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A review on seasonal agriculture pattern and agrochemicals utilisation in different regions of Gujarat state, India

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Abstract
With the development of technology and blessed natural resources, Gujarat stands in the row of developed state with annual growth rate more than 9 % in recent years. The agriculture is a vital sector for the state's economy. The modern agricultural practices, implementation of government social welfare programme and water resource management has played major role in success of agriculture. The seasonal agriculture pattern as well as climatic conditions favours the cultivation of commercial crops that strengthened the state economy. The present review paper is prepared based on cropping pattern in different regions of Gujarat having agrochemicals utilization in different types of crops.

Keywords: seasonal agriculture pattern, agrochemicals, Gujarat

Introduction

The growing population and increasing urbanization at the expense of agricultural resources leads to continuous shrinking of arable land, which poses a critical challenge to ensuring food and nutritional security for the nation. According to United Nation study on global population, India will surpass China to become the most populous nation in the world by 2022. With a present size of 1.32 billion, India currently supports nearly 17.84% of the world population, with 2.4% land resources and 4% of water resources. The Indian agriculture needs to ensure food and nutritional security for the nation by improving its slow pace of food production and loss of agricultural produce due to pest attacks. It therefore becomes imperative to implement measures not only for enhancing crop production but also for crop protection. It is noted that annually average 45% of the world total food productivity was lost due to pest infestations (Abhilash and Singh 2009) [1]. Keeping pace with the growing population and their increasing demand for food, agrochemicals such as fertilizers and pesticides have become a need to increase agricultural production as well as protection from pest to ensure food and nutrition security of the nation.

1. Agriculture scenario in India

The agriculture sector has remained backbone of the Indian economy from earlier and presently accounts for ~15% of the country's total Gross Domestic Product (GDP) and holds a prime importance in the socio-economic fabric of India. About 44% of India's geographical area is used for agricultural purposes and is the principal source of livelihood for about 58% of its population (Singh and Nair 2012) [2]. The agriculture sector has faced many challenges like high monsoon dependency, unpredictable weather patterns, reduction in arable land, low per hectare yield, increase in pest attacks, etc. But, after green revolution, agricultural practices have changed having high yielding crop varieties, intensive cultivation, an ever increasing application of fertilisers and pesticides and applied irrigation leading India, a global crop producing country. Although yield per hectare has doubled in the past few years, Indian agriculture is still grappling with challenges.

In recent years, climate change also threaten India food security by negative effect on agriculture. Climate is the primary determinant of agricultural productivity which directly impact on food production across the globe. Although, the effect of increasing CO_2 concentrations will increase the net primary productivity of plants, but change in climate will also affect the soil moisture, groundwater recharge, frequency of flood or drought (Pasupalak and Pasupalak, 2009; Priyadarshi, 2009; Rai, 2010) [3, 4, 5] that leads to decreased net food productivity. Indian agriculture consumes about 80-85% of the nation's available water (Eriksson *et al*., 2008) [6]. Effect of climate change will affect water cycle (Reddy *et al*., 2009) [7] and finally groundwater level in different areas. Increase in the mean seasonal temperature can reduce the duration of many crops and hence reduce final yield. In regions, where temperatures are already close to the physiological maxima for crops, warming will impact yields more immediately (IPCC, 2007) [8]. Any alteration in the climatic parameters such as temperature and humidity which govern crop growth will have a direct impact on quantity of food produced. In the states of Jharkhand, Odisha and Chhattisgarh alone, rice production losses during severe droughts average about 40% of total production, with an estimated value of $800 million (Pandey, 2007) [9].

2. Agriculture pattern in Gujarat

Gujarat is very unique and blessed state with various natural resources. Gujarat is located on the west coast of India with longest sea coast of 1600 km of the Arabian Sea. It is situated between 20°1'& 24°7' North Latitude and 68°4'to 74°4' East Longitude covering geographical area of 196 lakh hectares,

which is 6 % of the country. The state is comprised of 33 districts having 246 talukas and 18569 villages (http://midh.gov.in/PDF/JIT_Gujarat2015.pdf) [10].

Agriculture is an important sector in the state of Gujarat as it is one of the primary sources of livelihood for more than half (*approximately* 60%) of its workforce (Planning Commission, 2002; UNDP, 2004) [11, 12]. Among all states of India, specially Gujarat has drawn attention by its spectacular agricultural growth due to meticulous planning and implementation of programmes aimed at increasing water availability that has helped farmers to increase productivity.

Due to modern agricultural practices, Gujarat has witnessed an agricultural growth rate of over 9% per annum in last decade (Dholakia and Datta 2010) [13]. In this context, Gujarat government has also played an important role to aggressively pursued an innovative agriculture development programme by liberalizing markets, inviting private capital, reinventing agricultural extension, improving roads and other infrastructure (Shah *et al.,* 2009; Kumar *et al.*, 2010) [14, 15]. The districts of Gujarat state have been categorized in broad five regions viz., Kutch, North Gujarat, Central Gujarat, Saurashtra and South Gujarat. The whole Kutch region is a single district, while, North Gujarat region contains Banaskantha, Patan, Mahesana, Aravalli, Sabarkantha and Gandhinagar district. The Central Gujarat region has Ahmedabad, Anand, Kheda, Panchmahal, Chota Udaipur, Mahisagar, Dahod and Vadodara district whereas, Saurashtra region contains Surendranagar, Rajkot, Jamnagar, Porbandar, Gir Somnath, Morbi, Botad, Devbhumi Dwarka, Junagarh, Amreli and Bhavanagar district. The South Gujarat region has seven districts viz., Surat, Narmada, Bharuch, Dang, Navasari, Valsad and Tapi. The major crop production of these five regions are summarised in Table 1.

Table 1: Region wise crop production in Gujarat

Region	Major crop production
Kutch	Bajra, Cluster bean, Jowar, Groundnut, Short duration legume
North Gujarat	Bajra, Cluster bean, Vegetables, Jowar, Cotton, Mustard,
Central Gujarat	Rice, Wheat, Maize, Tobacco, vegetables, Cotton, Groundnut, Castor, Mustard
Saurashtra	Groundnut, Cotton, Seasamum, Sugarcane, Rice, Pulses, Jowar, Bajra
South Gujarat	Cotton, Sugarcane, Rice, Wheat, Jowar, Ragi, Groundnut, Castor

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Govt. of Gujarat, Gandhinagar [16].

The nature of growth and development in the state would revolve around the crop diversification, value addition and linking crops with the markets. The mass based water harvesting and farm power reforms in dry Saurashtra and Kutch, and North Gujarat have helped energize Gujarat's agriculture. *Due to which,* these semi-arid regions have outperformed the canal irrigated South and Central Gujarat. The climatic conditions of Gujarat allow cultivation of variety of crops in different area of Gujarat (Fig.1).

Fig 1: Gujarat agricultural map showing cultivating area of different crops (Source: www.mapsof india.com) [17].

3. Climatic condition of Gujarat state

Three climatic types viz., sub-humid, arid and semi-arid are spread over different regions of the state, with temperature ranging from a minimum of 13°C to 27°C in January and maximum of 45°C in May-June. The normal annual rainfall of Gujarat state is 852 mm, however there is a wide annual variation in rainfall, affecting the productivity of the crops. Out of total area of the state 58. 60 % fall under arid and semi-arid climatic zone. The arid zone contributes 24.94 %, while the semi-arid zone forms 33.66 % of the total area of the state. The climatic condition of Gujarat favours cultivation of different types of fruits like; kesar alphonso mangoes, sapota, banana, amla and dates. The vegetables like; okra, beans, cucurbits, onion, potato, the spices like cumin, fennel, chilly, coriander, garlic and flowers like rose, lily, marigold, jasmine and tuberose. Grape, cashewnut, medicinal & aromatic crops like aloe, palmarosa are emerging as potential new crops in suitable areas of the state. The climatic condition such as land area, rainfall, temperature, soil types are the determining factors that influence crop production in the state.

3.1 Land area: Total geographical area of the state is about 161.98 lakhs hectares, in which 61% is under cultivation. Kheda, Mehsana, Amreli, Surat, Gandhinagar, Anand, Patan, Bhavnagar and Banaskantha districts have more than 70% of their area under cultivation, 9% as waste land, 9% under various watershed projects, 5% of area are under pasture land and 15% under non-agriculture or cultivable unutilized categories.

3.2 Rainfall: The average annual rainfall over different parts of the state varies widely from 300 mm in the Western half of Kutch to 2100 mm in the Southern part of Valsad and Dang district. The monsoon usually commences by the middle of June and withdraws by the end of September, about 95% of the total annual rainfall being received during these months.

3.3 Temperature: There is considerable variation in average temperature region wise during the course of the year. The average weekly minimum temperature is about 12.5°C, experienced generally in the month of January. The average weekly maximum temperature is 45°C, generally reached during the second week of May. Thus, January is the coldest month, while May is the hottest month for Gujarat. October is another month of higher temperature.

3.4 Soil types: Soil texture is an important soil characteristic that could influence water retention capacity, aeration, drainage, and susceptibility to erosion which drives crop production and management. The textual class of soil is determined by the percentage of sand, silt, loam and clay. Clayey and loamy types are predominant in the state under fine and medium textured soils. The soil texture of Kutch region belongs to the sandy class. The soils found in South Gujarat and Saurashtra are predominantly clayey. In Central Gujarat it is sandy loam to loam or clay loam to clay in midland, floodplains and the coastal saline area. The predominant texture of North Gujarat's soil is loamy (Table 2).

Table 2: Region wise distribution of different climatic conditions

Region	Land area (lakh Hectares)	Average annual rainfall (mm)	Soil types	Climate
Kutch	40.89	250 to 500	Sandy, saline	Arid to semi-arid
North Gujarat	28.91	400 to 700	Loamy, alluvium	Arid to semi-arid
Central Gujarat	34.13	800 to 1000	Medium black	semi-arid
Saurashtra	60.95	400 to 700	Shallow, medium black, calcareous	Dry sub humid
South Gujarat	23.22	1000 to 1500	Deep black, alluvium	Semi-arid to dry sub humid

Source: Department of Agriculture and Co-operation (2012) [18]

4. Seasonal cropping system in Gujarat: Around 51% of the total geographical area of Gujarat is under cultivation (Department of Agriculture, Gujarat, 2014) and agriculture contributes to about 18.3% of the states GDP. The output of the agriculture sector grew at an average annual rate of more than 11 % in Gujarat (GoG, 2013) [19].

There are two major crop growing season as for climate point of view. The summer or 'Kharif' crop growing season (June to September) coincides with southwest monsoon and the winter or 'Rabi' crop growing season starts after the summer monsoon, and continues up to the following spring or early summer. The major crops in both Kharif and Rabi seasons in Gujarat are cereals, pulses, oil seeds and other crops such as cotton, tobacco, vegetables etc. The seasonal variation in Kharif and Rabi season influence the growth of different crops (Table-3).

Table 3: Season wise growth of different crops

Major crop types	Kharif	Rabi
Cereals	Rice, Bajra, Jowar, Maize, Other cereals	Wheat, Jowar, Maize, Other cereals
Pulses	Tur, Moong, Math, Udid, Other pulses	Gram, Other pulses
Oil seeds	Groundnut, Seasamum, Castor, Soyabean, Other oil seeds	Mustard, Other oil seeds
Other crops	Cotton, Tobacco, Guar, Vegetables, Fodder etc.	Sugarcane, Tobacco, Cumin, Coriander, Garlic, Sawa, Isabgul, Funnel, Onion, Potato, Vegetables, Fodder etc.

***Source*:** Directorate of Agriculture, Gujarat State, Gandhinagar [20]

The major Kharif crops are rice, maize, cotton, jute, groundnut, soybean and bajra etc. Depending on crop duration, Kharif crops can be harvested during the autumn (October-November) or winter (December- February) months.

The major Rabi crops are wheat, mustard, barley, potato, onion, Isabgul, vegetables and gram etc. The southwest monsoon is critical to the Kharif crop, which accounts for more than 50% of the food-grain production and 65% of the oilseeds production in the country, while rainfall occurring at the end of the monsoon season provides stored soil moisture and often irrigation water for the Rabi crop, which is shown in the post monsoon season (October-November). The summer monsoon therefore, is responsible for both Kharif and Rabi crop production in India. The inter annual monsoon rainfall variability in India leads to large-scale droughts and floods, resulting in a major effect on Indian food grain production (Parthasarathy and Pant, 1985; Parthasarathy *et al.,* 1992; Selvaraju, 2003; Kumar *et al.*, 2004) [21, 22, 23, 24] and on the economy of the country (Gadgil *et al.*, 1999a; Kumar and Parikh, 2001) [25, 26].

While the performance of rice, wheat and pulses in Gujarat is below the national average, the performance for coarse cereals, oils seeds, cotton and onion is above the national average. Groundnut (highest production in the country), cotton, tobacco (second highest production in the country), isabgul, cumin, sugarcane, jawar, bajra, rice, wheat, pulses, tur and gram are the important crops of Gujarat. Although potato is not a major crop, its yields in Gujarat are high.

According to Directorate of Agriculture, report 2017, in Gujarat state, cereals crops are cultivated on 7760 hectares area in Rabi season, while 13443 hectares in Kharif season. The area covered by pulses are 2687 hectares in Rabi season and 5629 hectares in Kharif season. Similarly, oil seeds are grown on 2172 hectares area in Rabi season and 24415 hectares area in Kharif season of the state. The other crops like sugarcane, tobacco, cumin, coriander, garlic, sawa, isabgul, fennel, onion, potato, vgetables, fodder etc. holds the maximum area of the state with 11014 hectares in Rabi season and 41813 hectares in Kharif season. The crop wise cultivated area of the different region of the state are summarised in Table-4 for Kharif season and Table-5 for Rabi season.

Table 4: Region wise/ crop wise area (in hectares) during Kharif Season in Gujarat (2017-18)

Crops	Kutch	North Gujarat	Central Gujarat	Saurashtra	South Gujarat
Cereals	420	1293	8112	471	3147
Pulses	890	1124	1503	526	1586
Oil Seeds	2027	5800	1745	14313	530
Other Crops	2623	8382	6169	22339	2300

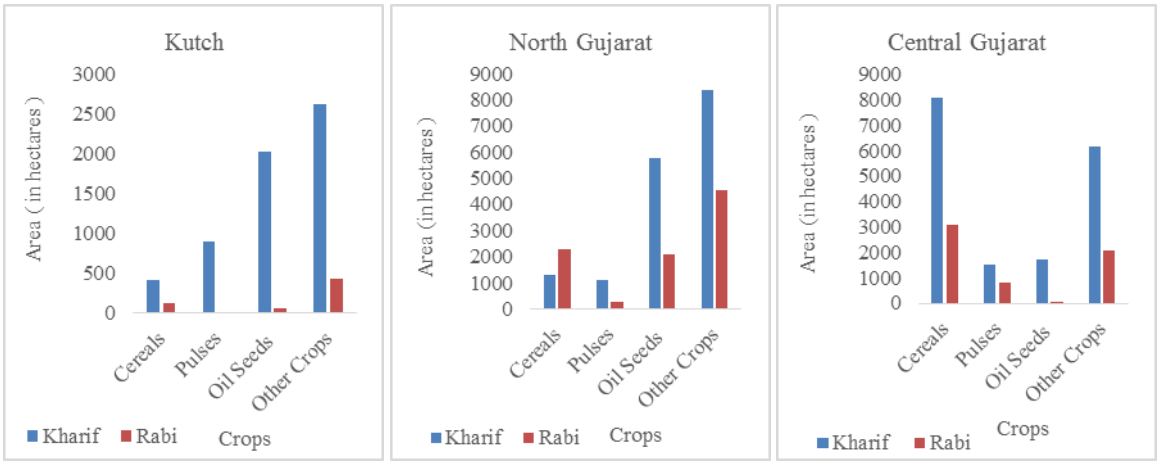
***Source*:** Directorate of Agriculture, Gujarat State, Gandhinagar [27]

Table 5: Region wise/ crop wise area (in hectares) during Rabi Season in Gujarat (2017-18)

Crops	Kutch	North Gujarat	Central Gujarat	Saurashtra	South Gujarat
Cereals	124	2305	3099	1984	248
Pulses	2	278	828	1226	353
Oil Seeds	58	2067	27	19	1
Other Crops	437	4568	2083	2999	927

Source: Directorate of Agriculture, Gujarat State, Gandhinagar [27]

The overall data shows that Kharif season crops are dominating on Rabi season crops in all the five regions of Gujarat. The total area cultivated in Kharif season is 85300 hectares with respect to 23634 hectares in Rabi season. The graphical representation indicates the dominancy of all crop types in all the regions of Gujarat, except cereals in North Gujarat, and cereals and pulses in Saurashtra (Fig.2).



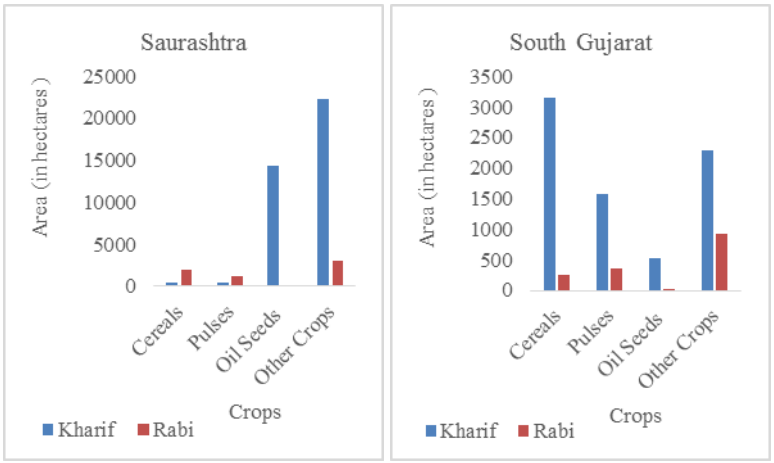


Fig 2: Graphical representation of area shared by different crop types during Kharif and Rabi season in five different regions of Gujarat

5. Agrochemicals utilisation in different crops in Gujarat for pest management: Gujarat tops the agriculture growth table in the country with a Compound Annual Growth Rate (CAGR) of 10.7% over the last decade. Around 65% of the total geographical area of Gujarat state is under cultivation. The state has five regions having wide varieties of soil and agricultural diversity. The production of total food grains witnessed a high growth, with a production of 10.1 million metric tonnes during 2010-11, as compared to 5.6 million metric tonnes in 2009-10. The state is also a leading contributor in the cotton production and accounts for 31% of production in the country. The production of cotton during 2010-11 is at 9.8 million bales as against 7.4 million bales in 2009-10. In all these, agrochemicals such as pesticides has play an important role by protecting crops from pest infestation and improving crop production. Improved agricultural yields help the farmers to produce more food without expanding their agricultural land which consequently protects biodiversity. A vast majority of population in Gujarat have engaged in agricultural works for their livelihood and therefore, exposed huge amount of pesticides in agriculture for higher productivity. The increased demand of agrochemicals in changing regional climate has resulted in an increase in consumption and application of pesticides (Shetty *et al*., 2008) [28].

Pesticides are the chemical substances used to kill pests such as unwanted plants, fungus, insects etc. in agricultural as well as domestic field. Pesticides can be defined as any chemical substance or mixture of substances intended for preventing, repelling, destroying, or mitigating the effect of any pest of plants and animals. They include insecticides, fungicides, herbicides, nematicides, molluscides, rodenticides, avicides, attractants and repellents used in agriculture, horticulture, public health, food storage or a chemical substance used for a similar purpose (NAFDAC, 1996) [29]. According to the Directorate of Plant Protection, Quarantine and Storage, Government of India (2016) [30], Gujarat with 1980 MT technical grade pesticides utilization, stands at tenth position in India. The major crops of the state such as cereals, pulses, oilseeds, and other crops viz. cotton, tobacco, sugarcane, cumin, rice, vegetables, chillies etc. have maximum consumption of technical grade pesticides (Table - 6).

Table 6: Pesticides utilization in different crops

Crops	Pesticides
Cereals	Azoxystrobin, Cyprodinil, Fenbuconazole, Pendimethalin, Bifenthrin, Chlorpyrifos, Cyfluthrin, Metolachlor, Cypermethrin, Diazinon, Dieldrin, Diflubenzuron, Fenvalerate, Endosulfan
Pulses	Dicloran, Fludioxonil, Pyraclostrobin, Vinclozolin, Metolachlor, Pendimethalin, Cypermethrin, Diflubenzuron, Fenvalerate
Oil seeds	Metolachlor, Pendimethalin, Chlorpyrifos, Cypermethrin, Diflubenzuron, Methyl parathion, Phorate, Mancozeb
Other crops	Azoxystrobin, Boscalid, Carbendazim, Chlorothalonil, Cyprodinil, Dicloran, Fenbuconazole, Pyraclostrobin, THPI, Vinclozolin, Metolachlor, Trifluralin, Pendimethalin, Propazine, Oxyfluorfe, Aldicarb sulfone, Aldicarb sulfoxide, Acephate, Acetamiprid, Chlorpyrifos, Cyfluthrin, Cypermethrin, Diazinon, Dichlorvos, Dicofol, Diflubenzuron, Dieldrin, Endosulfan, Fenvalerate, Pyridaben,

***Source*:** www.pastatebeekeepers.org/other/pesticides.htm[31]

Conclusion

Gujarat is one of the most progressive state of India with a positive development quotient. *The agriculture sector in Gujarat play an important role in its development* providing the required food grains for the state's population as well as raw materials for most of the agro-based industries. *The agrochemicals utilization and seasonal cropping pattern according to different climatic condition has given the pace for enhancement of crop productivity. The replacement of* less valuable crops like cereals and other crops by high valuable crops like cotton, groundnuts, tobacco fruits, vegetables, condiments and spices has great role in incensement of state economy. *Although agrochemicals utilizattion has many drawbacks but their utilization becomes essential for pest infestation and higher production of crops in this increasing population scenario.*

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