Technical Bulletin No. 53

Onion and Garlic Production Technologies for Tribal Livelihood Enhancement (TSP)

ICAR-Directorate of Onion and Garlic Research
(Indian Council of Agricultural Research)
Pune-410505, Maharashtra, India

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Compiled and edited by

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Preface

Onion and garlic are among the most important vegetable crops, widely valued for their culinary, nutritional and medicinal properties. India is global leader in onion and garlic production, with a steadily expanding cultivation area and growing market demand. According to FAOSTAT (2023), onions are cultivated on nearly 18 lakh hectares, producing about 30 million tones across the *kharif*, *late kharif* and *rabi* seasons. Notably, the *rabi* season contributes nearly 50-60% of India's total onion production, while the *kharif* and *late kharif* seasons account for about 20-25% each. Garlic is grown on approximately 4 lakh hectares, with a production of around 32 lakh tones during the *kharif* and *rabi* seasons. Major onion and garlic producing states include Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Andhra Pradesh, Rajasthan, Haryana, Bihar and Uttar Pradesh.

Beyond being staple food crops, onion and garlic are high value commercial commodities that play a significant role in India's agricultural economy. Their successful cultivation depends on the adoption of scientific production practices to meet the increasing demand for both quality and quantity. While predominantly cultivated by commercial farmers, these crops also hold substantial potential for improving the livelihoods of tribal communities. Recognizing this potential, the ICAR-Directorate of Onion and Garlic Research (ICAR-DOGR) initiated the Tribal Sub-Plan (TSP) in April 2013. This initiative aims to empower tribal farmers by providing access to improved production technologies, high-yielding varieties and scientific knowledge to enhance productivity. Onion and garlic cultivation can serve as a sustainable source of income, enabling tribal farmers to integrate into the broader agricultural economy

while preserving their traditional knowledge. ICAR-DOGR, Pune has been at the forefront in developing high yielding varieties suited to diverse agro-climatic conditions. The institute remains committed to advancing sustainable production technologies that ensure productivity, market stability and improved farmer livelihoods, particularly in tribal regions.

This technical bulletin serves as a comprehensive guide for farmers, researchers and extension workers offering practical and scientific insights into onion and garlic cultivation. It is hoped that the knowledge presented herein will enhance the economic well-being of tribal farmers and promote sustainable cultivation practices across India.

Date: 26.3.2026

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A. TSP ACTIVITIES OF ICAR-DOGR

Objective

- To conduct training, demonstrations and input distribution on cultivation and seed production of onion and garlic to provide a source of livelihood to the ST population.

Targets

- Organize training program for commercial cultivation of onion and garlic.
- Conduct field demonstrations on cultivation and seed production of onion and garlic at selected fields of farmers.
- Provide planting material and inputs to the selected farmers for cultivation and seed production of onion and garlic.

ICAR-DOGR R&D Technologies and Area of TSP Implementation

- Onion and garlic are important cash crops that can enhance the socio-economic status of tribal farmers through adoption of improved technologies.
- ICAR-DOGR has developed 18 onion and 4 garlic varieties along with several production and post-harvest technologies to improve onion and garlic cultivation in India.
- After approval of the TSP by ICAR in April 2013, Nandurbar district (MS) was selected for implementation through KVK, Nandurbar.
- Ambegaon and Khed talukas of Pune (MS) were also selected through ITDP.
- The program was expanded to NEH states from 2017-18 including Meghalaya, Nagaland, Manipur and Arunachal Pradesh.
- Activities were also implemented in Leh and Ladakh through SKUAST-K.
- In Sonbhadra district (UP), the program was implemented through Agrimitra FPC and ICAR-IIVR.

Beneficiary farmers ~ 2700

- 1670 tribal farmers (167 groups) in Nandurbar district (Navapur, Akkalkuva and Dhadgoan talukas).
- 830 tribal farmers (83 groups) in Pune (Khed and Ambegaon talukas).
- 200 tribal farmers (20 groups) in Sonbhadra district.

Collection of Basic Information and Baseline data

- Collection of baseline data was carried out before initiating TSP activities in Nandurbar.
- The agricultural economy of the region showed poor performance due to low adoption of improved technologies.

Major constraints identified:

a. Lack of knowledge, illiteracy and low awareness.
b. Poor financial management and political interference.
c. Low motivation, dissatisfaction and limited employment opportunities.
d. Non-competitive and weak agricultural environment.

Strengths of the region:

a. Good road and rail connectivity with access to markets.
b. Availability of low-cost labour.
c. Cooler climate, high rainfall and fertile soils suitable for crop production.

- Onion and Garlic are important commercial crops that can improve livelihood and ensure food and nutritional security of tribal farmers.
- The tribal belt of Nandurbar district has favourable climatic conditions for commercial onion and garlic cultivation.
- However, before TSP implementation by ICAR-DOGR, these crops were mainly grown in kitchen gardens.

Baseline yield levels recorded:

Kharif onion: 38 q/acre

Rabi onion: 72 q/acre

Onion seed production: 155 kg/acre

Garlic: 22 q/acre (Low productivity due to lack of technological intervention)

- Under TSP, systematic efforts were made to increase area and productivity of onion and garlic through improved varieties and technologies.
- Major interventions included field demonstrations, distribution of quality seed/bulbs, knowledge dissemination, capacity building and entrepreneurship development.

Human Resource Development

- The need for HRD was recognized during implementation of TSP in Nandurbar, Pune, Leh, Ladakh and Sonbhadra district.
- Under TSP, several capacity building activities were organized such as: exposure visits, farmers meet, on-farm trainings, field days and field visits, awareness through technical publications etc.

Total programmes conducted: 75 trainings/field days.

Beneficiaries: About 8,200 tribal farmers benefited from the above regions.

S. No.	Topic of training/ field day	Farmers benefited
1	Commercial cultivation of onion and garlic	3833
2	Quality seed production of onion and garlic	1012
3	Nursery management in onion	949
4	*Kharif* onion production technology	1268
5	Improved varieties of onion and garlic	980
6	Construction of low-cost storage structure for onion and garlic	159

Selection of Location and Tribal Farmers for Implementation of TSP

Interaction with tribal farmers

Selection of fields for conduct of Demonstrations

Organized Trainings for Tribal Farmers in Nandurbar




Training-cum-Awareness Program for Tribal Farmers




Organized Field Day(s) for Tribal Farmers in Nandurbar




Creation of Farmer's Groups

- About 2700 tribal farmers were selected and organized into 270 groups under the TSP program.
- Each group consisted of 10 farmers, with one acre of land allocated per group for field demonstration, training and input distribution.
- In Nandurbar district, 167 farmer groups were formed from 32 tribal villages of Navapur, Akkalkuva and Dhadgaon tehsils.
- In Pune, 83 farmer groups were formed from 23 tribal villages of Ambegaon and Khed tehsils for implementation of onion and garlic TSP activities.
- In Sonbhadra district, 20 farmers groups were selected from 12 villages of Robertsganj tehsil under the programme.


Selection of tribal farmers in groups (10 farmers in each group)

Field Demonstrations

- Field demos were conducted on the principle of "seeing is believing".
- Commercial cultivation of onion (*kharif*) and garlic was initiated for the first time in Navapur of Nandurbar district.
- Demonstrations included onion seed production, drip irrigation and fertigation, IPDM and INM practices.
- Onion storage structures were provided to farmers for safe storage of *rabi* harvest.
- One acre field demos were conducted for each farmer group with input kits and planting materials.
- 1602 field demos on improved varieties and production technologies were conducted.
- 67 tribal villages benefited and farmers adopted commercial onion and garlic cultivation, which proved more profitable than traditional crops.

Activities	Varieties used	FLD	Farmers benefitted
Production of onion during *kharif* season	Bhima Super, Bhima Red and Bhima Dark Red	582	5820
Production of onion during *rabi* season	Bhima Shakti, Bhima Kiran and Bhima Light Red	908	9080
Quality seed production of onion	Bhima Shakti, Bhima Kiran, BLR, Bhima Super, Bhima Red, BDR, Bhima Shubhra and Bhima Shweta	88	880
Production of garlic	Bhima Omkar and Bhima Purple	24	240

Conducted Field Demos on Cultivation of Onion and Garlic and Seed Production at Fields of Tribal Farmers

Demonstration of onion bulb and seed production under TSP


Demonstration of onion seed and garlic production under TSP


Onion bulb production of improved onion variety under TSP

Creation of Assets and Input Distribution

- ICAR-DOGR created productive assets in tribal areas of Navapur (MS) through farm implements and drip irrigation systems.
- Conventional flood irrigation had low water use efficiency due to high conveyance and distribution losses.
- Despite receiving about 1194 mm rainfall, much of the water is lost as runoff, causing scarcity in the dry season.
- Therefore, drip irrigation and fertigation were demonstrated to improve water and nutrient use efficiency.
- In onion, drip irrigation increased marketable bulb yield by 15-25%, saved 35-40% water and 25-30% labour.
- Improved varieties of onion and garlic were distributed to selected tribal farmers for field demos.
- Input kits provided included seeds/bulbs, fertilizers, fungicides, insecticides, weedicides, ridgers, tarpaulin sheets, sprayer pumps and implements.
- Drip irrigation systems and on-farm storage structures were also installed/demonstrated for onion and garlic cultivation.

Assets and Input Distribution

Item	Quantity	Purpose
Implement and drip system		
Ridger	20 Nos.	Preparation of BBF (Broad Bed Furrows)
Knapsack Sprayer	562 Nos.	Spraying to control pest, diseases and weeds
Drip Irrigation System	30 Acres	Increasing water and fertilizers use efficiency
Bamboo sticks	For 10 structures	To make storage structure for onion bulbs
Planting materials		
Onion seed	2 kg/ acre	Production of onion bulbs
Onion bulbs	12 q/ acre	Production of onion seed
Garlic bulbs	2 q/ acre	Production of garlic bulbs

Input Distribution for Demonstrations

Items	Onion bulb production (per acre)	Onion seed crop/ Garlic production (per acre)
Fertilizers		
10:26:26	60 kg	80 kg
MOP	15 kg	-
Urea	75 kg	70 kg
Bensulf	20 kg	20 kg
Neem Cake	200 kg	200 kg
Polyfed 19:19:19 (2 Sprays)	2.0 kg	2.0 kg
Micronutrients (2 Sprays)	2.0 lit	2.0 lit
Multi K (0:0:50) (1 Spray)	1.0 kg	1.0 kg
Insecticides		
Fipronil	250 ml	250 ml
Profenofos	250 ml	250 ml
Carbosulfan (2 Sprays)	1000 ml	1000 ml

Items	Onion bulb production (per acre)	Onion seed crop/ Garlic production (per acre)
Fungicides		
Mancozeb (2 Sprays)	1.0 kg	1.0 kg
Hexaconazole	250 ml	250 ml
Propiconazole	250 ml	250 ml
Weedicides		
Oxyflurofen	500 ml	500 ml
Pendimethalin	100 ml	100 ml
Sticker	3.0 lit	3.0 lit

Distribution of Inputs and Planting Materials to Tribal Farmers

Distribution of fertilizers, insecticdes, fungicides, weedicides and micronutrients under TSP

Distribution of ridger and other inputs under TSP


Distribution of onion seed and bulbs to selected tribal farmers

Installation of Drip Irrigation at the Fields of Tribal Farmers






Drip irrigation installed at fields of tribal farmers

Impact of TSP Interventions

- Impact assessment was conducted to evaluate changes in production, productivity, profitability and farmers knowledge of onion and garlic cultivation.
- In Nandurbar district, the area and production of onion increased about 4 and 5 times, respectively after TSP implementation.
- ICAR-DOGR ensured buy-back of onion seed, providing assured income to tribal farmers.
- With increased income, farmers established NESU Parisar Farmers Producer Company at Nimboni, registered with the Ministry of Corporate Affairs, GOI.
- Commercial cultivation of *kharif* onion was initiated for the first time in the selected areas with yield of about 85 q/acre.
- Commercial garlic cultivation was also initiated in Navapur with yield of about 35 q/acre.
- Overall, the socio-economic status of tribal farmers improved significantly due to TSP interventions by ICAR-DOGR.

Adoption of Improved Varieties by Tribal Farmers

Bulb production of Bhima Shakti and seed production of Bhima Kiran by tribal farmers

Bulb production of garlic Bhima Omkar and seed production of onion Bhima Shweta by farmers

Adoption of Improved Technologies by Tribal Farmers

Traditional planting of onion

Onion planted through improved technology

Traditional irrigation

Improved irrigation through drip

Adoption of Onion Storage Structure for Income Enhancement

Income enhancement and returns

Activities	FLD	Av. MY (q/acre)	Net Return (Rs. in lakh/acre)	Farmers benefited
Production of onion during *kharif*	582	85	0.70-0.80	5820
Production of onion during *rabi*	908	120	0.70-0.80	9080
Quality seed production of onion	88	2	0.60-0.80	880
Production of garlic	24	35	0.80-1.00	240

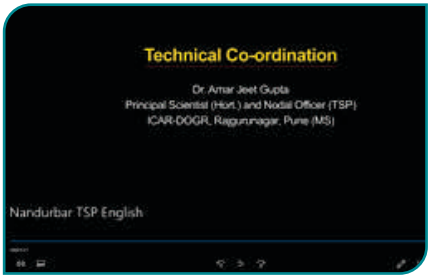
Socio-Economic Profile of Tribal Farmers

The socio-economic profile of the selected tribal farmers improved significantly after the initiation of TSP. Some examples are presented here for reference:

S. No.	Farmer's name	Crop	Yield/ acre	Net Profit (Rs.)
1.	Mr. Shital Balu Vasave (Nav Chaittanya Purush Bachat Gat, Nizampur, Navapur, Nandurbar)	Onion (Bhima Shakti)	109 q	Rs. 70,000/-
2.	Mr. Sandip Chandrasingh Kokani (Sai Shetkari Mandal, Shravani, Navapur, Nandurbar)	Onion (Bhima Shakti)	135 q	Rs. 1,25,000/-
3.	Mr. Harish Nurjee Valvi (Merali Yaha Shetkari Bachat Gat, Palipada, Navapur, Nandurbar)	Onion (Bhima Kiran)	200 q	Rs. 90,000/-
4.	Mrs. Archana Surupsingh Valvi (Saraswati Mahila Bachat Gat, Palipada, Navapur, Nandurbar)	Onion seed crop (Bhima Super)	279 kg	Rs. 1,04,000/-

Performance of Bhima Kiran at farmers fields in Nandurbar

Documentary Film on TSP



Conclusion

- Onion and Garlic are important commercial crops that can significantly improve the livelihood, food and nutritional security of tribal farmers.
- Adoption of improved technologies under TSP has promoted commercial cultivation of onion and garlic among farmers in Nandurbar district.
- These crops have proved more profitable than traditional crops, encouraging wider adoption by farmers.

- After TSP implementation, the area and production of onion increased about 4 and 5 times, respectively.
- Overall, interventions by ICAR-DOGR under TSP have significantly improved the socio-economic status of tribal farmers in the region.

B. ONION PRODUCTION TECHNOLOGY

1. Status of Onion Production in India and the World

Onion (*Allium cepa* L.) is the second most widely produced vegetable after tomato, cultivated across 146 countries worldwide. In 2023, it was grown on an area of 58.42 lakh hectares producing 111.27 million tons. Over the years, both the cultivation area and production have shown a steady upward trend. However, production has grown at a faster rate than the area under cultivation, indicating significant improvements in productivity. From 2011 to 2023, the area under onion cultivation has shown moderate growth, reflecting the steady expansion of agricultural land allocated to onion farming worldwide (Fig. 1). This increase is likely driven by rising global demand for onions due to their role as a staple ingredient in many cuisines. Despite the moderate growth in cultivation area, the notable surge in production points to advancements in agricultural practices. These include the adoption of high-yield onion varieties, better soil and crop management techniques, efficient irrigation systems and the use of modern farming technologies. The largest share of global onion

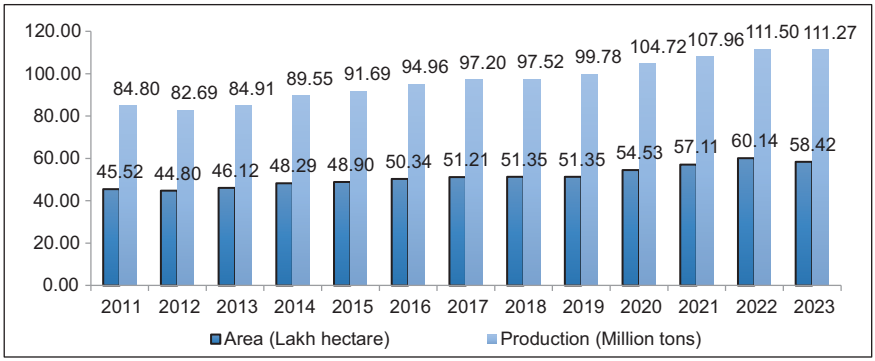


Fig. 1 Worldwide area and production of onion throughout the decade (*Source: FAOSTAT, 2023*)

cultivation area is contributed by India (17.40 lakh ha) and China (11.29 lakh ha) followed by Nigeria (6.23 lakh ha), Bangladesh (2.04 lakh ha), Indonesia (1.82 lakh ha), Pakistan (1.35 lakh ha), Egypt (1.05 lakh ha), Vietnam (1.02 lakh ha), Sudan (0.90 lakh ha), Uganda (0.82 lakh ha) and Myanmar (0.71 lakh ha) (Fig. 2) (*Source: FAOSTAT 2023*).

The major onion producing countries are India (30.21 MT), China (24.92 MT), Egypt (3.80 MT), USA (3.32 MT), Turkiye (2.60 MT), Bangladesh (2.55 MT), Iran (2.10 MT), Indonesia (1.99 MT) Pakistan (1.84 MT), Algeria (1.81 MT) and Mexico (1.80 MT) which was 69% of total world's production (Fig. 2). Earlier, China was the largest producer of onions globally. However, according to the latest reports, India has recently overtaken China as the largest onion producer with the production of 30.21 million tons on an area of 17.40 lakh hectare (Fig. 2). India and China together account for about 50% of total global onion production. The global average productivity is 27.06 t/ha. Republic of Korea ranks first in the world with productivity of 67.87 tons/ha followed by Guyana (64.36 t/ha), United States of America (61.28 t/ha), Australia (56.21t/ha), Spain (51.82 t/ha), Sweden (47.99 t/ha), Japan (47.83 t/ha), Canada (47.35 t/ha), Netherlands (45.92 t/ha) and Austria (44.69 t/ha). India ranks 93rd with 17.36 tons/ha productivity in 2022-23 (*Source: FAOSTAT 2023*). According to estimates, approximately 6.75% of the onion produced is processed. Globally the last two decades showed a rising trend in both the area and production of onion crop.

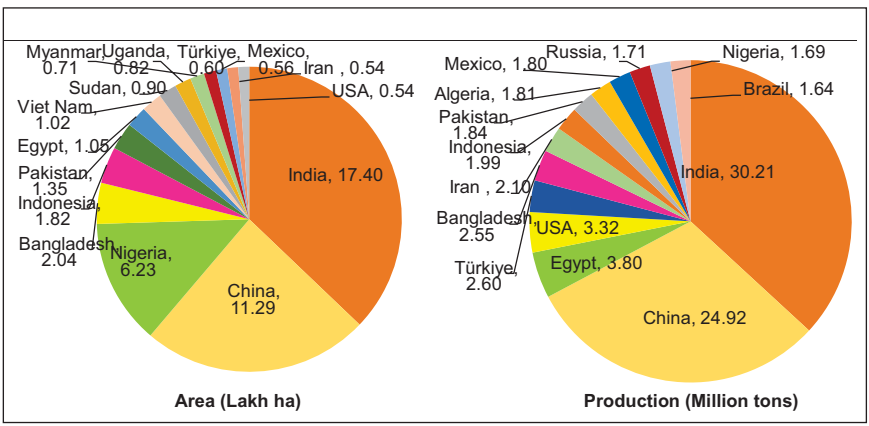


Fig. 2 Major onion producing countries in the world (*Source: FAOSTAT, 2023*)

The congenial environment of long day conditions favor's bulb bulking/enlargement and raises productivity in major European and American countries. For the Tropical and Subtropical countries; the majorly grown onions are short day onions which are inherently low in yield. The unavailability of enough quantity of quality seeds of improved varieties is also a constraint. This results in a higher share of farmer saved seed in total cultivation. The disease conditions and the susceptibility of the onion crop to the diseases prevalent in most of the growing seasons affect the productivity in the tropics. Besides this, erratic monsoon conditions and the shortage of irrigation water at critical growth stages pull down the productivity of onions in India.

India is one of the largest exporters of onion, with a substantial share of global onion exports, exporting 2 million metric tons in 2023 (Fig. 3). In recent years, India has exported 1.76 million metric ton onions earning revenue of 499 million USD in 2023-24. Significant markets include Saudi Arabia, UAE, Qatar, Iraq, Kuwait and Oman. The Middle East remains a major destination for Indian onion due to its high demand for imported onions. In Southeast Asia, major importers include Sri Lanka, Malaysia, Nepal, Singapore, Indonesia and Bangladesh. These countries are important markets for Indian onions due to their frequent shortfalls in local production (*Source: Ministry of Commerce and Industry, GOI, 2023-24*). The Netherlands, also contribute significantly in exports of onion with 1.72 million metric tons followed by China, Egypt and Mexico. Among the importers, highest imports of onion was observed in Bangladesh (7.12 Lakh tons) followed by USA, Malaysia, Pakistan and UAE.

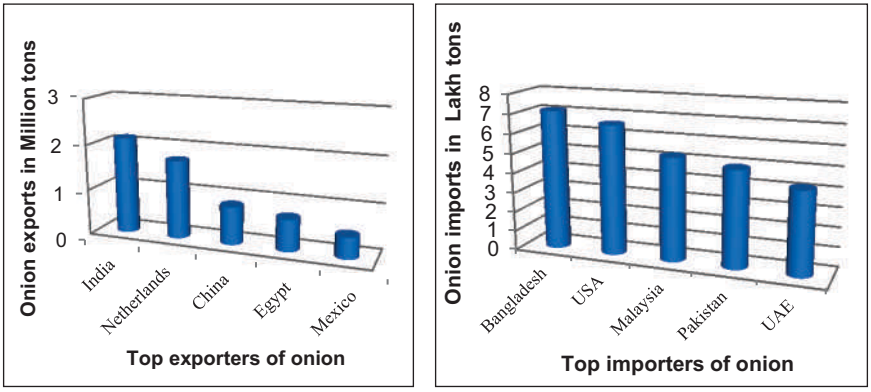


Fig. 3 Export import statistics of onion (*Source: FAOSTAT, 2023*)

Maharashtra, Karnataka, Gujarat, Bihar, Madhya Pradesh, Rajasthan, Andhra Pradesh, Tamil Nadu, UP, West Bengal, Odisha and Chhattisgarh are the main onion growing states. Out of them, Maharashtra and Karnataka are the chief onion producing states in India, contributing nearly 48% of the total production of onions in the country. In general, except North Eastern states, Jammu & Kashmir and Kerala, all other states grow onion. There is critical shortage in arrivals of onion in the market during October to January. From May to November stored onions are used for domestic as well as export market. November to December *kharif* onion is available in the market, whereas from January to March *late kharif* crop from Maharashtra is available and the *rabi* crop from April to May.

2. Nutritional Importance

Onion and garlic possess a variety of medicinal properties due to the presence of key compounds such as allicin, allin, thiosulfinates and sulfides, making them potent medicinal herbs (Table 1). Onions are a source of vitamin C, potassium, dietary fiber and folic acid. They also contain calcium, iron and have a high protein quality. Onions are low in sodium and contain no fat. Onions are low in calories (50 kcal/100 g) yet add abundant flavor to a wide variety of foods. Onion is known for its nutritional value and used as a herbal medicine in India. It has moderate amounts of protein, fat, fibre and good amounts of calcium, phosphorous, potassium, vitamin C and B. Apart from onion, as such even the stalk is edible which contains good amount of carotene and iron. Onion has both glucose (reducing sugar) and sucrose (non-reducing sugar). The pungent taste of onion is due to the volatile compound allyl propyl disulfide present in it (Table 1).

Table 1. Nutritional value of onion (nutritive value per 100 g of onion)

Particulars	Big onion*	Small onion*	Onion leaves**	Dehydrated onion**
Calories				
Moisture (g)	86.6	84.3	87.6	4.6
Protein (g)	1.2	1.8	0.9	10.6
Fat (g)	0.1	0.1	0.2	0.8
Minerals (g)	0.4	0.6	0.8	3.5
Fibre (g)	0.6	0.6	1.6	6.4

Particulars	Big onion*	Small onion*	Onion leaves**	Dehydrated onion**
Carbohydrate (g)	11.1	12.6	8.9	74.1
Energy (Kcal)	50.0	59.0	41.0	-
Sugar (%)	4.28	-	-	35.48
Macronutrients				
Calcium (mg)	46.9	40.0	50.0	300.0
Phosphorus (mg)	50.0	60.0	50.0	290.0
Potassium (mg)	127.0	-	109.0	1000.0
Micronutrients				
Iron (mg)	0.6	1.2	7.43	2.0
Magnesium (mg)	16.0	-	104.0	-
Sodium (mg)	4.0	-	2.2	40.0
Copper (mg)	0.18	-	0.45	-
Manganese (mg)	0.18	-	0.74	-
Molybdenum (mg)	0.03	-	2.29	-
Zinc (mg)	0.41	-	-	-
Selenium (mg)	0.50	-	2.10	-
Vitamins				
Carotene (µg)	-	15.0	595.0	-
Thiamine (mg)	0.08	0.08	-	0.42
Riboflavin (mg)	0.01	0.02	0.03	0.06
Niacin (mg)	0.4	0.5	0.3	-
Folic acid (mg)	6.0	-	-	-
Vitamin-B6	0.15	-	1.22	-
Vitamin-A	2.0	-	-	-
Vitamin-C	11.0	2.0	17.0	147.0
Vitamin-E	0.02	0.27	-	-
Vitamin-K	0.40	-	-	4.10

Particulars	Big onion*	Small onion*	Onion leaves**	Dehydrated onion**
Individual fatty acids				
Fat- saturated (g)	0.03	-	-	0.18
Fat- monounsaturated (g)	0.06	-	-	0.44
Fat- polyunsaturated (g)	0.00	-	-	-

(*Source: *Nutritive value of Indian foods, NIN, Hyderabad, ** Onion crop details, NHRDF, 2009*)

3. Crop Physiology

The bulbous vegetables are characterized by their bulb structure, which serves as a storage organ for nutrients and energy during dormancy period. The inner leaves thicken as the bulb develops. The stem is very small and inconspicuous during vegetative growth. After vernalization at temperatures below 10°C, the stem elongates rapidly, eventually producing seed bearing umbels. Bulb crops are shallow rooted, therefore requires light but frequent irrigation throughout the crop season. Bulbs are formed only of basal plate and fleshy, thick specialized scales. At the end of the growing season, leaf sheaths dry out and form the enveloping dry skins, which do not contain storage materials. The root system is diffused and consists of numerous annual, non-branching roots. Roots are ephemeral and allow fast and efficient water absorption during vegetative period.

Onion is an herbaceous annual for bulb production and biennial for seed production, with bisexual flowers and a high rate of cross-pollination. The edible part is a modified stem or bulb, which forms underground. Onion is a cool-season crop that tolerates mild frost but is sensitive to extreme heat. Ideal growing temperatures range from 20°C to 28°C, whereas consistent rainfall of 600 to 800 mm during the growing season supports healthy bulb development. The bulb is a modified stem with shallow, adventitious roots and consists of swollen leaf bases attached to a rudimentary stem. Botanically, onion is a monocot with tubular leaves and insect-pollinated perfect flowers. Bulb initiation involves the swelling of fleshy scales, with younger scales inside and older ones forming a protective skin that varies in color due to flavonoid concentration. Bulbing is triggered by increasing day lengths, while high temperatures can cause bolting, leading to flower and seed formation.

4. Seasonal Adaptability

Bulbous crops such as onion and garlic in India exhibit considerable seasonal adaptability, crucial for their successful cultivation across diverse agro-climatic regions. Onion is cultivated in three distinct seasons, namely *kharif, late kharif* and *rabi* seasons in India. In the *kharif* season, seeds are generally sown in mid-May on nursery beds, followed by transplanting during first week of July and harvesting in the month of October. During the growing season, moderate temperatures from 13-25°C are considered ideal while, temperatures above 32°C adversely affect bulb formation. *Rabi* onions, grown from October to May require relatively cooler conditions, with temperatures of 13-24°C during vegetative growth and 16-25°C during bulb development for optimum yield and quality. Table 2 presents sowing, transplanting and harvesting schedule of onion across different regions of India.

Table 2. Sowing, transplanting and harvesting schedule of onion across different regions of India

S. No	Seasons	Time of sowing	Time of transplanting	Time of harvesting
A.	**Maharashtra and some parts of Gujarat**			
	Kharif	May-June	July- mid August	October - December
	Early *Rabi* or *late kharif*	August to first week of September	September - October	Mid of January to end of February
	Rabi	October to mid of November	December - first week of January	April - May
B.	**Tamil Nadu / Karnataka and AP**			
	Early *kharif*	March - April	April - May	July - August
	Kharif	May - June	July - August	October - November
	Rabi	September - October	November - December	March - April
C.	**Rajasthan/Haryana/Punjab/UP and Bihar**			
	Kharif	End of May to June	July to mid Aug	November - December

S. No	Seasons	Time of sowing	Time of transplanting	Time of harvesting
	Rabi	End of October to November	Mid of December to Mid of January	May - June
D.	**West Bengal and Odisha**			
	Kharif	June - July	August - September	November - December
	Late kharif	August - September	October - December	February - March
	Rabi	September - October	November - December	March - April
E.	**Hills**			
	Rabi	September - October	October - November	June - July
	Summer (long day type)	November - December	February - March	August - October

For seed production, the onion bulbs are harvested, stored for some time and then replanted in proper season for seed production. Bulbs are planted in the month of October and the ideal soil temperature for onion seed germination lies between 20-25°C. *Kharif* and *late kharif* produce 20-25% each, while *rabi* produces about 50-60% of onions.

5. Improved Varieties

Varietal selection plays an important role in enhancing productivity of onion. Varieties are notified by either the Central Varietal Release Committee (CVRC) or State Varietal Release Committee (SVRC) for commercial utilization. To date, more than 86 onion varieties including 2 F_1 hybrids and 9 multiplier type have been developed and released from public sectors for different colors (light red, dark red, white and yellow), types (common, rose and multiplier type), locations (short and long day) and seasons (*kharif*, *late kharif* and *rabi*) at state or national level (Table 3 and Fig. 4). Short day varieties of onion are being maintained at ICAR-DOGR, Pune along with ICAR-IARI, New Delhi whereas long day varieties are being maintained at ICAR-CITH, Srinagar. Onion varietal development programs were strengthened under All India Network Research Project on Onion and Garlic (AINRPOG) through SAU's and ICAR institutes. The ICAR-DOGR has developed various improved varieties suitable for cultivation in different

seasons and regions of the country. The varieties Bhima Dark Red, Bhima Super, Bhima Raj, Bhima Red, Bhima Shubhra, Bhima Safed, Bhima Kesar (DOGR-1625), Bhima Gulab (RGP-3) are suitable for *kharif* season. Bhima Shakti, Bhima Kiran, Bhima Light Red, Bhima Shweta, Bhima Early (DOGR-1203-DR), Bhima Ujjwala (DOGR-W-361), Bhima Prasanskaran (DOGR-HT-3), Bhima Nirjala (DOGR-HT-4), Bhima Jyoti (DOGR-1550-Agg) and Bhima Jata (DOGR-1546-Agg) are recommended for *rabi* season and are suitable for storage. Varieties such as Bhima Shakti, Bhima Raj, Bhima Red, Bhima Super, Bhima Shubhra and Bhima Safed perform well and are recommended for cultivation during the *late kharif* season. The varieties Bhima Raj and Bhima Red can be grown in all three seasons.

Table 3. List of onion varieties along with their source

Varieties	Source
Bhima Super, Bhima Red, Bhima Raj, Bhima Kiran, Bhima Shakti, Bhima Dark Red, Bhima Light Red, Bhima Shweta, Bhima Shubhra, Bhima Safed, Bhima Gulab (RGP-3), Bhima Early (DOGR-1203-DR), Bhima Kesar (DOGR-1625), Bhima Prasanskaran (DOGR-HT-3), Bhima Nirjala (DOGR-HT-4) and Bhima Ujjwala (DOGR-W-361)	ICAR-DOGR, Pune
Pusa Red, Pusa White Round, Pusa White Flat, Pusa Madhavi, Pusa Riddhi, Early Grano, Brown Spanish, Pusa Ratnar, Selection 126 and Pusa Sona	ICAR-IARI, New Delhi
Arka Niketan, Arka Pitambar, Arka Pragati, Arka Bindu, Arka Kalyan, Arka Bheem, Arka Ujjwal, Arka Swadista, Arka Vishwas, Arka Sona, Arka Akshay, Arka Lalima, Arka Kirthiman and Arka Yojith	ICAR-IIHR, Bengaluru
Agrifound Dark Red, Agrifound Light Red, Agrifound Red, Agrifound Rose, NHRDF Red, NHRDF Red-2, NHRDF Red-3, NHRDF Red-4, NHRDF Fursungi and Agrifound White	NHRDF, Nashik
Baswant-780, Phule Samarth, Phule Safed, Phule Suwarna and Phule Swami	MPKV, Rahuri
Hissar-2, Hissar Onion-3, Hissar Onion-4 and HOS-1	HAU, Hissar
N-2-4-1 and N-53	Agril. Dept., MS
Punjab Naroya, Punjab White, Punjab-48, Punjab Selection and Punjab Red Round	PAU, Ludhiana
PKV White	PDKV, Akola
Udaipur-101, Udaipur-102 and Udaipur-103	RAU, Udaipur

Varieties	Source
RO-1, RO-59 and RO-252	RARI, Durgapura
GWO-1, GJRO-11 and GJWO-3	GAU, Junagadh
Kalyanpur Red Round	CSAUA&T, Kanpur
Palam Lohit	CSKHPAU, Palampur
VL Piaz-3	ICAR-VPKAS, Almora
Phursungi Local, Sukhsagar, Pillipatti Junagadh and Telagi Local	Farmer's varieties
Multiplier onion	
Bhima Jyoti (DOGR-1550-Agg) and Bhima Jata (DOGR-1546-Agg)	ICAR-DOGR, Pune
CO-1, CO-2, CO-3, CO-4, CO-5, CO-6 and MDU-1	TNAU, Coimbatore

Fig. 4 Onion varieties available for cultivation

6. Production Practices of Onion

6.1 Soil and climate: Onion grows best in well-drained, fertile soils with a pH range of 6.0 to 7.5, although it can tolerate slightly alkaline conditions. The crop is highly sensitive to water logging, as well as to extremely acidic and saline soils. Onion performs best under moderate climatic conditions and is adversely affected by extreme heat, severe cold and excessive rainfall. An average annual rainfall of 650-750 mm, if well distributed and accompanied by good drainage, is suitable. A relative humidity of around 70% is favourable for optimum growth. In India, short day onion cultivars are predominantly grown in the plains and require a photoperiod of about 10-12 hours. Vegetative growth is favoured by relatively low temperature and short day condition, while bulb initiation and development require comparatively higher temperatures in combination with longer photoperiod. The optimum temperature ranges from 13-24°C for vegetative growth and 16-25°C for bulb development. Exposure to very low

temperatures at early growth stages may induce premature flowering (bolting), whereas a sudden increase in temperature can lead to early maturity and reduced bulb size.

6.2 Nursery management: A deeply ploughed nursery bed is prepared with mould board plough. The soil should be well porous by breaking clods using cultivator. Approximately 0.08 hectares of nursery area is needed to produce seedlings for transplanting in one hectare of land. At the time of the final ploughing, 500 kg of well-decomposed farmyard manure (FYM) and 1.25 kg of *Trichoderma viride* should be thoroughly mixed in the soil. Nursery with broad bed furrow measuring 15 cm height and 1.2 m width and length equipped with drip or sprinkler irrigation arrangements is suggested for onion (Fig. 5). If drip or sprinkler systems are unavailable, raised bed furrows with a width of 1.0-1.2 m and a length of 5-6 m, along with furrows on all sides of the bed for irrigation, should be prepared. For transplanting one hectare, seeds of good germination potential (>70%) of about 5-7 kg for open pollinated and 4-5.5 kg for hybrids are recommended. Before preparation of nursery beds, NPK fertilizer @ 2:1:1 kg/500 m^2 should be well mixed in the soil. Thereafter 20 days 1 Kg of N should be applied to get healthy seedlings. To avoid soil as well as seed borne diseases, seeds should be treated with Thiram/ Captan/ Carbendazim @ 2-3 g/kg of seed. Application of pre-emergence herbicide Pendimethalin @ 2 ml/litre is recommended to control weeds in nursery after sowing followed by one hand weeding at 20 days after sowing.

Fig. 5 Onion nursery on broad bed furrow with sprinkler system

6.3 Field preparation and transplanting: For optimal onion production, ploughing should be done four to five times to obtain good tilth. After each ploughing, the soil should be worked to loosen and aerate it, allowing it to become more porous and well structured. Leveling the soil helps improve water use efficiency and enhances drainage by preventing excess water accumulation. About 40-50 day old nursery seedlings are suitable for transplanting. Seedlings of about 15-20 cm height and pencil thickness (approximately 0.3-0.4 mm collar diameter) are considered ideal for transplanting. The onion seedling should be transplanted after dipping roots in carbendazim solution (0.1%) for two hours to reduce the incidence of fungal diseases during the establishment. The optimum spacing is 15 cm between the rows and 10 cm between plants. Transplanting should be done on a raised bed of 1.2 m wide strip, raised 15 cm above the ground surface (Fig. 6). Optimum plant density is kept between 65-70 plants/m^2 to achieve higher productivity. Crowding may affect the bulb size while low plant density may result in splitting of bulbs. Transplanting seedlings from over aged nursery should be avoided to escape chance of premature bolting.

Fig. 6 Field preparation and transplanting of onion

6.4 Nutrient management: About 15 ton FYM/ha or 7.5 ton poultry manure or vermicompost/ha should be incorporated at the time of last ploughing. Besides this, the recommended dose of chemical fertilizers for *rabi* and *late kharif* is 110:40:60:30 kg NPKS. One third of recommended N and full dose of P_2O_5, K_2O and S are applied at the time of transplanting while remaining two thirds of N is applied in two equal splits at 30 and 45 days after transplanting. In case of sulphur, application of 15 kg S/ha is sufficient for growing onion crop in soils having sulphur level above 25 kg/ha, while 30 kg S/ha is needed for soils having sulphur level below 25 kg/ha for optimum production of onion. Application of micronutrients is beneficial based on soil test reports. Generally, zinc and boron are deficient in Indian soils. To avoid micronutrient deficiency, use of organic

manures and foliar application of micronutrients at 5 ml/litre at 30, 45 and 60 days after transplanting is required (Table 4).

Table 4. Fertilizer schedule for onion (per ha)

Schedule	N	P_2O_5	K_2O	Organic manures
***Kharif* onion (yield potential: 25-30 t/ha)**				Organic manures equivalent to 75 kg N (FYM 15 t/ha or poultry manure 7.5 t/ha or vermicompost 7.5 t/ha)
Basal	25 kg	40 kg	40 kg	
30 DAT	25 kg	-	-	
45 DAT	25 kg	-	-	
Total	75 kg	40 kg	40 kg	
***Late kharif* and *rabi* onion (yield potential: 40-50 t/ha)**				
Basal	40 kg	40 kg	60 kg	
30 DAT	35 kg	-	-	
45 DAT	35 kg	-	-	
Total	110 kg	40 kg	60 kg	
Sulphur management in onion				
Application of 15 kg sulphur/ha is sufficient for growing onion crops in soils having sulphur level above 25 kg/ha while 30 kg sulphur/ha is needed for soils having sulphur level below 25 kg/ha for optimum production of onion.				

6.5 Irrigation management: Onion, being a shallow rooted bulb crop is highly responsive to better irrigation. This crop should be irrigated frequently throughout the growing season. Normally, *rabi* onions require 10-12 irrigations while *kharif* onions require 5-6 irrigations. Fertigation is an effective and efficient method of applying fertilizers through drip irrigation, which is used as the carrier and distributor of irrigation water and crop nutrients. Application of 40 kg nitrogen as a basal dose at the time of transplanting and the remaining nitrogen in 6-7 equal splits at 8 days intervals from transplanting to 60 DAT through drip irrigation is recommended for achieving higher marketable bulb yield and profit.

6.6 Weed management: Weed management is of utmost importance in the successful production of onion crops. In general, monocot weeds are found more in number than dicot weeds. The shallow root system, comparatively low density and a canopy of short upright leaves indicate that the onion plant is very

susceptible to weed competition. Control of weeds at the initial growth stages is essential for getting high marketable bulb yield. Because of labor scarcity, chemical control of weeds along with cultural methods is inevitable. Application of Oxyflurofen @ 23.5% EC (1.5-2.0 ml/litre) or Pendimethalin @ 30% EC (3.5-4 ml/litre) before transplanting or at the time of transplanting followed by one hand weeding at 40-45 days after transplanting is recommended for efficient weed control.

6.7 Pests and disease management: Onion crop is susceptible to several insect pests and diseases (Table 5; Fig. 7 and 8). Among insect pests, thrips and onion maggots are the major constraints. Important diseases include damping-off, Anthracnose/twister, purple blotch and *Stemphylium* leaf blight. For detailed management of thrips, damping-off and Anthracnose/twister, refer to Table 5.

Table 5. Important pests and diseases, their symptoms and control measures of onion and garlic

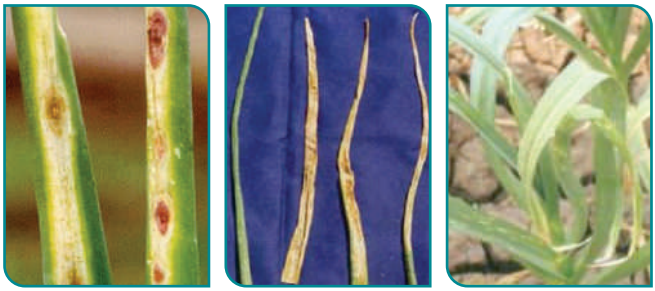
Pest/diseases	Symptoms	Control measures
Pest		
Thrips	• Thrips infestation at the early stage (transplanting to 45 days) can be identified by curling and twisting of leaves. • Typical symptom of onion thrips is the presence of white or silvery patches on the leaves. • In severe infestation, whole plant looks blemished and turns white.	• Planting of two rows of maize or one outer row of maize and one inner row of wheat as a barrier crop surrounding onion crop (250 sq. m) at least 30 days prior to transplanting helps block the movement of adult thrips. • Spray insecticide when thrips population crosses the economic threshold level of 30 thrips/plant. • Foliar spray of insecticides like Profenofos (0.1%), Carbosulfan (0.2%) or Fipronil (0.1%) depending upon the severity of infestation.
Eriophyid mite	• Leaves do not open completely. Whole plant shows curling.	• Spray Dicofol (0.2%) as soon as the symptoms appear in the field. Repeat the spray after 15 days, if necessary.

Pest/diseases	Symptoms	Control measures
	• Yellow mottling is seen mostly on the edges of the leaves.	• Foliar spray of sulphur @ 0.05%.
Red spider mite (*Tetranychus cinnabarinus*)	• Upper surface of the leaves seen mottled with yellow or bronze dots due to feeding punctures. • The mites tend to feed in "pockets" often near the midrib and veins. • In severe infestation, silken webbing are also visible. • The leaves eventually become bleached/ discolored and wither.	• Spray Dicofol (0.2%) or sulphur (0.05%) as soon as the symptoms appear. Repeat the spray after 15 days, if necessary.
Nematode		
Stem and bulb nematode (*Ditylenchus dipsaci*)	• Enters through stoma or plant wounds and create galls or malformations. • This allows for the entrance of secondary pathogens like fungi and bacteria. • Symptoms are stunted growth, discoloration of bulbs and swollen stems.	• Bulbs that show signs of disease should not be planted. • Proper sanitation of fields and tools is essential because this nematode can survive and reproduce in infected plants and residues.
Fungal Diseases		
Purple blotch (*Alternaria porri*)	• Initially small, elliptical lesions or spots that often turn purplish-brown which are surrounded by chlorotic margin. • If the spots enlarge, chlorotic margin extend above and below the actual lesion. Lesions usually girdle leaves, causing them to fall over. Lesions may also start at the tips of older leaves.	• Spray fungicides, Mancozeb @ 0.25% or Tricyclazole @ 0.1% or Hexaconazole @ 0.1% or Propiconazole @ 0.1% at 10-15 days intervals from 30 days after transplanting or as soon as disease appears.

Pest/diseases	Symptoms	Control measures
Stemphyllim blight (*Stemphylium vesicarium*)	• Small yellow to orange flecks or streaks develop in the middle of the leaf which soon develop into elongated, spindle shape to ovate elongate diffused spots surrounded by characteristic pinkish margin. • The spots progress from the tip to the base of the leaves. The spots coalesce into extended patches, blighting the leaves and gradually the entire foliage.	• Spray fungicides, Mancozeb @ 0.25% / Tricyclazole @ 0.1% / Hexaconazole @ 0.1% /Propiconazole @ 0.1% at 10-15 days interval from 30 days after transplanting or as soon as disease appears.
Anthracnose/Twister Disease (*Colletotrichum gleosporiodes*)	• The characteristic symptoms are curling, twisting, chlorosis of the leaves and abnormal elongation of the neck (false stem). • Initially pale yellow water soaked oval sunken lesions appear on leaf blades. Numerous black coloured slightly raised structures are produced in the central portion, which may be arranged in concentric rings. The affected leaves shrivel; droop down and finally wither.	• Soil treatment with Benomyl @ 0.2%. • Foliar spray of Mancozeb @ 0.25%. • Planting onion on the raised bed. • Avoid water logging.
White rot (*Sclerotium cepivorum*)	• Yellowing and dying back of leaf tips. Roots are normally destroyed. Superficial white fluffy mycelium may be present on decaying scales. • Brown or black sclerotia develop on surface or within tissue.	• Crop rotation should be followed; infected plant may be destroyed and the soil around these plants should be treated. • Soil solarization at high temperature reduces the disease incidence. • Carbendazim @ 0.1% may be applied.

Pest/diseases	Symptoms	Control measures
Damping off disease	• Seedlings topple over after they emerge from the soil. It usually occurs at or below the ground level and infected tissues appear soft and water soaked.	• Planting onion on the raised bed. • Seed treatment with Thiram or Captan @ 0.3%. • Drenching the nursery beds by Captan or Thiram @ 0.2% or Carbendazim @ 0.1% or Copper oxychloride @ 0.3%.
Viral diseases		
Iris Yellow Spot Virus (IYSV)	• Symptoms first appear as straw-coloured, dry, tan, spindle or diamond-shaped lesions, with or without distinct green centers with yellow or tan borders on leaves. The symptoms are more pronounced on flower stalks. Infected leaves and stalks lodge during the later part of the growing season.	• Plant high quality transplants free from thrips and Iris yellow spot virus. • Practice three years or longer rotation between onion crops. • Eliminate volunteers, culls and weeds in and around onion fields. • Avoid crop stress. • Thrips control may provide some reduction in iris yellow spot, but thrips control alone is not sufficient to economically control the disease
Onion Yellow Dwarf Virus (OYDV)	• Mild chlorotic stripes to bright yellow stripes, mosaic, curling of leaves and stunted growth.	• Use virus free planting material. • Use resistant cultivars. • Aphid control will reduce the incidence of OYDV which is a vector for OYDV. • Foliar spray of insecticides like Profenofos @ 0.1%, Carbosulfan (0.2%) or Fipronil (0.1%) for controlling Aphids.

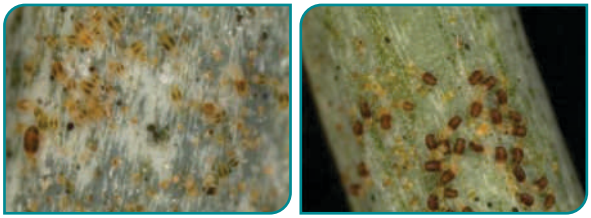
Pest/diseases	Symptoms	Control measures
Leek Yellow Stripe Virus (LYSV)	• Causes light yellow striping on the distal part the leaves and dwarfing of the entire plant. • Bulbs get smaller and malformed, which results in yield loss and post-harvest storage loss.	• Use virus-free planting material. • Foliar spray of insecticides like Profenofos @ 0.1% or Carbosulfan (0.2%) or Fipronil (0.1%) for controlling aphids, the virus vector.
Storage diseases		
Penicillium rot (*Pencillium corymbiferum*)	• Affected bulbs are light in weight and individual cloves are soft, spongy and powdery dry. • In an advanced stage of decay, the cloves break down in a green or gray powdery mass.	• Store under dry conditions in storage structures to reduce rot development.
Black mould (*Aspergillus* spp.)	• Bulbs show black discoloration at the neck and streaks of black mycelium and conidia beneath the outer dry scales. • In advanced stages all scales are infected and the bulb shrivels.	• After proper drying, store bulbs in dry conditions. • Avoid bruising when bulbs are harvested, stored or transported.
Fusarium basal rot (*Fusarium oxysporum cepae*)	• Shattering of the cloves. • Bulbs appear spongy or sunken and / or brown and watery when cut open. • White or light pink growth appear over the cloves.	• Do not store damaged bulbs. • Store bulbs in dry conditions with good ventilation. • Follow crop rotation with non-host crops such as wheat and cowpea for 3-4 years.
Bacterial rot (*Erwinia* spp. and *Pseudomonas* spp.)	• Watery, foul-smelling fluid squeezes from the neck of diseased bulbs when pressed.	• Proper curing after harvest. • Store bulbs in dry conditions with good ventilation.



Purple blotch | Anthracnose | Iris Yellow Spot Virus

Fig. 7 Diseases of onion and garlic

Onion and garlic thrips damage and symptoms



Red spider mites

Eriophyide mite infestation | Leaf tier *Archips machlopis*

Fig. 8 Pests of onion and garlic

Integrated pest and disease management (IPDM):

Adoption of integrated practices is essential to minimize pest and disease incidence and ensure sustainable production. Crop rotation with non-host crops such as maize or millets helps break the pest and disease cycle. Drip irrigation should be preferred to reduce humidity and disease spread, while raised beds are recommended during the *kharif* season to improve drainage. Seed treatment with Thiram + Carbendazim or Trichoderma helps in managing soil borne diseases. Border crops such as maize act as physical barriers against thrips. Timely foliar sprays should be undertaken when the economic threshold level (ETL) of 30 thrips per plant is reached.

Recommended spray schedule:

DAT	Fungicide	Pesticide
30	Mancozeb @ 0.25%	Fipronil @ 0.1%
45	Tricyclazole @ 0.1%	Carbosulphan @ 0.2%
60	Hexaconazole @ 0.1%	Profenofos @ 0.1%

6.8 Harvesting and post-harvest management: When more than 50% of the tops are down, the bulbs are harvested along with leaves by hand-pulling from beds. After harvesting, bulbs are field cured for 3-4 days under dry conditions, followed by shade curing for 10-12 days to ensure proper drying of neck tissues and outer scales. After curing, the roots and tops are trimmed, leaving a neck length of about 2-3 cm above the bulb. Proper curing facilitates neck drying, improves bulb firmness and enhances shelf life by reducing moisture content and minimizing microbial infection. Pre-mature harvesting increases post-harvest losses due to physiological weight loss, decay and sprouting. At all temperatures, there is a gradual loss in weight of onion. Bulbs harvested during rain are not preferred for storage. The onion bulbs are classified into three grades based on bulb size *i.e.* A (> 80 mm), B (50-80 mm) and C (30-50 mm) grades. In India, grading of onion is usually performed manually either before storage or before marketing.

The ICAR-DOGR has developed manual and motorized machines for grading. Onion bulbs can be classified into five categories with grading machine based on the bulb size. The efficiency of manual operated grading machine is five times of the manual grading while the efficiency is almost 20 times with motorized grading machine. The accuracy of grading of onion with grading machine is around 90% as against 70% with manual grading.

6.9 Storage: Field and shade cured bulbs should be stored in recommended bottom ventilated storage structure (Fig. 9). Selected and graded bulbs should be filled at height of 4-5 feet in storage. There are mainly two types of storage structures, one is single compartment (single chawl) and another is of double compartment (double chawl). Single compartment storage should be erected opposite to the flow of wind direction whereas, double compartment should be along the flow of the wind. Storage structure is to be prepared at proper height, away from wet land at well aerated location. The onion bulbs can be stored at temperatures of 23.9-29.4°C or higher for 5-6 months without sprouting and without excessive loss in weight.

Fig. 9 Onion storage structures

i. *Rabi* onion production technology

Rabi onions, also known as winter onions, constitute the major onion-growing season in India, accounting for about 50-60% of total cultivation. This crop is grown during the winter months, with sowing typically undertaken from October to November and harvesting extending up to April-May. *Rabi* onions are crucial for ensuring steady market supply during the lean or off-season period, when the availability of onions from other seasons is limited.

For *rabi* onion cultivation, all agronomic practices such as soil and climate requirements, nursery management, field preparation, nutrient management, irrigation, weed management, pest and disease management, harvesting and storage should be followed as per the production practices described in section 6. However, certain aspects specific to the *rabi* season require attention. Transplanting should be done using 45-50 days old seedlings for optimum establishment and growth. In addition, the selection of suitable varieties is crucial for achieving higher yield and better storage quality under *rabi* conditions.

Varieties: Varieties suitable for this season typically exhibit traits such as resistance to diseases common during cooler weather and the ability to withstand mild temperatures without premature bolting. Varieties with good bulb storability, along with efficient water and nutrient uptake capabilities, are preferred. Some popular varieties of onions grown during the *rabi* season include Bhima Kiran, Bhima Shakti, Bhima Light Red, Bhima Early, NHRDF Red (L-28), NHRDF Red-2 (L-355), Agrifound Light Red and Arka Niketan are preferred for their dark/medium red bulb color and adaptability to various soil types. N-2-4-1 is valued for its uniform bulb size and good storage characteristics, making it suitable for commercial cultivation. Agrifound White, Bhima Shweta, Bhima Ujjwala, Bhima Prasanskaran and Bhima Nirjala are preferred for white bulbs during *rabi* season (Fig. 4).

ii. *Kharif* onion production technology

The *kharif* onion is produced in parts of Maharashtra, Gujarat, Karnataka, Rajasthan etc. The major portion of *rabi* season crop is stored throughout the country. This stored material is available for domestic markets as well as for export from May to October. There is a critical gap in supply of onion from October to December in the country and as a result of which price increases sharply. The *kharif* crop plays an important role in fulfilling consumer's demand and stabilizing the prices of onion in the country. If *kharif* crop is delayed or spoiled due to erratic monsoon conditions, the prices increase very rapidly in October and remain high till January-February. *Kharif* onion, therefore, is most crucial in controlling market prices and making onions available to consumers.

At the onset of monsoon, water stagnation and high incidence of diseases spoil the seedlings and restrict the healthy nursery production for *kharif* season. Therefore, *kharif* onion production through sets can be done to avoid the losses. Many farmers raised *kharif* onion sets in their field and harvested them as greens or at fully developed stage for domestic needs as well as for commercial purpose. *Kharif* onion is harvested from October to November when price of onion goes very high due to scarcity of onion. Therefore, *kharif* onion production earns profits to the farmers and this technology needs to be popularized in the other parts of the state as well as in Northern India.

In *kharif* onion cultivation, most agronomic practices such as soil and climate requirements, field preparation, irrigation management, weed management, pest and disease management and storage should be followed as per the production practices described in section 6. However, certain practices specific to the *kharif* season are given here.

Nursery management: The nursery for *kharif* onion is usually sown in April-May. It is difficult to raise healthy seedlings due to scorching heat and lack of irrigation water in summer as the seedling mortality is high due to high temperature and low humidity. Further, after onset of monsoon the heavy showers, water stagnation and high incidence of diseases spoil the seedlings. The irrigation through drip or sprinkler saves 40-50% water and ensures 90-100% seed germination with good seedling stand. The transplantable seedlings are more in broad bed furrow (BBF) with drip irrigation than flat beds. The use of 50% shade net or hessian cloth for shading over nursery beds during summer protects young seedlings from scorching sunlight and ensures rapid and higher seed germination. After proper stand of seedlings, shade net should be removed after 40-45 days to avoid etiolation and lanky growth.

Transplanting age: In *kharif* season, 40-45 day old nursery seedlings are suitable for transplanting.

Nutrient management: About 15 t FYM/ha or 7.5 t poultry manure or vermicompost/ha should be incorporated at the time of last ploughing. The recommended dose of fertilizers for *kharif* onion is 75:40:40:15 kg NPKS per hectare (Table 4). One-third of nitrogen (25 kg N/ha) along with the full dose of phosphorus (40 kg P/ha), potassium (40 kg K/ha) and sulphur (15 kg S/ha) should be applied as basal at the time of transplanting. The remaining nitrogen should be applied in two equal splits of 25 kg N/ha at 30 and 45 days after transplanting. Application of sulphur is important for bulb development and quality. A dose of 15 kg S/ha is generally sufficient for *kharif* onion under normal soil conditions. In addition to soil application, foliar nutrition may be adopted to enhance crop performance. Spraying of water-soluble fertilizer (19:19:19) @ 5 g/litre along with micronutrients (Zn, B, Ca, Mg) @ 3-5 ml/litre at 45-60 days after transplanting is beneficial. Further, application of potassium nitrate (Multi-K, 0:0:50) @ 5-10 g/litre at 75-90 days after transplanting improves bulb development and quality.

Varieties: A perfect variety for *kharif* would have a slender neck, high photosynthetic efficiency, early bulking, disease resistance and water logging tolerance. Although it is quite difficult to choose the ideal variety, a variety with a thin neck and a maturity time of 90 to 105 days should be chosen for the *kharif* season. Bhima Super, Bhima Dark Red, Bhima Raj, Bhima Red, Bhima Kesar, Bhima Gulab, Bhima Shubhra, Bhima Safed, Agrifound Dark Red, N-53, Baswant-780, Arka Kalyan and Phule Safed perform better in *kharif* season.

Harvesting and post-harvest management: Onion crops should be harvested when 50% of the tops have fallen, indicating maturity. However, during the *kharif* season, bulbs typically mature in about 90-110 days, but the plants continue to grow actively without any top fall. The post-harvest management of *kharif* crop will be maintained same as the production practices (section 6).

iii. *Late kharif* onion production technology

In the *late kharif season*, most agronomic practices such as nursery management, field preparation, nutrient management, weed management, pest and disease management, harvesting and storage should be followed as per the *rabi* season production practices. However, irrigation management requires 8-10 irrigations depending on soil type and rainfall. In addition, the selection of suitable varieties is crucial for achieving better performance under *late kharif* conditions. Varieties such as Bhima Shakti, Bhima Raj, Bhima Red, Bhima Super, Bhima Shubhra and Bhima Safed perform well and are recommended for cultivation during the *late kharif* season.

7. Seed Production of Onion

The seed producing area should have low humidity, mild cool temperature during initial growth, followed by increase in temperature at later stages of the crop. While onion is in flower, clear, bright days are necessary to ensure insect activity for pollination. For seed production, the onion bulbs are harvested, stored for some time and then replanted in proper season for seed production. Mother bulbs are grown in the same way as the crop for market and are stored in well-ventilated storage structures. Generally medium sized bulbs are selected for planting for seeds. About 30-35 q of bulbs are required for planting one hectare area for seed crop. Bulbs are planted in the month of October. The spacing depends on the size of bulbs; however, the ideal spacing is 50 cm between the rows and 20 cm within the rows. An isolation distance of about 1000 m should be maintained to ensure genetic purity in seed production plots. Fertilizer doses and plant protection measures are same as in bulb crop. For maintaining high seed vigour and viability, onion seeds should be treated with Thiram and stored in 400 gauge poly pack. Seed priming with 2% K_2HPO_4 for 24 hours at 15°C enhances the seedling vigour and seed viability. Pre-harvest prophylactic spray of Iprodione + Carbendazim @ 0.2% (2 g/litre) during seed development is most effective in controlling the seed infection. Vernalization treatment of bulbs for 10 days at 15°C before planting enhances the seed yield (Fig. 10).

Fig. 10 Quality seed production in onion

7.1 Climate and season: Onion flowering is a thermo-sensitive phenomenon influenced by temperature and photoperiod. Short-day tropical types initiate flowering under relatively moderate temperatures of about 25°C during the day and 10-15°C at night, whereas long-day temperate types require lower temperature conditions (0-25°C) for flowering. For tropical types, planting during October-November is considered optimum for seed production.

As per recommended production practices, mother bulbs for the *rabi* crop should be raised during the *rabi* season and stored up to October. The bulbs should be stored in well-ventilated structures under conditions of 25-30°C temperature and 65-70% relative humidity. Plants developed from bulbs stored under these optimum conditions exhibit early flowering and maturity, resulting in higher seed yield.

7.2 Field preparation and planting methods

In onion seed production technology, there are two main methods: the seed-to-seed method and the bulb-to-seed method. The seed-to-seed method involves directly sowing onion seeds in the field, allowing the plants to grow, flower and produce seeds within a single growing season. This method is simpler but requires precise field management to ensure optimal growth conditions. The bulb-to-seed method, on the other hand, involves planting onion bulbs, which were grown from seeds of previous season, into the field. These bulbs then produce flowering stalks and seeds. This method typically results in higher seed yields and better quality seeds, as the bulbs can be selected for desirable traits. Both methods require careful attention to factors like soil fertility, irrigation, pest control and isolation distances to maintain seed purity and quality. At a spacing of 45 × 30 cm, bulb requirement ranges from 50 to 80 g, with bulb quantity of 26-41 q/ha. Under drip irrigation with a spacing of 60 × 20 cm, bulb size requirement remains in the range of 50-80 g, with bulb quantity of 30-45 q/ha.

7.3 Bulb to seed method: The onion bulbs are produced which after maturity are harvested and bulbs of true to type are sorted and stored. The stored bulbs are planted in the next season to produce seeds. It is opted for quality bulb selection. Bulbs produce several flower stalks, higher seed yield which requires 4-4½ months for bulb production with 6-7 months for bulb to seed maturity.

7.4 Seed to seed method: Seedlings after transplanting are allowed to over winter in the field. The bulbs are not lifted and allowed to flower in the same field. No need to harvest bulbs, produces fewer flower stalks and less seed yield compared with bulb to seed method. It requires 7-8 months for seed production.

7.5 Nutrient management: FYM @ 15 tons/ha, NPK @ 100:50:50 kg/ha apply 50:50:50 kg/ha NPK at the time of planting and remaining nitrogen in 2 splits, first at 30 days and second at 45-60 days after planting. Give 1% spray of Polyfeed (19:19:19, NPK) at 30 and 60 days after planting and one spray of multi-K (0:0:50) after 60 days of planting

7.6 Roguing: Plot should be visited regularly. Yellow and lanky plants should be removed before flowering; plants with differential umbel height should be removed before opening of flowers; plants affected by aster yellow and *Stemphyllium* blight should be removed before seed harvest.

7.7 Weed management: Spray Oxyfluorfen @ 1.5 ml/l after planting of bulbs and one hand weeding after 40-45 days after planting should be done.

7.8 Pest and disease management: The eradication of pests and diseases during seed production follows similar kind of treatment as followed during *rabi* season (Table 5; Fig. 7 and 8).

7.9 Harvesting and post-harvest management: When onions are cultivated for seed production, harvesting occurs in 3 to 4 stages because the flowers on each plant do not mature simultaneously. Seeds typically require 30 to 50 days after anther dehiscence to mature, depending on the variety. Mature onion seed is dull black in colour, hard and completely dry. Harvesting of onion seeds can begin when more than 25% of the seeds on an umbel are exposed and appear black. However, to avoid premature harvesting of onion seeds, it is recommended to begin harvesting when 50% of the seeds on an umbel are exposed and have turned black. Umbel heads can be cut 4-6 inches below and laid on the cloth. Harvested umbels are sun dried either on plastic sheets or on canvas when weather is warm and sunny. Flower heads can be spread in loose layer and avoid putting them in thick layer to avoid rotting. Regular altering of sides of umbel is practiced. Onion seed umbels can also be air-dried as an

alternative to sun drying. However, it is crucial to monitor the air temperature during this process, ensuring it does not exceed 32ºC till the moisture content of seeds drops below 18%. The dried umbels should be regularly inspected for complete removal of moisture, if the endosperm of seed is not fully ripe the seed will be soft and doughy. These soft seeds are very easily damaged during the threshing process.

7.10 Seed processing and storage

To thoroughly clean onion seeds, it is crucial to use a combination of winnowing and screening to eliminate debris, bracts and immature seeds. In cases where seed lots have low germination rates or contain persistent bracts and stems; flotation can be an effective method. This involves placing the seeds in water to allow the lighter materials to rise and be easily skimmed off. After using flotation, it is vital to dry the seeds immediately and avoid leaving them submerged in water for too long to prevent mold growth. For small quantities, hand cleaning with sieves and wind also can be done.

Seed yield can vary significantly and is largely influenced by vigorous and stronger plants which can support more flowers and umbels. Yield typically ranges from 500-600 kg seed/ha, in best management and climatic conditions 800-1000 kg/ha seed can be obtained. Proper storage conditions are vital to maintain seed viability. Seed should be packed in 400 gauge poly bags after proper drying. Room temperature should be 30-35° C for 15-18 months, cold storage should be 15°C with 30-40% RH for 3-4 years.

C. GARLIC PRODUCTION TECHNOLOGY

Garlic (*Allium sativum* L.) is one of the oldest cultivated vegetables, valued for its pungency and rich history. Unlike seed-propagated crops like onions, garlic is exclusively propagated vegetatively through cloves or bulbils. Known for its higher nutritive value compared to other bulb crops, garlic has been a staple in India for centuries. It is rich in protein, phosphorous, potassium, calcium, magnesium and carbohydrates. Green garlic is rich in ascorbic acid. Allicin found in garlic offers a range of health benefits, including anti-microbial, anti-oxidant and anti-inflammatory properties. It supports cardiovascular health, boosts immunity, regulates blood sugar and may help prevent cancer.

In India, garlic is cultivated during *kharif* and *rabi* seasons. The *kharif* season, which typically starts in June and extends to October, is crucial for garlic cultivation in regions with heavy rainfall and warm temperatures. During this period, garlic cloves are planted and the crop benefits from ample moisture and

warmth for germination and early growth. In contrast, the *rabi* season, spanning from October to March, is significant for garlic bulb development and maturation in regions with milder winters. Farmers harvest garlic during this season, benefiting from cooler temperatures that help in the proper formation and storage of garlic bulbs. These two distinct seasons complement each other, ensuring a year-round availability of garlic in Indian markets.

8. Status of Garlic Production in India and the World

Trends in garlic cultivation area (in lakh hectares) and production (in million tons) in world from 2011 to 2023 are given in Fig. 11. Over the years, there has been a steady increase in both cultivation area and production. The area under garlic cultivation expanded from 1.38 lakh hectares in 2011 to 1.69 lakh hectares in 2023, while production rose from 1.38 million tons in 2011 to 2.87 million tons in 2023. The growth in production appears to be more pronounced than the increase in cultivated area, suggesting improvements in yield and farming practices. China dominates garlic cultivation with 8.40 lakh hectares, followed by India with 4.09 lakh hectares, while other countries like Bangladesh (0.72 lakh hectares), Myanmar (0.28) and Spain (0.26) contribute smaller shares. China leads overwhelmingly with 207.43 lakh tons, accounting for the majority of global production, followed by India with 32.66 lakh tons. Other notable producers include Bangladesh (5.49 lakh tons), Egypt (4.90 lakh tons) and South Korea (3.18 lakh tons) (Fig. 12). Per hectare productivity of garlic is highest in Kuwait (57.50 t/ha) followed by Uzbekistan (30.87 t/ha), Haiti (26.41 t/ha), China (24.68 t/ha), Oman (24.64 t/ha), Kazakhstan (24.11 t/ha), Egypt (23.99 t/ha), Jordan (23.78 t/ha), Türkiye (22.39 t/ha), Algeria (18.70 t/ha) Kyrgyzstan (16.86 t/ha) and United States of America (16.81 t/ha). India ranks 50th in productivity with an average of 9.03 tons/ha which is one of the lowest productivities in the world (*Source: FAOSTAT 2023*). The low productivity of garlic in India can be mainly attributed to the non-availability of virus free planting material, which is of utmost importance in a vegetatively propagated crop like garlic. Further, higher productivity in many countries than in India is due to cultivation of long day type garlic whereas India grows typical short day type garlic, which matures in 130 days in short winter. Further, higher incidence of pests and diseases under tropical conditions also reduce productivity per unit area.

Indian garlic is grown primarily in the states of Madhya Pradesh, Gujarat, Uttar Pradesh, Maharashtra and Rajasthan. Madhya Pradesh accounts for 62.85% of India's total garlic production followed by Rajasthan (16.81%), Uttar Pradesh (6.57%), Gujarat (3.29%) and Punjab (2.66%) with significant garlic production (Fig. 13) (*Source: NHB, 2022*). Karnataka, Bihar, Tamil Nadu, Punjab, Haryana and

Andhra Pradesh also produce substantial quantity of garlic in cooler regions of the states. Garlic in plains is grown from October to March. The genotypes mostly grown in plains are tropical type, which have very low productivity. Himachal Pradesh, Uttaranchal and Jammu & Kashmir grow long day type garlic from September to June.

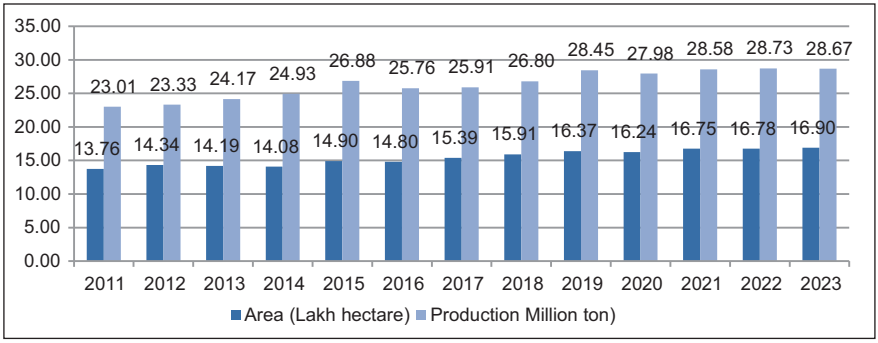


Fig. 11 Worldwide area and production of garlic throughout the decade (FAOSTAT, 2023)

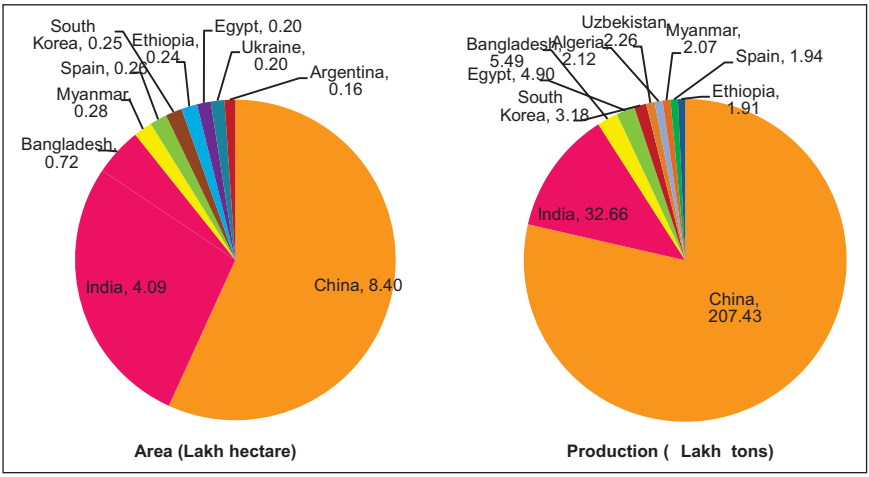


Fig. 12 Major garlic producing countries in the world (*Source: FAOSTAT, 2023*)

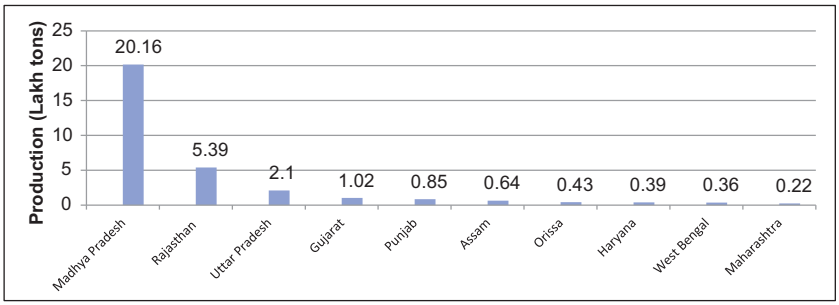


Fig. 13 Garlic production of major garlic producing states in India (*Source: NHB, 2022*)

9. Nutritional Importance

Garlic is a rich source of carbohydrates, protein and phosphorus, contributing significantly to its nutritional value. It has been reported that green garlic contains high levels of ascorbic acid (vitamin C), making it particularly beneficial in fresh form. Fresh garlic bulbs typically contain about 62.8% water, 6.3% protein, 0.1% fat and 29% carbohydrates, including approximately 3.9% sucrose. In addition, garlic provides essential minerals such as calcium (Ca), iron (Fe) and zinc (Zn), along with phosphate salts. It also contains small amounts of vitamins including thiamine, riboflavin, niacin and ascorbic acid (Table 6). Garlic contains about 0.06-0.1% volatile oil, which is responsible for its characteristic aroma and therapeutic properties. This oil primarily consists of diallyl disulfide, along with smaller quantities of allyl propyl disulfide. These compounds are formed from the breakdown of alliin (S-allyl cysteine sulfoxide), a sulfur-containing compound present in garlic. Garlic cloves contain an enzyme alliinase, which is released when they are crushed.

Table 6. Nutritive value of Garlic

Particulars	Fresh peeled garlic cloves	Dehydrated garlic powder
Moisture (%)	62.80	5.20
Protein (%)	6.30	17.50
Fat (%)	0.10	0.60
Mineral matter (%)	1.00	3.20
Fiber (%)	0.80	1.90

Particulars	Fresh peeled garlic cloves	Dehydrated garlic powder
Carbohydrates (%)	29.00	71.40
Energy (kcal)	145.00	-
Calcium (%)	0.03	0.10
Phosphorus (%)	0.30	0.42
Iron (%)	0.001	0.004
Thiamine (mg/100g)	0.06	-
Riboflavin (mg/100g)	0.23	0.08
Niacin (%)	0.04	0.70
Vitamin C (mg)	13.00	12.00
Magnesium (mg/100g)	71.00	-
Sodium (%)	0.02	0.01
Potassium (%)	0.46	0.70
Manganese (mg/100g)	0.86	-
Zinc (mg/100g)	1.93	-
Chromium (mg/100g)	0.02	
Vitamin- A (IU)	0.40	175.00
Nicotinic acid (mg/100g)	0.40	-
Vitamin- B (mg/100g)	16.00	0.68

Source: Vegetable crops in India by T.K. Bose and M.G. Som

10. Crop Physiology

Garlic is the second most important bulb crop after onion in India and is closely related to other *Allium* crops such as shallots, leeks and chives. The plant reaches 50-60 cm in height with flat, linear, grey-green leaves. Each plant produces a bulb composed of numerous cloves, each encased in a papery sheath and surrounded by a thin, white or pinkish outer skin. Depending on the variety, bulbs can contain few to over twenty cloves. Garlic plants produce a green, curling flowering stalk called a scape, which can grow up to 1 meter long and has a cluster of small, white or pinkish hermaphroditic flowers at the top. The flowers are typically insect-pollinated and the plant is usually sterile and propagated asexually.

11. Seasonal Adaptability

In the *kharif* season, garlic is planted during June-July in regions with adequate irrigation facilities and where rainfall patterns support its growth. For the *rabi* season, garlic is predominantly planted from October to November in various parts of the country, taking advantage of cooler temperatures and ensuring optimal bulb development and storage quality (Table 7).

Table 7. Planting and harvesting time of garlic in different regions of India

State	Season	Time of planting	Time of harvesting
Chhattisgarh, Gujarat, Madhya Pradesh and Maharashtra	*Kharif*	June-July	October-November
	Rabi	September-November	March
Tamil Nadu	*Kharif*	June-July	October-November
	Rabi	October-November	March-April
Karnataka	*Kharif*	June-July	October-November
	Rabi	September-October	March
Andhra Pradesh	*Rabi*	September-October	March
Bihar, Haryana, Punjab, Rajasthan, Uttar Pradesh and Uttarakhand	*Rabi*	October-November	March-April
Odisha and West Bengal	*Rabi*	October-November	March
Hilly areas (Long day types)	*Rabi*	September	May

12. Improved Varieties

Table 8. List of garlic varieties along with their source

Variety	Recommended areas	Source
Bhima Omkar	Delhi, Gujarat, Haryana and Rajasthan	ICAR-DOGR, Pune
Bhima Purple	Delhi, UP, Haryana, Bihar, Punjab, Maharashtra, Karnataka and AP	
DOGR-PB-10	Jammu & Kashmir, Rajasthan, Haryana, Punjab and Delhi	

Variety	Recommended areas	Source
DOGR 746	Maharashtra and Gujarat	
Agrifound White (G-41)	Maharashtra and Madhya Pradesh	NHRDF, Karnal
Yamuna Safed (G-1)	All over the country	
Yamuna Safed-2 (G-50)	Northern parts of India	
Yamuna Safed-3 (G-282)	Madhya Pradesh, Maharashtra, Haryana, Gujarat, Punjab, Rajasthan, Uttar Pradesh and Chhattisgarh	
Yamuna Safed-4 (G-323)	North and Central India	
Yamuna Safed-5 (G-189)	Delhi, Uttar Pradesh, Haryana, Bihar, Punjab, Rajasthan, Gujarat, Maharashtra, Karnataka and Andhra Pradesh	
Yamuna Safed-8 (G-384)	Jammu, Punjab, Delhi, Haryana and Rajasthan	
Yamuna Safed-9 (G-386)		
Agrifound Parvati (G-313)	Jammu Kashmir, Himachal Pradesh and Uttarakhand	
Agrifound Parvati-2 (G-408)		
Yamuna Purple-10 (G-404)	Delhi, Rajasthan, Haryana, Jammu & Kashmir, Punjab, Punjab, Tarai region of Uttar Pradesh, Uttarakhand, Bihar and Jharkhand	
Yamuna Safed-6 (G-324)	Maharashtra, Gujarat and Madhya Pradesh	
Yamuna Safed-7 (G-378)	Hilly areas	
GG 2, GG 3, GG 4, GJG 5, GJG 6, GJG 7	Gujarat and Maharashtra	JAU, Junagadh
Godavari, Shweta	Maharashtra	MPKV, Rahuri
Phule Baswant, Phule Nilima	Madhya Pradesh and Maharashtra	

Variety	Recommended areas	Source
Ooty 1	Tamil Nadu	TNAU, Coimbatore
VL Lahsun 2, VL Lahsun 7 VL Garlic 1	Bihar, Himachal Pradesh, Jammu & Kashmir, Punjab, Uttarakhand and Uttar Pradesh	ICAR-VPKAS, Almora
VGP-5	Jammu & Kashmir, Uttarakhand, Himachal Pradesh	
CITH-G-1, CITH-G-2, Mukteshwer Sel-2, CITH-G-3	Himachal Pradesh, Jammu & Kashmir and Uttarakhand	ICAR-CITH, Srinagar
HG-1, HG-2, HG-17	Haryana	CCSHAU, Haryana
PG-17, PG-18	Punjab	PAU, Ludhiana
Sabour Garlic-2	Bihar	BAU, Sabour
Other local varieties		
Rane Bennur Local, Sikkim Local, Shilkui Local, Navapur Local, Faizpur Local, Anta Lahsun, Chunar Local and Ooty Local		Farmer's varieties

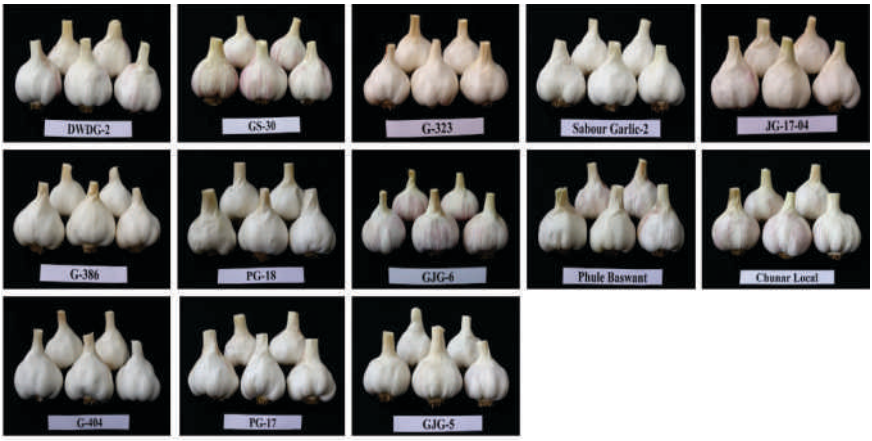


Fig. 14 Garlic varieties available for cultivation

13. Production Practices of Garlic

13.1 Soil and climate: Garlic is grown under wide range of climatic conditions. However, it cannot withstand too hot and too cold temperatures. It requires cool and moist climate during vegetative growth and bulb development stages but warm dry weather during maturity. In general, cool growing period results in higher yield than warm conditions. The suitable growth temperature for garlic is 13 to 24°C. However, longer exposure to low temperature may produce bulbils in the axils of the leaves, which reduce the bulb yield. The critical day length for bulbing is 10-12 h for short day garlic and 13-14 h for long day garlic. Garlic can be successfully cultivated in a wide range of soil types, but well drained fertile loamy soil with a pH of 6-8 is desirable for growing this crop. Like onion, garlic is sensitive to highly acidic, alkali and saline soils and water logging conditions. Soils with high organic matter are preferred, due to their increased moisture and nutrient holding capacity. These are less prone to crusting and compaction. In heavy soils, the bulbs produced may be deformed. Bulbs become discolored in poorly drained soils. The threshold electrical conductivity of a saturation extract (ECe) for garlic crop is 3.9 dS/m. When the ECe level exceeds this, crop yield starts declining.

13.2 Field preparation and planting methods: The field should be prepared by ploughing three to four times using a cultivator, followed by a mould board plough to obtain a fine tilth and remove soil clods. During the final land preparation, well decomposed organic manure such as FYM, poultry manure or vermicompost @ 7.5 t/ha should be incorporated. The field should then be

levelled and beds of appropriate size prepared. Successful garlic cultivation depends on proper clove selection. Cloves should be separated from seed bulbs just before planting, taking care no damage to the basal plate. Only healthy, large cloves weighing about 1.2-1.5 g (preferably >1.5 g) should be selected, while small, diseased or damaged cloves should be discarded. Prior to planting, cloves should be treated with 0.1% Carbendazim to minimize fungal infection during establishment. Cloves are planted vertically at a depth of about 2 cm below the soil surface on flat beds (Fig. 15). A spacing of 15 cm between rows and 10 cm between plants is recommended, resulting in approximately 65-70 plants per m^2. The seed rate is generally 400-500 kg of cloves per hectare. The time of planting varies with region. In peninsular India (Maharashtra, Karnataka and Andhra Pradesh), garlic is typically planted from August to October.

Fig. 15 Flat-bed cultivation of garlic

13.3 Nutrient management: Based on the field experiments carried out through All India Network Research Project on Onion and Garlic at different locations, application of 75:40:40:40 kg NPKS/ha along with a combination of two or three organic manures (FYM, Poultry manure and Vermicompost) equivalent to 75 kg N/ha (7.5 t Poultry manure or 7.5 t vermicompost or 15 t FYM/ha) is recommended for Bihar, Chhattisgarh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Tamil Nadu (Ooty). Application of 100:50:50:50 kg NPKS + 20 t FYM/ha is recommended for Haryana, Uttarakhand and Uttar Pradesh. Recommended organic manures should be applied before last ploughing and mixed well in the soil. One third of nitrogen and full recommended dose of phosphorus, potassium and sulphur should be applied as basal at the time of planting. Remaining two third of nitrogen should be applied in two equal splits at 30 and 45 days after planting (Table 9).

Table 9. Fertilizer schedule for garlic (per ha)

Schedule	N	P_2O_5	K_2O	Organic manures
Garlic (yield potential < 8 t/ ha)				
Basal	25 kg	40 kg	40 kg	Organic manures equivalent to 75 kg N (FYM 15 t/ha or poultry manure 7.5 t/ha or vermicompost 7.5 t/ha)
30 DAT	25 kg	-	-	
45 DAT	25 kg	-	-	
Total	75 kg	40 kg	40 kg	
Sulphur management in garlic (yield potential < 8 t/ ha)				
Application of 40 kg sulphur/ha				
Garlic (yield potential > 8 t/ ha)				
Basal	40 kg	50 kg	50 kg	Organic manures equivalent to 75 kg N (FYM 15 t/ha or poultry manure 7.5 t/ha or vermicompost 7.5 t/ha)
30 DAT	30 kg	-	-	
45 DAT	30 kg	-	-	
Total	100 kg	50 kg	50 kg	
Sulphur management in garlic (yield potential > 8 t/ ha)				
Application of 50 kg sulphur/ha				
Micronutrient: Foliar application of micronutrient mixture (Fe: 0.5%, Zn: 0.5%, B: 0.25%, Cu: 0.25% and Mn: 0.5 %) at 30, 45 and 60 days after planting				

13.4 Irrigation management: Garlic is a shallow-rooted bulb crop, with most roots confined to a depth of 15-20 cm. Therefore, maintaining adequate soil moisture within this root zone is essential for optimum growth and bulb development. The crop is highly sensitive to moisture stress, particularly during bulb initiation and development stages. Irrigation should be applied immediately after planting, followed by a second irrigation after 3-4 days to ensure proper establishment. Subsequent irrigations should be scheduled based on soil type and climatic conditions. Generally, irrigation at 7-10 days interval is recommended. During cooler months (November-December), irrigation can be given at 10-12 days interval, whereas during warmer periods (January-February), the interval should be reduced to 7-8 days. On average, garlic requires about 12-15 irrigations during its growing period. Each irrigation typically supplies 5-6 cm of water. Excess irrigation and waterlogging should be avoided, as they adversely affect bulb development and increase disease incidence. Micro-irrigation systems such as drip and sprinkler irrigation

significantly improve water-use efficiency, enhance bulb yield and reduce weed and pest incidence. Under drip irrigation, planting should be done on broad bed furrows (BBF) of about 120 cm width and 15 cm height. Two drip laterals (16 mm diameter) are placed at 60 cm spacing, with emitters spaced 30-50 cm apart and a discharge rate of approximately 4 L/hour. Sprinkler irrigation can also be adopted, with laterals spaced 6 m apart and a discharge rate of about 135 L/hour for uniform water distribution. Studies conducted at ICAR-Directorate of Onion and Garlic Research have shown that drip irrigation increases garlic yield by 15-20%, while sprinkler irrigation results in comparatively lower yield improvement (Fig. 16).

Fig. 16 Drip and sprinkler irrigated garlic on raised beds

13.5 Weed management: Control of weeds at the initial growth stages is essential for getting high marketable bulb yield. Because of labour scarcity, chemical control of weeds along with cultural methods is inevitable. Application of Oxyflurofen 23.5% EC @ 1.5 -2.0 ml/litre or Pendimethalin 30% EC @ 3.5-4 ml/litre before or at the time of planting followed by one hand weeding at 40- 45 days after transplanting is recommended for efficient weed control.

13.6 Pest and disease management: Garlic crop is affected by several insect pests and diseases (Table 5; Fig. 7 and 8). Major pests include thrips and nematodes, while important diseases include *Stemphylium* blight, white rot and basal rot. For detailed management practices, refer to Table 5.

13.7 Harvest and post-harvest management: Harvesting starts when the leaf tops begin to dry, change color and bend towards the ground. Another sign of bulb maturity is the thinning of the sheath leaves surrounding the bulb. Typically, garlic matures within 130-150 days, depending on the cultivar, location and season. The plants are pulled out and tied into small bundles in the field for curing and drying so that the bulbs become hard and their keeping quality is prolonged by minimizing microbial, fungal infection and water loss during storage.

i. *Rabi* garlic production technology

In *rabi* garlic cultivation, most agronomic practices such as soil and climate requirements, field preparation and planting methods, nutrient management, irrigation, weed management, pest and disease management and harvesting and post-harvest operations should be followed as per the production practices described in section 13. However, variety selection plays an important role in enhancing productivity of garlic.

Improved varieties: The ICAR-DOGR has developed various improved varieties suitable for cultivation in different seasons and regions; Bhima Omkar, Bhima Purple, DOGR-PB-10 and DOGR-746. The garlic varieties developed by other organizations are Agrifound White, Agrifound Parvati, Agrifound Parvati-2, Yamuna Safed, Yamuna Safed-2, Yamuna Safed-3 and Yamuna Safed-4 from National Horticultural Research and Development Foundation (NHRDF), Nashik and Shweta, Godavari, Phule Baswant, Phule Nilima from MPKV, Rahuri. Among these, Yamuna Safed-3 and Agrifound Parvati have bigger cloves suitable for export.

ii. *Kharif* garlic production technology

In *kharif* garlic cultivation, field preparation and planting, weed management and pest and disease management, practices should be followed as per the production practices described in section 13. However, certain practices specific to the *kharif* season are given here.

Soil and climate: Follow as per the production practices described in section 13. However, during the *kharif* season, garlic is grown on broad bed furrows (BBF) of about 15 cm height, 120 cm top width and 45 cm furrow depth, which are suitable for drip and sprinkler irrigation. Flat beds should be avoided during the rainy season to prevent waterlogging.

Nutrient management: After planting, the garlic crop needs 75-80% of the NPKS nutrients for 15-75 days. To increase short-day garlic yield, nutrient use efficiency and water productivity, farmers who want to apply NPKS through drip irrigation should apply 100:50:50:45 kg NPKS/ha using water-soluble fertilizers in about 10-11 split applications at 5-7 day interval from 15-75 days after planting (Table 9).

Irrigation management: Irrigation of the garlic crop should begin as soon as it is planted and continue every 7 to 10 days, depending on the soil moisture content. When the *kharif* garlic crop reaches maturity (10-15 days prior to harvest), irrigation should be discontinued. In general, this requires 5-8 irrigations. At every stage, stay away from wet circumstances as they might cause diseases like purple blotch and basal rot.

Improved varieties: A perfect variety for *kharif* would have a slender neck, high photosynthetic efficiency, early bulking, disease resistance and water logging tolerance. Bhima Purple and Yamuna Safed-6 (G-324) perform better in *kharif* season.

Harvest and post-harvest management: Garlic should be harvested after 50% drying of leaves. Generally, garlic matures within 120-130 days depending on the cultivar and location of *kharif* season.

14. Seed Production of Garlic

Garlic is a vegetatively propagated crop and the term 'seed' refers to cloves used as planting material. For seed production, healthy and true-to-type bulbs are selected from a well-managed crop. Medium to large-sized cloves are preferred, as they ensure better establishment and higher bulb yield. Cloves should be separated from bulbs just before planting, taking care no damage to the basal plate. Prior to planting, cloves should be treated with carbendazim (0.1%) to minimize fungal infection during establishment. The crop is grown following recommended agronomic practices similar to bulb production. An isolation distance of about 5 m is maintained to avoid physical or mechanical mixture of varieties. Regular roguing is essential to remove off-type and diseased plants in order to maintain genetic purity. Proper irrigation, nutrient management and plant protection measures should be followed to produce healthy bulbs.

At maturity, when the tops start drying and bending, the crop is harvested and bulbs are properly cured in shade to improve keeping quality. After curing, bulbs are graded and only healthy, well-developed and true-to-type bulbs are selected for seed purpose. These bulbs are stored in well-ventilated structures under low humidity conditions to maintain viability and prevent rotting or sprouting. Proper selection, curing and storage of bulbs ensure availability of quality planting material for the next planting season.

D. MARKETING AND EXPORT OF ONION AND GARLIC

A major share of onion production in India is consumed domestically, while the surplus is channelized into processing and exports. The Government of India regulates onion trade through various policy measures, particularly in relation to exports and imports, to ensure price stability and adequate domestic availability. The National Agricultural Cooperative Marketing Federation of India (NAFED) plays a crucial role in this system. It is authorized to undertake export operations and is also entrusted with market intervention activities. NAFED

procures onions from farmers, maintains buffer stocks and regulates their release into domestic and export markets in consultation with affiliated agencies and farmer organizations, thereby stabilizing prices and ensuring steady supply.

The marketing and export of onion and garlic in India have shown significant growth, supported by data from the Agricultural and Processed Food Products Export Development Authority (APEDA) and Food and Agriculture Organization (FAO). According to APEDA, India exported approximately 1.72 million tons of fresh onions during 2023-24, valued at about ₹3,922.78 crores (USD 473.72 million). Major export destinations include Bangladesh, Malaysia, Sri Lanka, United Arab Emirates, Nepal, Indonesia, Vietnam, Qatar and Kuwait. Popular onion varieties in trade include Bhima Shakti, Bhima Kiran, Bhima Light Red, Agrifound Dark Red, Agrifound Light Red, NHRDF Red, Agrifound White, Agrifound Rose, Agrifound Red, Pusa Ratnar, Pusa Red and Pusa White Round.

Onion production in India is concentrated in states such as Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Bihar, Andhra Pradesh, Rajasthan, Haryana and Telangana. Maharashtra is the leading producer, contributing about 35% of total production, followed by Madhya Pradesh with around 17% (2023-24). *Rabi* production is dominant in Maharashtra, Madhya Pradesh and Bihar, whereas, Karnataka, Andhra Pradesh, Rajasthan and Gujarat contribute significantly during the *kharif* season. In Maharashtra, major onion producing districts include Nashik, Pune and Ahilyanagar. Three seasonal crops are marketed, with approximately 20-25% from *kharif*, 20-25% from *late kharif* and 50-60% from *rabi* harvests. The Lasalgaon Mandi is recognized as Asia's largest onion market, serving as a major hub for both domestic distribution and exports.

India is also one of the leading exporters of garlic globally, following China. Garlic production is predominantly concentrated in Madhya Pradesh, which contributes about 62.85% of the national output, followed by Rajasthan and Uttar Pradesh. Important garlic varieties include Bhima Omkar, Bhima Purple, Yamuna Safed series, Agrifound White, Phule Baswant, Phule Nilima and Godavari. As per APEDA data, India exported about 56,823 tons of garlic valued at ₹277 crores during 2023-24. Major export destinations include Indonesia, United States, Vietnam, Malaysia and Brazil, while key global importers include the United States, Malaysia, Brazil, Germany, United Kingdom, Netherlands, Canada and Australia.

Overall, the marketing and export of onion and garlic plays a vital role in strengthening India's agricultural economy, providing remunerative prices to farmers and enhancing the country's presence in the global horticultural trade.

E. LIST OF BENEFICIARIES: TRIBAL FARMERS/GROUPS (TSP)

List of 167 Farmers' Groups selected under TSP for Field Demos in Nandurbar (MS)

S. No.	Name of Bachat Gat	Name of Group Leader
1.	Jai Siyaram Shetkari Gat, Malwan	Mr. Sunil Ravilaal Kokani
2.	Jai Balaji Shetkari Gat, Khairve	Mr. Shidya Chama Gavit
3.	Jai Siyaram Shetkari Gat, Khairve	Mr. Shinga Jalu Valvi
4.	Navchaitanya Purush Bachat Gat, Nizampur	Mr. Shital BaluVasave
5.	Deomogra Shetkari Bachat Gat, Shehi	Mr. Vishnu Jolu Vasave
6.	Jai Bajrang Shetkari Gat, Mehendipada	Mr. Chunilaal Shivtya Kokani
7.	Eklavay Purush Bachat Gat, Palipada	Mr. Kochrya Kotya Padvi
8.	Balram Shetkari Gat, Palsun	Mrs. Bankabai Todya Kokani
9.	Ganga Mahila Bachat Gat, Karanjali	Mrs. Yamuna Gulabdas Gavit
10.	Meraliyaha Shetkari Bachat Gat, Palipada	Mr. Harish Nurji Valvi
11.	Jai Bajrang Shetkari Gat, Talavipada	Mr. Anis Damu Valvi
12.	Utkarsh Sheti Utpadak Gat, Patibedki	Mrs. Nima Vasu Gavit
13.	Ravikiran Sheti Utapadak Gat, Thuva Gadat	Mr. Jaisingh Hurji Gavit
14.	Shri Yogeshvar Shetkari Gat, Nizampur	Mr. Kalpesh Singha Vasave
15.	Aai Kuwarli Shetkari Gat, Zhamanjar Khekda	Mr. Jalamsingh Jiva Maavchi
16.	Yaha Shetkari Gat, Sonpada	Mr. Mansingh Ethya Valvi
17.	Deomogra Mata Sheti Utapadak Gat, Chadapada Umran	Mr. Ajitsingh Shyamsingh Valvi
18.	Shri Kukumba Bhatiji Maharaj Bachat Gat, Maulipada	Mr. Yashvant Magya Valvi
19.	Kisan Shetkari Gat, Nagare	Mr. Subhash Jedya Vasave
20.	Navnirmaan Shetkari Bachat Gat, Nizampur	Mr. Philip Jetya Valvi
21.	Jai Kisan Shetkari Gat, Palshi	Mr. Dilip Chotiram Kokani
22.	Arpit Shetkari Purush Gat, Raingan	Mr. Vechya Supdya Gavit
23.	Smital Mahila Bachat Gat, Raingan	Mrs. Sumabai Anil Gavit
24.	Shramik Shetkari Purush Gat, Raingan	Mr. Vantya Nura Gavit
25.	Adarsh Shetkari Purush Gat, Umran	Mr. Subhash Dhanji Vasave
26.	Deomogra Yuva Shetkari Mandal, Shravani	Mr. Sandip Mohan Kokani
27.	Shriram Sheti Utapadak Gat, Nimboni	Mr. Sadashiv Gangaram Kokani

S. No.	Name of Bachat Gat	Name of Group Leader
28.	Nirmal Sheti Utapadak Gat, Morthuva	Mr. Dasu Velji Gavit
29.	Sai Shetkari Mandal, Shravani	Mr. Sandip Chandrasingh Kokani
30.	Navyuvak Shetkari Mandal, Nimboni	Mr. Krushna Ashok Kokani
31.	Vikas Sheti Utapadak Gat, Suli	Mr. Krushna Fuljii Gavit
32.	Saraswati Mahila Bachat Gat, Palipada	Mrs. Sunita Subhash Gavit
33.	Eklavya Shetkari Gat, Navapada	Mr. Baban Itya Kokani
34.	Kisan Harit Kranti Sheti Utapadak Gat, Savrat	Mr. Gulabsingh Kotya Vasave
35.	Kalyani Mahila Bachat Gat, Palipada	Mrs. Archana Surupsingh Valvi
36.	Jai Malhar Shetkari Purush Gat, Sagali	Mr. Chandulal Chaitram Kokani
37.	Jai Kisan Shetkari Purush Gat, Sagali	Mr. Jaisingh Ramdas Kokani
38.	Shivshakti Shetkari Gat, Shravani	Mr. Mansu Magan Kokani
39.	Sai Krupa Shetkari Gat, Shravani	Mr. Mangdya Dhendya Kokani
40.	Pragati Shetkari Purush Gat, Palsun	Mr. Shantilal Fakira Kokani
41.	Ujawal Shetkari Purush Gat, Chorvihir	Mr. Hopanji Padvya Gavit
42.	Eklavya Shetkari Mandal, Nimboni	Mr. Gulab Sukhlal Kokani
43.	Jai Bajrang Jalsrot Upabhokta Gat, Nimboni	Mr. Surupsingh Mangu Kokani
44.	Rajnagar Shetkari Mandal, Khadki	Mr. Madhukar Gobji Gavit
45.	Jai Gurudev Shetkari Bachat Gat, Nizampur	Mr. Madhukar Dharma Valvi
46.	Mangalmurti Bachat Gat, Karanjali	Mr. Kisan Ramji Valvi
47.	Aai Kuwarli Mahila Bachat Gat, Bhardu	Mrs. Surta Vishnu Valvi
48.	Devi Deomogra Shetkari Gat, Navi Savrat	Mr. Rajesh Nelji Gavit
49.	Nachiketa Sheti Utpadak Gat, Ucchi Shevdi	Mr. Ishra Fatya Gavit
50.	Jai Sheti Utpadak Gat, Ucchi Shevdi	Mr. Jagan Vikram Gavit
51.	Rajendra Padav Shetkari Mandal, Malpada	Mr. Rajendra Amarsingh Padvi
52.	Maharana Tantra Mandal, Dhanaje	Mr. Jatrya Limba Pawara
53.	Rani Kajal Shetkari Mandal, Shelkui	Mr. Fendya Janglya Pawara
54.	Dev Pawad Shetkari Mandal, Malpada	Mr. Bhimsingh Kiresingh Padvi
55.	Nruhsingh Bhagwan Shetkari Mandal, Umrani Khurd	Mr. Dhakalsingh Kalu Pawara
56.	Jivan Udyog Gat, Zamtyavad	Mr. Anand Bakaram Kokani

S. No.	Name of Bachat Gat	Name of Group Leader
57.	Anand Yuva Shetkari Gat, Nagare	Mr. Anand Ramsingh Naik
58.	Namrata Shetkari Gat, Nagare	Mr. Magan Sega Vasave
59.	Yashoda Mahila Bachat Gat, Nimboni	Mrs. Nalini Gulab Kokani
60.	Abhimanyu Bachat Gat, Khairve	Mr. Karan Ramsingh Valvi
61.	Shri Krushna Shetkari Gat, Shravani	Mr. Rahul Sakharam Kokani
62.	Ishwar Bachat Gat, Talavipada	Mr. Krushna Nima Valvi
63.	Yaha Mogi Bachat Gat, Talavipada	Mr. Sharad JalamsinghValvi
64.	Shriram Bachat Gat, Palsun	Mr. Kunal Somnath Kokani
65.	Yaha Mogi Bachat Gat, Karanjali	Mr. Bansilal Amrut Gavit
66.	Kisan Purush Bachat Gat, Nimboni	Mr. Sunil Lala Kokani
67.	Jai Bajrang Bachat Gat, Asaalipada	Mr. Jayantilal Dhirsingh Padvi
68.	Jai Bajrang Bachat Gat, Zhamjarpadav	Mr. Bakaram Shankar Kokani
69.	Yaha Mogi Sheti Utapadak Gat, Chedapada	Mr. Suresh Jelramsingh Naik
70.	Shri Swami Samarth Shetkari Gat, Shravani	Mr. Sanjay Chandrasingh Kokani
71.	Shri Krushna Aadim Shetkari Gat, Shravani	Mr. Dinesh Kantilal Kokani
72.	Vivekanand Bachat Gat, Khairve	Mr. Dharamsingh Ija Kokani
73.	Jai Siyaram Gat, Gogalpada	Mr. Ajit Gobji Padvi
74.	Jai Hari Shetkari Gat, Palsun	Mr. Bijlal Avsha Kokani
75.	Saikripa Shetkari Gat, Shravani	Mr. Mahendra Kokani
76.	Angel Bachat Gat, Sonkhadke	Mrs. Kalpana Jagdish Gavit
77.	Birsa Munda Shendriya Sheti Utpadak Gat, Sonkhadke	Mr. Manji Huraji Gavit
78.	Mother Teresa Mahila Bachat Gat, Raingan	Mrs. Malati Dayaram Gavit
79.	Prachi Mahila Bachat Gat, Raingan	Mrs. Savita Gemji Vasave
80.	Asha Swayam Sahayata Mahila Bachat Gat, Bandharfali, Raingan	Mrs. Babita Ramesh Gavit
81.	Ashish Mahila Bachat Gat, Raingan	Mrs. Vina Vecha Gavit
82.	Sagar Mahila Bachat Gat, Dhandipada	Mrs. Usha Amesh Gavit
83.	Devmogra Mahila Bachat Gat, Umran	Mrs. Anusaya Lalu Vasave
84.	Gauri Swayam Sahayata Mahila Bachat Gat, Maulipada	Mrs. Savita Dinesh Kokani
85.	Jai Kisan Jalsrot Upbhogta Gat, Maulipada	Mr. Jitendra Jaisingh Kokani
86.	Durgamata Mahila Bachat Gat, Shravani	Mrs. Jyoti Udaysingh Kokani
87.	Arjun Purush Bachat Gat, Nimboni	Mr. Magan Uttam Kokani
88.	Jai Bajrang Shetkari Gat, Shravani	Mr. Arvind Laxman Kokani
89.	Avishak Yuva Bachat Gat, Nimboni	Mr. Kanilal Bava Kokani

S. No.	Name of Bachat Gat	Name of Group Leader
90.	Adarsh Yuva Bachat Gat, Nimboni	Mr. Suraj Hadagu Kokani
91.	Bahugonit Shetkari Gat, Karanji Budruk	Mr. Ramesh Payala Gavit
92.	Taniska Mahila Bachat Gat, Karanji Budruk	Mrs. Usha Shilas Gavit
93.	Pragati Mahila Swayam Sahayata Bachat Gat, Karanji Budruk	Mrs. Kusum Ramesh Gavit
94.	Jidnyasa Mahila Bachat Gat, Nimboni	Mrs. Pramila Brijlal Kokani
95.	Adarsh Purush Bachat Gat, Nimboni	Mr. Dharamdas Kolshiram Kokani
96.	Dropadi Mahila Bachat Gat, Nimboni	Mrs. Devikabai Krushna Kokani
97.	Jai Bhavani Mahila Bachat Gat, Nimboni	Mrs. Ramila Rustam Kokani
98.	Neha Mahila Bachat Gat, Umran	Mrs. Rina Dilip Vasave
99.	Devmogra Krishi Mahila Bachat Gat, Palipada	Mrs. Sunanda Dinkar Valvi
100.	Shri Ganesh Mahila Bachat Gat, Nimboni	Mrs. Zhugarabai Sunil Kokani
101.	Laxmi Swayam Sahayata Samuh Gat, Nimboni	Mrs. Geeta Vasant Kokani
102.	Adarsh Purush Bachat Gat, Nimboni	Mr. Kanilal Jalu Kokani
103.	Nirmalsang Mahila Swayam Sahayata Samuh, Palsun	Mrs. Nirmala Sanjay Kokani
104.	Laxmi Swayam Sahayata Samuh, Dhong	Mrs. Usha Raju Kokani
105.	Siddhi Ganesh Mahila Bachat Gat, Khairve	Mr. Dharamsingh Ija Vasave
106.	Prabhat Mahila Swayam Sahayata Gat, Palipada	Mrs. Chaya Kiran Valvi
107.	Jagdamba Mahila Swayam Sahayata Samuh, Palipada	Mrs. Aruna Udaysingh Valvi
108.	Jijamata Mahila Bachat Gat, Nimboni	Mrs. Ravita Ganesh Kokani
109.	Ashish Mahila Bachat Gat, Raingan	Mrs. Avitri Dilip Gavit
110.	Angel Mahila Bachat Gat, Kareghat	Mrs. Sara Prabhudas Mavachi
111.	Annapurna Mahila Bachat Gat, Mograni	Mrs. Rupali Vasan Kokani
112.	Aradhana Swyam Sahayata Bachat Gat, Vaagde	Mrs. Soniya Devidas Naik
113.	Arya Mahila Swayam Samuh Gat, Shravani	Mrs. Roshani Bhaskar Kokani
114.	Bhagyalakshmi Mahila Bachat Gat, Mograni	Mrs. Sarika Ganesh Kokani
115.	Bhumata Shetkari Gat, Ghogalpada	Mr. Mahendra Dharamdas Gavit
116.	Dhanashri Swayam Sahayata Samuh Gat, Vadada	Mrs. Nutan Ratilal Kokani
117.	Divyani Swayam Sahayata Samuh, Nimboni	Mrs. Rekha Ajay Kokani
118.	Eklavya Shetkari Gat, Pimpale	Mr. Satish Goma Gavit
119.	Gajraj Purush Bachat Gat, Nimboni	Mr. Dinesh Vasant Valvi
120.	Geeta Mahila Bachat Gat, Nimboni	Mrs. Babita Mevalal Kokani

S. No.	Name of Bachat Gat	Name of Group Leader
121.	Jagruti Mahila Swayam Sahayata Samuh, Vadphali	Mrs. Priyanka Dilip Vasave
122.	Jai Bajrang Bachat Gat, Navapada	Mrs. Pooja Rahul Kokani
123.	Jai Bajrang Shetkari Gat, Kokanipada	Mr. Maansingh Saradha Kokani
124.	Jai Kisan Purush Bachat Gat, Nimboni	Mr. Arjun Suman Kokani
125.	Jai Malhar Purush Gat, Nimboni	Mr. Dinesh Parshram Kokani
126.	Jan Jagruti Swayam Sahayata Samuh, Vadphali	Mrs. Megha Kishor Valvi
127.	Kanya Mahila Bachat Gat, Nimboni	Mrs. Ranjanmala Jalamsingh Kokani
128.	Krushna Mahila Swayam Sahayata Bachat Gat, Ghogalpada	Mrs. Mamta Ramesh Valvi
129.	Kuber Mahila Swayam Sahayata Samuh, Navapada	Mrs. Puja Rahul Kokani
130.	Laxmi Swayam Sahayata Samuh, Mograni	Mrs. Shivanti Kalidas Kokani
131.	Mahadev Mahila Swayam Sahayata Samuh, Vaatvi	Mrs. Chandrakala Kailas Kokani
132.	Maheshwari Mahila Swayam Sahayata Samuh, Savrat	Mrs. Maheshwari Pravin Gavit
133.	Mauli Krushi Mitra Shetkari Gat, Antipada	Mr. Jatansingh Vinayak Vasave
134.	Mazi Kanya Mahila Shetkari Bachat Gat, Karanjali	Mrs. Lalita Kisan Valvi
135.	Navyuvak Shetkari Mandal, Nimboni	Mr. Ashok Gopya Kokani
136.	Nirant Swayam Sahayata Samuh, Juni Savrat	Mrs. Sangeeta Yaspal Vasave
137.	Om Swayam Sahayata Mahila Samuh, Vadsatra	Mrs. Randhi Sandip Gavit
138.	Om Swayam Sahayata Samuh, Nimboni	Mrs. Taravanti Rakesh Kokani
139.	Pragati Shetkari Gat, Lahan Kadvaan	Mr. Devidas Dhirya Paadvi
140.	Pragati Swayam Sahayata Samuh, Nimboni	Mrs. Jatri Mahaar Valvi
141.	Punjivan Shetkari Mandal, Nagare	Mr. Ravi Gemji Valvi
142.	Rani Mahila Swayam Sahayata Samuh, Vatvi	Mrs. Radhika Pravin Kokani
143.	Ripal Mahila Bachat Gat, Karanji Bk.	Mrs. Shalini D. Gavit
144.	Sakshi Mahila Swayam Sahayata Samuh Gat, Kareghat	Mrs. Milaka Shala Gavit
145.	Samta Swayam Sahayata Samuh, Saindanipada	Mrs. Jyoti Anil Kokani
146.	Sanjivani Mahila Swayam Sahayata Samuh, Raingan	Mrs. Omana Jaysingh Kokani
147.	Satmala Shetkari Purush Bachat Gat, Karanji	Mr. Ramesh Shippya Gavit
148.	Savitribai Phule Mahila Bachat Gat, Borchak	Mrs. Champabai Kantilal Naik

S. No.	Name of Bachat Gat	Name of Group Leader
149.	Shetkari Dudh Utpadak Purush Bachat Gat, Shravani	Mr. Dinesh Dogarsingh Kokani
150.	Shri Ganesh Mahila Swayam Sahayata Samuh, Mograni	Mrs. Phulabai Kashinath Kokani
151.	Shri Gurudatta Mahila Bachat Gat, Nimboni	Mrs. Shomali Shyamlal Kokani
152.	Shriram Shetkari Mandal, Nimboni	Mr. Eknath Bhavlya Kokani
153.	Soni Mahila Swayam Sahayata Samuh, Anjane	Mrs. Manju Vinayak Naik
154.	Suhani Mahila Bachat Gat, Suli	Mrs. Vipin Shivaji Gavit
155.	Suvarna Mahila Bachat Gat, Zhamanjar	Mrs. Hnnavali Manohar Mavchi
156.	Tejasvini Mahila Bachat Gat, Nimboni	Mrs. Kamal Kanilal Kokani
157.	Tulsi Swayam Sahayata Samuh, Juni Savrat	Mrs. Malti Subhash Vasave
158.	Tulsimata Mahila Swayam Sahayata Samuh, Palipada	Mrs. Minabai Sudhirrao Valvi
159.	Vadsatra Vikas Sheti Utpadak Gat, Vadsatra	Mr. Avinash Arjun Gavit
160.	Varad Mahila Bachat Gat, Shravani	Mrs. Sukshma Ranjit Kokani
161.	Yaha Mogi Mahila Swayam Sahayata Samuh, Vadphali	Mrs. Minabai Dinesh Vasave
162.	Yaha Mogi Shetkari Purush Bachat Gat, Palipada	Mr. Manila Yogesh Valvi
163.	Yaha Mogi Mahila Bachat Gat, Gataadi	Mrs. Savita Arjun Gavit
164.	Yaha Mogi Mahila Swayam Sahayata Bachat Gat, Vadphali	Mr. Satish Narshi Vasave
165.	Devmogra Mahila Swayam Sahayata Samuh Bachat Gat, Sagali	Mrs. Suman Jalamsingh Kokani
166.	Devmogra Swayam Sahayata Samuh, Palshi	Mrs. Jyoti Gorakh Kokani
167.	Jai Adivasi Yuva Swayam Sahayata Samuh, Vadada	Mrs. Sunita Yashwant Kokani

List of 53 Farmers' Groups selected under TSP for Field Demos in Ambegaon/ Junnar Talukas (MS)

S. No.	Name of Bachat Gat	Name of Group Leader
1.	Birsa Munda Shetkari Bachat Gat, Mhatarbachiwadi, Ambegoan	Mr. Mangal Shankar Vanaghare
2.	Gurudevdatta Bachat Gat, Dhagewadi, Ambegoan	Mr. Dunda Krushna Lokhare
3.	Kalikamata Purush Bachat Gat, Nigdale, Ambegoan	Mr. Hanuman Govind Ghode
4.	Hanuman Shetkari Bachat Gat, Nigdale, Ambegoan	Mr. Shantaram Dhumaji Lohkare

S. No.	Name of Bachat Gat	Name of Group Leader
5.	Vanadev Shetkari Bachat Gat, Mhatarbachiwadi, Ambegoan	Mr. Kisan Mhatarba Lohkare
6.	Kamaljadevi Shetkari Bachat Gat, Nigdale, Ambegoan	Mr. Kantaram Dhumaji Lohkare
7.	Dhartiaaba Birsa Munda Bachat Gat, Nigdale, Ambegoan	Mr. Ashok Chindhoo Asvale
8.	Vanadev Shetkari Bachat Gat, Savrali, Ambegoan	Mr. Janku Laxman Pekari
9.	Tambdeshwar Bachat Gat, Kushire, Ambegoan	Mr. Dilip Kisan Mudgun
10.	Shri Kalbhairavnath Bachat Gat, Terungan, Ambegoan	Mr. Ramdas Dagadu Lohkare
11.	Bhairavnath Shetkari Bachat Gat, Sukalvedhe, Ambegoan	Mr. Budhaji Mogha Thengale
12.	Kalubai Purush Bachat Gat, Bordar, Ambegoan	Mr. Ramchandra Rawaji Khamkar
13.	Vetaleshwar Purush Bachat Gat, Kondwal, Ambegoan	Mr. Pandurang Dagadu Bhawari
14.	Shambhu Bachat Gat, Pokhari, Ambegoan	Mr. Chintaman Rama Bhendari
15.	Anjanimata Shetkari Bachat Gat, Pokhari, Ambegoan	Mr. Soma Dhawala Bhendari
16.	Pandharinath Krishi Gat, Pokhari, Ambegoan	Mr. Balasaheb Honaji Kolap
17.	Janakidevi Shetkari Bachat Gat, Shirgoan, Ambegoan	Mr. Dondibhau Kisan Landhi
18.	Tathwadidevi Purush Bachat Gat, Taleghar, Ambegoan	Mr. Suresh Bhagu Kathe
19.	Har Har Mahadev Shetkari Bachat Gat, Terungan, Ambegoan	Mr. Tukaram Shankar Khamkar
20.	Kolateshwar Shetkari Bachat Gat, Nigdale, Ambegoan	Mr. Santosh Chintaman Unde
21.	Krantiveer Raghoji Bhangare Shetkari Gat, Rajapur, Ambegoan	Mr. Vilas Kisan Dhadwad
22.	Kamaljamata Shetkari Bachat Gat, Rajapur, Ambegoan	Mr. Ramchandra Ganpat Masale
23.	Dhagoba Bachat Gat, Chikhali, Ambegoan	Mr. Vijay Anant Aadhari
24.	Ganesh Shetkari Bachat Gat, Ambegoan	Mr. Subhash Namdev Date
25.	Shri Ram Bachat Gat, Kondwal, Ambegoan	Mr. Dyaneshwar Tukaram Katore
26.	Kamaljamata Shetkari Bachat Gat, Pimpri, Ambegoan	Mr. Pihula Ramchandra Lohkare
27.	Hanuman Shetkari Bachat Gat, Pokhari, Ambegoan	Mr. Dattatray Kisan Lohkare

S. No.	Name of Bachat Gat	Name of Group Leader
28.	Pandubaba Bachat Gat, Kondwal, Ambegoan	Mr. Mahadu Rama Lohkare
29.	Vetaleshwar Swayam Sahayta Bachat Gat, Junnar	Mr. Bajirao Maruti Dhengale
30.	Pandharinath Shetkari Bachat Gat, Sukalvedhe, Junnar	Mr. Eknath Vitthal Dhengale
31.	Anandimata Shetkari Bachat Gat, Gohe BK	Mr. Vinayak Chintaman Dangat
32.	Bhiaravnath Shetkari Bachat Gat, Gohe Khurd	Mr. Rajendra Satu Gabhale
33.	Chedoba Shetkari Bachat Gat, Gohe BK	Mr. Mangesh Barku Joshi
34.	Durgadevi Shetkari Bachat Gat, Gohe Khurd	Mr. Chintaman Maruti Damse
35.	Gavalinath Shetkari Gat, Gohe BK	Mr. Punaji Sakharam Gengaje
36.	Hanuman Shetkari Gat, Mapoli	Mr. Martand Ramchandra Lohkare
37.	Jaimalhar Shetkari Bachat Gat, Gohe Bk	Mr. Laxman Dhondiba Bhawari
38.	Kalambjai Shetkari Bachat Gat, Koltawade	Mr. Ramesh Suryakant Shelke
39.	Kamaljaamata Shetkari Gat, Mapoli	Mr. Pandurang Mahadev Lohkare
40.	Khanderaya Shetkari Bachat Gat, Gohe BK	Mr. Subhash Kisan Bhawari
41.	Kothai Shetkari Bachat Gat, Dimbe	Mr. Kiran Dnyaneshwar Sable
42.	Kulswamini Shetkari Bachat Gat, Gohe BK	Mr. Dattatray Nakaaji Bhawari
43.	Mauli Shetkari Bachat Gat, Gohe BK	Mr. Sachin Rambhau Bhawari
44.	Moraya Bachat Gat, Gohe Khurd	Mr. Vipul Sunil Gabhale
45.	Muktabai Shetkari Gat, Mapoli	Mr. Tanaji Thaksen Karvande
46.	Ranubai Shetkari Bachat Gat, Gohe BK	Mr. Dattaray Ramchandra Gengaje
47.	Shivshambho Shetkari Bachat Gat, Gohe BK	Mr. Pravin Ramchandra Bhawari
48.	Shri Wagheshwar Adivasi Bachat Gat, Gohe Khurd	Mr. Shankar Baban Dhumal
49.	Swamisamarth Shetkari Bachat Gat, Gohe BK	Mr. Sunil Balu Bhawari
50.	Vetaleshwar Bachat Gat, Kondhval	Mr. Dinkar Chindhu Vable
51.	Virbaba Shetkari Bachat Gat, Gohe BK	Mr. Santosh Kashinath Gengaje
52.	Vitthal Rukhmini Shetkari Bachat Gat, Gohe BK	Mr. Rohidas Dattaray Bhawari
53.	Waghoba Adivasi Shetkari Bachat Gat, Gohe Khurd	Mr. Ganesh Dhondibhau Karvande

List of 30 Farmers Groups selected under TSP for Field Demos in Khed taluka (MS)

S. No.	Name of Bachat Gat	Name of Group Leader
1.	Baliraja Adivasi Shetkari Bachat Gat, Bursewadi	Mr. Bhaguji Kondaji Burse
2.	Baliraja Swayam Sahayata Purush Bachat Gat, Bursewadi	Mr. Chindu Dhondu Kondhavale
3.	Bharari Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Asha Ganesh Zhanjare
4.	Durgamata Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Mangal Ashok Kondhavale
5.	Jai Sadguru Mahila Bachat Gat, Bursewadi	Mrs. Mangal Sanjay Burse
6.	Kalamjai Mahila Bachat Gat, Bursewadi	Mrs. Shantabai Bandubhau Burse
7.	Kamaljai Adivasi Bachat Gat, Bursewadi	Mr. Suresh Mahadu Madge
8.	Kranti Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Mangal Goraksh Pardhi
9.	Mahalaxmi Swayam Sahayata Bachat Gat, Bursewadi	Mrs. Shanta Bandu Burse
10.	Mauli Purush Swayam Sahayata Bachat Gat, Bursewadi	Mr. Satish Sahebrao Burse
11.	Om Sai Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Rekha Vikram Burse
12.	Om Sai Swayam Sahayata Purush Bachat Gat, Bursewadi	Mr. Ravindra Shantaram Burse
13.	Pragati Swayam Sahayata Mahila Gat, Bursewadi	Mrs. Gauri Vaibhav Gavari
14.	Prerna Swyam Sahayata Mahila Samuh, Bursewadi	Mrs. Pratiksha Ankush Burse
15.	Sai Baba Swayam Sahayata Gat, Bursewadi	Mr. Gaurav Anil Sable
16.	Saraswati Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Asha Dashrath Mose
17.	Shiv Shambho Adivasi Bachat Gat, Bursewadi	Mr. Ramchandra Kashinath Burse
18.	Shiv Shambho Swayam Sahayata Bachat Gat, Bursewadi	Mr. Kisan Laxman Gavari
19.	Shiv Shambho Swayam Sahayata Purush Bachat Gat, Bursewadi	Mr. Sunil Kisan Gavari
20.	Shivbaba Swayam Sahayata Purush Bachat Gat, Bursewadi	Mr. Kailas Sahadu Aswale

S. No.	Name of Bachat Gat	Name of Group Leader
21.	Shivgarjana Swayam Sahayata Purush Bachat Gat, Bursewadi	Mr. Laxman Shivram Bhange
22.	Shivshambo Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Komal Vijay Madge
23.	Shri Shambo Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Tarabai Pandurang Pardhi
24.	Shrii Dattakrupa Mahila Bachat Gat, Bursewadi	Mrs. Reshma Navnath Burse
25.	Shrishambo Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Surekha Laxman Bhange
26.	Someshwar Swayam Sahayata Purush Bachat Gat, Bursewadi	Mr. Dattatray Dagdu Kondhavale
27.	Swamini Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Mangal Avinash Mose
28.	Veerbhadra Swayam Sahayata Purush Bachat Gat, Bursewadi	Mr. Nilesh Ramchandra Burse
29.	Veeroba Swayam Sahayata Mahila Bachat Gat, Bursewadi	Mrs. Akshada Ravindra Burse
30.	Vitthal Rakhumai Adivasi Bachat Gat, Bursewadi	Mr. Vikram Bhimaji Burse

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