 0.08				
CD (axb) 5%	= NS				

Table 4: Total addition of nutrients through litterfall (kg/ha/yr) of Populus deltoids as affected by age and treatments

Treatments	Duration (months)				
	12	24	36	48	60
	N				
Poplar S7C15(pure)	32.4	39.5	44.2	47.4	39.4
Poplar+ M. arvensis (Shivalik)	36.1	43.2	49.5	50.6	46.5
Poplar+ Sugarcane (Co Pant 84212)	39.2	47.8	52.2	54.9	49.7
Poplar + Wheat (PBW-373)	34.5	41.2	46.6	49.9	40.6
CD (a) 5% for stand age	= 0.821				
CD (b) 5% for species mixture	= 1.092				
CD (axb) 5%	= 2.425				
	P				
Poplar S7C15(pure)	3.5	4.8	5.3	6.4	7.7
Poplar+ M. arvensis (Shivalik)	6.6	6.9	7.7	8.4	9.2
Poplar+ Sugarcane (Co Pant 84212)	10.2	12.5	15.2	18.4	20.6
Poplar +	3.9	5.2	6.5	7.6	8.5
Wheat (PBW-373)					
CD (a) 5% for stand age	= 0.726				
CD (b) 5% for species mixture	= 1.019				
CD (axb) 5%	= 2.056				
	K				
Poplar S7C15(pure)	20.6	25.7	33.6	42.2	48.4
Poplar+ M. arvensis (Shivalik)	24.4	26.5	28.7	34.2	44.6
Poplar+ Sugarcane (Co Pant 84212)	27.1	29.4	32.1	36.6	47.8
djustrightPoplar +	21.4	26.4	34.9	43.7	49.5
Wheat (PBW-373)					
CD (a) 5% for stand age	= 0.915				
CD (b) 5% for species mixture	= 1.259				
CD (axb) 5%	= 2.592				

Table 5: Nutrient Contents of Soil (Kg/ha) under Poplar after 60- month duration

Treatment	Depth of Soil (cm)								
	N			P			K		
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
Poplar S7C15(pure)	469	252	214	39.6	46.7	34.6	316.1	234.4	202.5
Poplar+ M. arvensis (Shivalik)	446	235	202	36.4	42.5	31.9	292.1	278.5	261.6
Poplar+ Sugarcane (Co Pant 84212)	439	227	195	34.2	39.7	29.6	278.6	249.9	225.5
Poplar +	451	243	208	37.2	44.2	33.5	305.4	209.6	185.5
Wheat (PBW-373)									

REFERENCES

- Gill, B.S. 2002. Evaluation of productivity potential of crops in association with trees. In: Tree crop interface, pp 14-20. Chauhan, S.K. and Gill, S.S.(Eds.) Department of Forestry and Natural Resources, Punjab Agricultural Univ. Ludhiana.
- Gill, B.S., Singh, A., Singh, Gursharan and Saini, S.S. 2004. Effect of age of Poplar on growth and yield of turmeric. (*curcuma longa* L.) intercrop. *Indian Journal of Forestry*, 7 (3) : 313-315.
- Gill, B.S., Singh, A., Singh, D. and Gandhi, N. 2008. Studies on intercropping of medicinal, aromatic and spice crops in poplar plantation. *Indian Journal of Agronomy*, 53(4): 295-298.
- Hazra, C.R. and Tripathi, S.B. (1986). Influence of nitrogen on some soil properties and forage production of safflower and Chinese cabbage with and without tree association. *Journal of Indian Society of Soil Science*, 34: 275-280.
- Jackson, M.L. 1967. Soil chemical analysis. Prentice Hall of India. Pvt. Ltd., New Delhi.
- Mohsin, F., Singh, R.P. and Singh, K. 1996. Nutrient cycling of poplar plantation in relation to stand age in agroforestry system. *Indian Journal of Agroforestry*.19(4):302-310.
- Mohsin, F. and Baburam. 2002. Sixty-month study on litter production, changes in soil-chemical properties and productivity under Poplar (*Populus deltoids*), intercropped with wheat. *Indian Journal of Agroforestry*.4(2):81-87.
- Mohsin, F. and Omveer Singh. 2009. Litterfall and Nutrient return in Poplar with Aromatic grasses under Agro Forestry System. *Annals of Horticulture*, 2 (1): 43-48.
- Nandal, D.P.S., Kumar, Anil and Hooda, M.S. 1999. Performance of wheat varieties in association with Eucalyptus and Poplar wind breaks and sissoo block plantation. *Indian Journal of Forestry*, 22(1): 73-77.
- Nye, P.H. and Greenland, D.J.1964. Changes in the soil after clearing tropical forest. *Plant and Soil*, 21 :101-112.
- Singh. K., Singh, V., Singh, J.P. and Kothari, S.K. 1985. Cultivating Medicinal and Aromatic plants along agroforestry. *Indian Farming Digest*, 18(9) :34-36.
- Singh, K., Chauhan, H.S., Rajput, D.K. and Singh, D.V. 1989. Report of 60-month study on litter production, changes in soil chemical properties and productivity under Poplar (*P. deltoides*) and Eucalyptus (*E. hybrid*) interplanted with aromatic grasses. *Agro Forestry Systems*, 9: 37 – 45.
- Subiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soil. *Curr. Sci.*, 25: 259.

Short Communication

AN ASSESSMENT OF WILD EDIBLE PLANTS DIVERSITY IN TEHRI DISTRICT, UTTARAKHAND

PANTISINGLIU RUANGMEI, VIKASPAL SINGH*, ANIL KUMAR UNIYAL, SANDHYA GOSWAMI AND MANISH KUMAR

Dolphin PG Institute of Biomedical & Natural Sciences, Dehradun

Corresponding author's email: vikaspals@gmail.com

A wild edible plant refers to any plant species that can be safely consumed by humans after proper identification and preparation. These plants typically grow naturally in the wild, without human cultivation, and have historically been used as food sources by various cultures and indigenous peoples around the world. Wild edible plants include a wide variety of species, such as fruits, berries, nuts, leaves, roots, and tubers. According to Sharma *et al.*, (1997), India hosts a rich diversity of plant life, including 14,500 species of fungi, 2,021 species of algae, 845 species of liverworts, 1,980 species of mosses, 1,200 species of pteridophytes, 48 species of gymnosperms, and 17,500 species of angiosperms. Overall, India is home to more than 53,000 plant species and approximately 150,000 species of other living organisms. Moreover, Arora and Pandey (1996) noted that nearly 1,532 plant species in India are utilized as wild edibles by various ethnic groups.

Wild edible plants (WEPs) play a vital role in human societies, contributing significantly to food security, nutritional diversity, and cultural heritage. According to Lulekal *et al.*, (2011), WEPs are often essential supplements to diets in developing countries, providing nutrients that may be lacking in cultivated crops. They are also valued for their medicinal properties. Furthermore, Ford-Lloyd *et al.*, (2011) emphasize the genetic importance of

WEPs, suggesting that they represent valuable genetic resources for agriculture, offering traits that can be utilized in breeding programs to enhance crop resilience and productivity. This dual role of WEPs in both food security and genetic resource conservation underscores their significance in sustainable development efforts. Ecologically, WEPs contribute to biodiversity conservation and ecosystem stability. They are part of natural ecosystems and support various ecological functions, such as soil conservation and habitat provision.

Millions of people in many developing countries do not have enough food to meet their daily requirements and even more are deficient in one or more micronutrients. The same is true for India, the country with the second-largest human population on the planet. In India, most rural communities depend on wild resources, including wild edible plants, to meet their food needs during periods of food crisis, as well as for additional food supplements. The diversity of wild plant species offers variety in the family diet and contributes to household food security. Various publications provide detailed knowledge about the utilization of wild edible plants as food in specific locations around the world (FAO, 2017). Uprety *et al.*, (2012) documented 81 species, including 74 Angiosperms, 5 Pteridophytes, and 2 Fungi.

Most of the species were used as fruits (44 species), followed by vegetables (36 species).

The diversity of wild edible plants in the Indian Himalayan region has attracted greater research interest from various scholars. Mishra *et al.*, (2008) explored six villages in the Nanda Devi Biosphere Reserve Buffer Zone to assess the knowledge, availability, and consumption patterns of wild leafy vegetables. The diversity of wild leafy vegetables used by local inhabitants included 21 species belonging to 14 genera and 11 families. In another study, Chandra *et al.*, (2012) identified the popular wild edible tuber-bearing plant of the Indian Himalayas, *Dioscorea deltoidea*, known for its nutritional and medicinal value. Dangwal *et al.*, (2014) documented wild edible plants used by the Gujjar and Bakerwal tribes of District Rajouri (J&K), reporting a total of 58 wild edible plant species belonging to 50 genera and 39 families. These species are utilized in raw form, as vegetables, spices, drinks, and various food substitutes by the local community. Chandra *et al.*, (2013) recorded 700 wild plant species, of which 282 were consumed by local people for various purposes, indicating the great diversity in such wild edible plant species.

The Garhwal Himalayas region is home to various attractive holy sites, valleys, and hills where the mountains of the Himalayas are rich in natural resources. The forest resources are essential to the livelihoods of the people living in the area. People in the region utilize the diverse geographical landscape for many purposes, including food, fuel, medicine, timber, fodder and agricultural tools. Among these, edible wild plants are essential for providing food during seasons of famine. Due to their limited land holdings and subsistence farming practices, people in this area collect a variety of wild plants for food (Kala, 2009). Based on the above points, the present study aims to explore: (i) the identification of wild

edible plants used by the people in the study area, and (ii) the utilization patterns of wild edible plants in the study area.

This study was conducted in the Narendra Nagar and Chamba blocks of Tehri Garhwal district in Uttarakhand. The district lies in the outer ranges of the Central Himalayas, or Mid Himalayas, which consist of low-lying peaks that run parallel to the northern Indian plains. Tehri Garhwal is situated between longitudes 77° 56' to 79° 04' and latitudes 30° 3' to 30° 53' N. The district shares its borders with Dehradun to the west, Pauri Garhwal to the south, Rudraprayag to the east and Uttarkashi to the north (Dhanus, 2016).

The temperature of the area varied from -4°C to 24°C. The mean temperature of Tehri Garhwal district ranges between 10.1°C and 19.1°C, with annual relative humidity between 54.7% and 79.5%. The mean minimum and maximum temperatures vary inversely with altitude, with January expected to be the coldest month and June the warmest month of the year (Bhandari *et al.*, 2022). In order to investigate local wild edible plants, a pre-survey was conducted in the surrounding areas-Gujrada, Saldogi, Kasmoli, Agarkhal, Agar, Chuanpa, Fakot, Pipaleth, Khadi, Nagni, Savali and Chamba villages were selected because the locals possess a wealth of traditional knowledge about edible wild plants. The natural resources in the study area are extremely important to the population. A pre-prepared survey was developed, and the survey of the villages was carried out in April to June 2024. Individuals with traditional knowledge were selected from each studied village. Participants were asked about their knowledge of wild edible plant species using the free-listing technique. Additionally, literate individuals could also employ this technique (Chauhan *et al.*, 2016).

The current study was carried out in a region of Tehri district, Uttarakhand. A survey was conducted across 12 villages to document wild edible plants and their uses by local inhabitants. A total of 35 species were encountered across all surveyed villages. Of these, 22 species were recorded as trees, 9 as shrubs, 3 as herbs and one as a fern. Various plant parts, such as fruits, seeds, leaves, flowers and whole plants, are used by local people for different purposes. The survey revealed that 63% of the species were trees, 26% were shrubs, 9% were herbs and 2% were gymnosperms. Among the 35 species frequently used in the region, respondents highlighted 7 species as the most preferred: *Rhododendron arboreum*, *Myrica esculenta*, *Berberis asiatica*, *Rubus ellipticus*, *Ficus auriculata*, *Bauhinia variegata* and *Rumex hastatus*. *Rhododendron arboreum* and *Myrica esculenta* were identified as the most popular species. *Diplazium esculentum* was identified as a Pteridophyte. Among the identified plants, *Zanthoxylum armatum* seeds are used as a spice. The survey also documented *Diplazium esculentum* in higher elevations, where its young fronds serve as a food source and *Emblia officinalis* (syn. *Phyllanthus emblica*), valued for its fruit in both culinary and medicinal contexts. Plants like *Ficus auriculata* and *Juglans regia* provide edible fruits and nuts, respectively. Additionally, *Myrica esculenta*, *Phyllanthus emblica* and *Pinus roxburghii* contribute to the local diet through their fruits and seeds, while *Rhododendron arboreum* and *Rubus ellipticus* add diversity with their edible flowers and fruits. *Cinnamomum tamala* and *Diplazium esculentum* also contribute to the diet with their leaves and young fronds, respectively. This traditional knowledge, which includes the use of plants like *Chenopodium album* and *Urtica dioica*, is crucial for local nutrition and medicine.

Following an extensive survey of wild edible plants across 12 villages in Tehri district, which highlighted significant species diversity reflecting the area's ecological richness and traditional knowledge, detailed information on these species was compiled. The findings were categorized into trees, shrubs, herbs and ferns. In total, 35 species were identified, including 22 tree species, 9 shrubs, 3 herbs and 1 fern. A total of 21 families were recorded for all plant species, with Rosaceae, Fabaceae, and Moraceae being the major dominating families.

Figure 1 indicates that Rosaceae was the most prevalent family in the survey of WEPs, representing 16.67% of the total followed by Moraceae at 13.89%. Three families – Pinaceae, Anacardiaceae and Berberidaceae each account for 5.56%. The remaining families Caesalpiniaceae, Cornaceae, Juglandaceae, Myricaceae, Euphorbiaceae, Fagaceae, Ericaceae, Rutaceae, Leguminosae, Asparagaceae, Apocynaceae, Polygonaceae, Urticaceae and Dryopteridaceae each make up 2.78% of the total, showing similar abundance.

Similar studies have been conducted on wild edible plants (WEPs), highlighting various findings. Thakur *et al.*, (2020) identified 58 WEPs utilized by the Gujjar and Bakerwal tribes in the Rajouri district of Himachal Pradesh. Satpute *et al.*, (2021) documented 41 species of wild edible fruits from local and tribal villages, with 24 families represented by flowering plants and 17 families each comprising only one species. In Kotla Valley, Uttarkashi, Bajpai *et al.*, (2022) reported 64 wild edible plant species distributed across 56 genera and 39 families, encompassing various life forms. Ballabha *et al.*, (2013) assessed the wild edible plant resources of the Kedarnath Forest Division and reported 28 trees, 23 shrubs, 24 herbs, and 7 climbers used by locals as food sources. This extensive use of various plant parts

reflects the adaptability of local communities and their deep knowledge of available resources. However, the findings also highlight the need for sustainable management practices to protect these valuable resources from overharvesting and habitat destruction.

The survey underscores the rich diversity of wild edible plants in Tehri district and their significant role in local diets and cultural practices. Promoting sustainable management and ongoing research will be crucial for preserving these valuable resources and maintaining the ecological balance in the region. Future research could further explore the ecological roles of these plants and their responses to environmental changes, ensuring their continued availability and contribution to local diets and cultures.

The present survey was carried out in villages of Tehri district, including Gujrada, Saldogi, Kasmoli, Agarkhal, Agar, Chuanpa,

Fakot, Pipaleth, Khadi, Nagni, Savali, and Chamba. It highlights the critical role of wild edible plants in local diets and cultural practices. The survey underscores the traditional knowledge embedded in the use of these plants, emphasizing their importance in sustaining local diets and cultural heritage. The variety of edible parts ranging from fruits and seeds to leaves and young shoots demonstrates a well-developed system of resource utilization, adapted to the region's diverse environments. This study concludes that systematically preserving local wild edible plants is crucial, as they play an essential role in the daily lives of local communities. Various conservation methods should be explored and discussed with villagers, with assistance from the forest department. Additionally, educating locals on seed preservation techniques is vital to prevent these wild edible plants from becoming extinct.

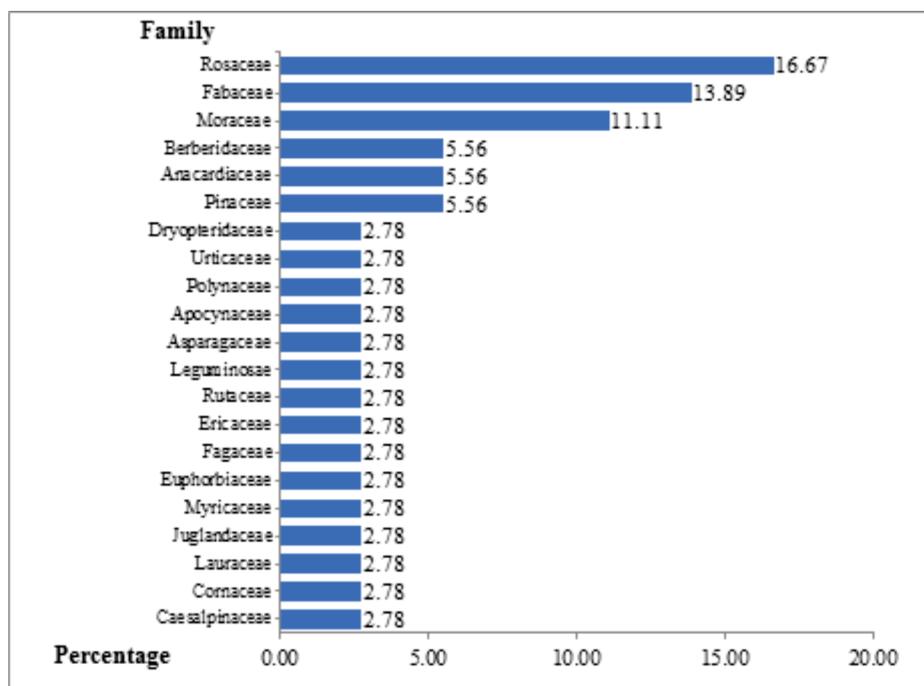


Fig 1. Plant family abundance (%) of identified medicinal plants in studied villages.

REFERENCE

- Arora, R. K. and Pandey, Anjula. 1996. Wild edibles plants of India diversity, conservation and use in NBPGR (ICAR), New Delhi India.
- Bajpai, A. B., Koranga, N., Srivastava, N., Koshal, K.A, and Rana, K. P. S. 2022. Diversity of Wild Edible Plants in the Kolta Valley in Uttarakashi, Uttarakhand, India. *The Scientific Temper*, **13** (2):341-347.
- Ballabha, R., Rawat, D.S., Tewari, J.K., Tewari, P. and Gairola, A. 2013. Wild edible plant resources of the Lobha range of Kedarnath Forest Division, Garhwal Himalaya, India. *International Journal of Biological Sciences*, **2** (11): 65-73
- Bhandari, R., Uniyal, A. K., Singh, V. 2020. Study on wild edible plants diversity in the parts of the district Tehri, Garhwal Uttarakhand, India *Research Journal of Agriculture and Forestry Sciences*, **9** (3):1-5.
- Chandra, K., Nautiyal, B. P. and Nautiyal, M. C. 2013. Ethno-botanical resources as supplementary foods and less known wild edible fruits in District Rudraprayag, Uttarakhand, India. *Journal of Human Ecology*, **42** (3): 259-271.
- Chandra, S., Saklani, S. and Dimari, M. 2012. Evaluation of Garhwal Himalaya wild edible tuber *Dioscorea deltoidea*. *International Research Journal of Pharmacy*, **3** (3): 152-156.
- Chauhan, P.P., Nigam, A. and Virender Santvan K. 2016. Ethnobotanical study of wild fruits in Pabbar Valley, District Shimla, Himachal Pradesh. *Journal of Medicinal Plants Studies*, **4** (2): 216-220.
- Dangwal, L. R., Singh, T., and Singh, A. 2014. Exploration of wild edible plants used by Gujjar and Bakerwal tribes of District Rajouri (J&K), India. *Journal of Applied and Natural Science* **6** (1): pp 164–169. doi.org/10.31018/jans.v6i1.394
- Dhanus, C. 2016. Diversity, Quantitative availability and Livelihood Support of Wild Edible Plants in a Part of Tehri Garhwal Region, Uttarakhand. M. Sc. Thesis submitted to UHF Bharwar, Uttarakhand pp. 15 – 17. <http://krishikosh.egranth.ac.in/handle/1/87534>
- FAO. 2017. Sustainable wood fuel for food security. A smart choice: green, renewable and affordable. Working paper. Rome. [also available at <http://www.fao.org/3/a-i7917e.pdf>]
- Ford-Lloyd, B. V., Schmidt, M., Armstrong, S. J., Barazani, O., Engels, J., Hadas, R., Hammer, K., Kell, S. P., Kang, D., Khoshbakht, K., Li, Y., Long, C, Lu, BR, Ma, K, Nguyen, VT, Qiu, L, Ge, S, Wei, W, Zhang, Maxted, N. 2011. Crop wild relatives—Undervalued, underutilized and under threat. *Biosci.* **61**: 559–565.
- Satpute J., Rajasekaran A., Negi, A. K. and Negi, S.P. 2021. Utilization of edible wild plants as supplementary source of nutrition by indigenous communities in Kinnaur District, Himachal Pradesh, India. *Ind Forester*, **145** (6): 561-577.
- Kala, C.P. (2009). Medicinal plants conservation and enterprise development. *Medicinal Plants*. **1** (2). 79-95
- Lulekal, E., Asfaw, Z., Kelbessa, E. and Damme, P. V. 2011. Wild edible plants in Ethiopia: a review on their potential to combat food insecurity. *Afrika Focus* **24** (2): 71-121.
- Mishra, S., Maikhuri, R. K., Kala, C. P., Rao, K. S. and Saxena, K. G. 2008. Wild leafy vegetables: A study of their subsistence dietetic support to the inhabitants of Nanda Devi Biosphere Reserve, India. *Journal of Ethnobiology and Ethnos medicine* **4**: 15.
- Sharma, J. R., Mudgal, V. and Hajra, P. K. 1997. Floristic diversity- Review, Scope and Perspective. In: V. Mudgal and P.K. Hajra (eds.) *Floristic Diversity and conservation Strategies in India*. Vol. I. *Botanical Survey India*, Kolkata, pp. 1-45.
- Thakur, A., Singh, S., and Puri, S. 2020. Exploration of Wild Edible Plants Used as Food by Gaddis-A Tribal Community of the Himalaya. *The Scientific World Journal* **6**:1-6.
- Upreti, Y., Poudel, R. C., Shrestha, K. K., Rajbhandary, S., Tiwari, N. N., Shrestha, U. B. and Asselin, H. 2012. Diversity of use and local knowledge of wild edible. *Journal of Ethnobiology & Ethnomedicine* **8**:16.<https://doi.org/10.1186/1746-4269-8-16>

Short Communication

POPULATION DYNAMICS OF MANGO FRUIT FLY (BACTROCERA DORSALIS) TRAPPED THROUGH METHYL EUGENOL TRAPS IN WESTERN UTTAR PRADESH

RAJENDRA SINGH¹, D. RAGHVENDRA², P.N. MEENA², SUBHASH CHANDER², NAVNEET KUMAR¹, AND S.P. SINGH³

¹*Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut*

²*ICAR - National Centre for Integrated Pest Management, Pusa, New Delhi.*

³*ICAR-Indian Institute of Farming System Research, Modipuram, Meerut*

Corresponding author's email: singhrajendra0112@gmail.com

Fruit flies are the very serious pest attacking on mango and other fruits in India and other country. Fruit flies belongs to the family Tephritidae of the order Diptera. Tephritidae is the one of largest families of insect order Diptera, the extend of the damage may go to 80 per cent when the pest incidence occurs in an epidemic from (Abdullah *et al.* 2002). And damage in guava was up to 44 per cent as reported by Stonehouse *et al.* 2005. And it also causes indirect loss by affecting the export market due to strict restriction of importing nation (Serem, 2010). The economic losses approx. 27 per cent Reported by (Kumar *et al.* 1994) and 31-86 per cent losses recorded by (Mann, *et al.* 1996). Performance ie methyl eugenol is a good male attractant and plays an important role in the management and monitoring of fruit flies Sukla and Mishra (2005). Hanging of methyl eugenol traps with wooden blocks soaked in methyl eugenol, ethanol and Malathion (6:4:1) @ 8 traps/ha, in mango orchards from august 21 to July 22 for management and check the population fluctuation of *Bactocera dorsalis*.

The studied carried out at Meerut district (U.P.) during august 2021 to July 2022. Methyl eugenol trap recommended by (NCIPM) National Centre for Integrated Pest Management, (Ministry of Agriculture and

Farmers Welfare) supply by NCIPM Pusa Campus, Vindhya Ave, Pusa, New Delhi, 10012. It was used in one liter plastic container, with 100 mm base, 90 mm diameter top and 115 mm deep. It has a hole on top of lid of container, an iron wire pass in this lid hole, bottom of this iron wire U shaped hooked, which U shaped hooked holding the wick/plywood. The lure was recharged fortnightly and was replaced at quarterly intervals in a 30 to 40 days. Traps were hang in mango orchard at 1.5 to 2.0 meter above from ground surface in shady area to avoid sunlight and were located within the canopy of mango trees bearing fruits. Approximately half the distance from the trunk to the outer edge of the foliage. The trapped flies were removed and counted every week starting from August 2021 to July 2022. Correlation between mean number of fruit flies and abiotic factors like maximum temperature, mean minimum temperature and relative humidity has been worked out.

This data presented in Table 1 indicates the fruit flies trapped in different farmer field locations is Walidpur Daurala, Pawali I, and Pawali II Modipuram, Meerut district Uttar Pradesh, fruit flies *viz.* *Bactocera dorsalis*. *B. dorsalis* was active and dominant from August 2021 to July 2022. Its maximum population

recorded as 712.21 fruit flies/5 trap in the month of July. Result comes of the mango orchard, *Bactrocera dorsalis* was active during August to July. Its maximum population in Aug 533.52 fruit flies /5 trap and maximum population in July 712.21 fruit flies/5 trap. In the winter season of the fruit flies population was low which showed in the table, in the month of January mango fruit flies population was 10.10 fruit flies /5 traps. *Bactrocera dorsalis* round the year found in the mango orchard Kumar and Prasad, (2018). And the result of current study revealed high efficacy of the chipboard block by capturing more flies and reducing *B. dorsalis* infestation rate in the fruits. Integrated pest management technique making the fruit flies trapped is the best solution of the against the mango fruit flies. It is necessary to avoid mango intercropping with susceptible species such as *ziziphus*, furthermore, volunteer *ziziphus* plants in the mango plantation should be also removed from the orchard.(Abdoolnabi Bagheri *et al.* (2017).

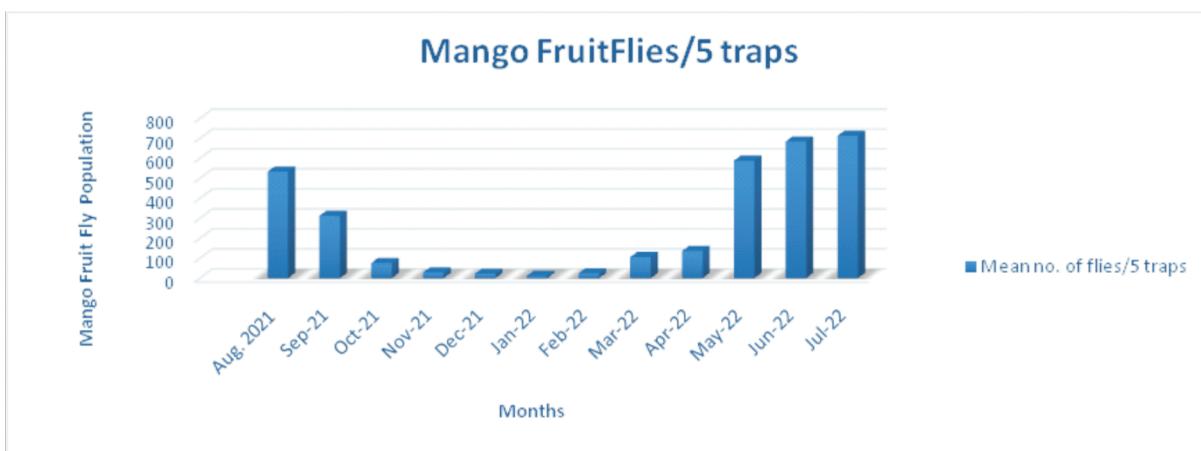


Table 1: Population fluctuations of mango fruit fly during 2021-22 at walidpur Daurala.

Months	Mean no. of flies/5 traps	Temperature (0C)			Relative humidity (%)			Rainfall (mm)
		Max	Min	Mean	Max	Min	Mean	
Aug. 2021	533.25	33.14	25.68	29.41	92.46	56.34	74.40	48.22
Sep 2021	311.17	32.22	24.80	28.51	92.97	55.57	74.27	45.48
Oct 2021	75.36	31.89	20.60	26.25	79.33	55.12	67.23	23.10
Nov 2021	27.31	28.53	12.46	20.50	77.49	48.20	62.84	0.00
Dec 2021	21.11	22.59	8.87	15.73	84.07	44.36	64.21	0.68
Jan 2022	10.10	18.14	5.69	11.92	89.94	69.52	79.73	3.71
Feb 2022	23.31	23.03	8.30	15.66	85.50	59.29	72.39	1.97
Mar 2022	105.02	33.99	16.86	25.43	70.65	38.26	54.45	0.00
Apr 2022	135.63	40.90	21.60	31.27	41.50	20.90	31.20	0.00
May 2022	587.21	41.09	23.90	32.50	43.58	22.32	32.95	1.57
Jun 2022	683.62	40.44	25.55	33.00	55.40	27.63	41.50	2.86
July 2022	712.21	33.95	23.68	28.81	81.06	47.42	64.24	9.89

Table 2: Population fluctuations of mango fruit fly during 2021-22 at Pawali I.

Months	Mean no. of flies/5 traps	Temperature (0C)			Relative humidity (%)			Rainfall (mm)
		Max	Min	Mean	Max	Min	Mean	
Aug. 2021	580.31	33.14	25.68	29.41	92.46	56.34	74.40	48.22
Sep 2021	297.49	32.22	24.80	28.51	92.97	55.57	74.27	45.48
Oct 2021	80.43	31.89	20.60	26.25	79.33	55.12	67.23	23.10
Nov 2021	30.51	28.53	12.46	20.50	77.49	48.20	62.84	0.00
Dec 2021	23.31	22.59	8.87	15.73	84.07	44.36	64.21	0.68
Jan 2022	13.32	18.14	5.69	11.92	89.94	69.52	79.73	3.71
Feb 2022	27.29	23.03	8.30	15.66	85.50	59.29	72.39	1.97
Mar 2022	113.43	33.99	16.86	25.43	70.65	38.26	54.45	0.00
Apr 2022	147.21	40.90	21.60	31.27	41.50	20.90	31.20	0.00
May 2022	590.39	41.09	23.90	32.50	43.58	22.32	32.95	1.57
Jun 2022	705.32	40.44	25.55	33.00	55.40	27.63	41.50	2.86
July 2022	716.49	33.95	23.68	28.81	81.06	47.42	64.24	9.89

Table 3: Population fluctuations of mango fruit fly during 2021-22 at Pawali II

Months	Mean no. of flies/5 traps	Temperature (0C)			Relative humidity (%)			Rainfall (mm)
		Max	Min	Mean	Max	Min	Mean	
Aug. 2021	563.21	33.14	25.68	29.41	92.46	56.34	74.40	48.22
Sep 2021	305.21	32.22	24.80	28.51	92.97	55.57	74.27	45.48
Oct 2021	79.41	31.89	20.60	26.25	79.33	55.12	67.23	23.10
Nov 2021	31.23	28.53	12.46	20.50	77.49	48.20	62.84	0.00
Dec 2021	24.31	22.59	8.87	15.73	84.07	44.36	64.21	0.68
Jan 2022	33.21	18.14	5.69	11.92	89.94	69.52	79.73	3.71
Feb 2022	26.41	23.03	8.30	15.66	85.50	59.29	72.39	1.97
Mar 2022	110.21	33.99	16.86	25.43	70.65	38.26	54.45	0.00
Apr 2022	138.41	40.90	21.60	31.27	41.50	20.90	31.20	0.00
May 2022	498.32	41.09	23.90	32.50	43.58	22.32	32.95	1.57
Jun 2022	689.21	40.44	25.55	33.00	55.40	27.63	41.50	2.86
July 2022	687.21	33.95	23.68	28.81	81.06	47.42	64.24	9.89

Based on finding of the studies of fruit fly dynamic population of different places in Meerut region it is evident that fruit fly population in the mango crops is strongly influenced, which could be indication for use proper time of fruiting, maturity time of fruiting. Fruiting and storage time. So we

have advice to apply methyl eugenol (ME) traps starting from fruiting time and till harvest to storage of mango crop. Besides, methyl eugenol trapping could be a tactics for management of this pest as it exerted significantly lower level of infestation.

REFERENCES

- Abdullah, K., Akram, M. and Alizai, A.A. 2002. Nontraditional Control of fruit flies in guava orchards in D.I.Khan, Pakiat. J Agric. Res. 17 (2): 71-74
- Abdoolani Bagheri, Majeed Askari Seyahooei, Seyed saeed Modares Najafabadli and Giti Faraji. 2017. Efficacy of methyl eugenol bait traps for controlling the mango fruit fly; 181-188.
- Mann, G.S.1996.seasonal incidence and buildup of *Bactrocera dorsalis* Hendel on mango in Punjab. J. Insect Sci. 9: 129-132.
- Shukla RP, Mishra AK. Controlling Insect Pest and Disease on mango. India Horticulture. 2005; 50(1):33-36.
- Kumar Umesh, C. S. Prasad, Visvash Vaibhav and Saty Saran.2018 Population dynamics of mango fruit fly species caught through methyl eugenol traps at different locations of Western plain zone of Uttar Pradesh.; 2167-2168.

Guidelines to Contributors

Journal of Farming System Research and Development, is a bi-annual official publication of the Farming System Research and Development Association, Modipuram, Meerut, Uttar Pradesh, India. The Journal is open to papers of original work on farming systems in India and abroad. Full length articles, short notes and book reviews are accepted for publication. All the authors should be a member of the Farming System Research and Development Association. The papers, submitted for publication in the journal must not carry materials already published in the same form or even a part of it should not be offered for publication elsewhere. The Editorial Board takes no responsibility of facts or the opinions expressed in this journal which rests entirely with the authors.

All full length papers should have the following heads. SHORT TITLE, ABSTRACT, MATERIALS AND METHODS, RESULTS AND DISCUSSION AND REFERENCES.

Each paper should be briefly introduced without the heading, INTRODUCTION. Short communications should have no sub-headings.

The reference citations should follow the order, author, year of publication, title of the paper, name of the journal abbreviated according to the world list of scientific periodicals (edn. 4, London) publisher, place of publication and page number are to be given.

Tables should be submitted on separate sheets. They should be numbered consecutively in the order in which they are mentioned in the text and their approximate position should be indicated in the margin of the manuscript. Each table should have a brief title or caption.

Information in tables should not be duplicated in the text, symbols (asterisk, dagger, etc.) should be used to indicate foot-notes to table. Maximum size of table acceptable to the journal is what can be conveniently composed within one full printed page.

All diagrams and photographs should be submitted on separate sheets and securely enclosed with the manuscript so that there may not be any crack or fold. These should be numbered consecutively in the order in which they are mentioned in the text. The position of the figures should be indicated in the margin of the text. Each figure should bear a caption written with pencil. Figures should not depict the same data presented in tables.

The illustrations should be so designed as to fit when reduced in to one column width (7 cm) or a full page width (14 cm) of printing shape. The number of the figure, author(s) and the title of the article, should be written by pencil on the back of each figure. Line drawings should be made with Indian ink on heavy white drawing paper. Lines and lettering should be sufficiently bold to stand reduction. All measurements in the text, tables and figures are to be represented in metric system. Use numeral whenever number is followed by a unit of measure or its, abbreviation e.g., log, 3 cm 5 hours (5 hr.) 6 months).

All papers and notes on floppy duely typed in MS-Word with hard copy should be submitted along with figure (drawn on butter paper with due captions) to the Chief Editor/ Secretary, Journal of Farming System Research and Development C/o ICAR-IIFSR, Modipuram, Meerut-250 110. India. All articles are sent to referees for SCRUTINY and authors should meet criticism by improving the article. The Chief Editor reserves the right to modify or reject a paper. A gratis copy of the journal will be supplied to members. Reprints 25 or its multiples may be supplied to authors on advance request and payment only.

