

## **Existing Cropping Patterns of Rajasthan: 2014-15**

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**Abstract:** The present study deals with cropping pattern of Rajasthan during 2014-15. It is observed that five crops are major ones with over 10 per cent area individually and these combined cover 82.43 per cent of the total cropped area. Among them, oilseeds and guar have 19.53 per cent and 19.00 per cent area under their cultivation respectively. Third and fourth crops are bajra with 16.53 per cent and pulses with 15.01 per cent. Whereas wheat has 12.54 per cent area under its cultivation. Other crops are spices, maize, jowar, fodder, cotton and barley, each having a share varying from 1 to 4 per cent in the cropping pattern. Rest of the crops under the heading of other crops, combined have 2.56 per cent under their cultivation. The study has deduced that oilseeds are predominant in eastern and southern parts of Rajasthan, while guar and bajra are more significant towards west of Aravallis. Pulses are dominant in central parts, but the predominance of wheat is associated with areas of moderate to high rainfall and irrigational facilities. Whereas, the remaining crops are area specific like maize in southern parts, jowar in eastern parts, cotton in extreme northern and central parts, spices in central and western parts, etc. It is found that geo-climatic conditions and magnitude of irrigation are the main determinants in the per cent share of crops among the cropping pattern of Rajasthan. In the present study, data is obtained from secondary sources, unit of study is district, simple percentages are used and cartographic technique is applied for mapping the results.

**Keywords:** Cropping pattern, extent of irrigation, rainfall, cartographic, geo-climatic, rain fed.

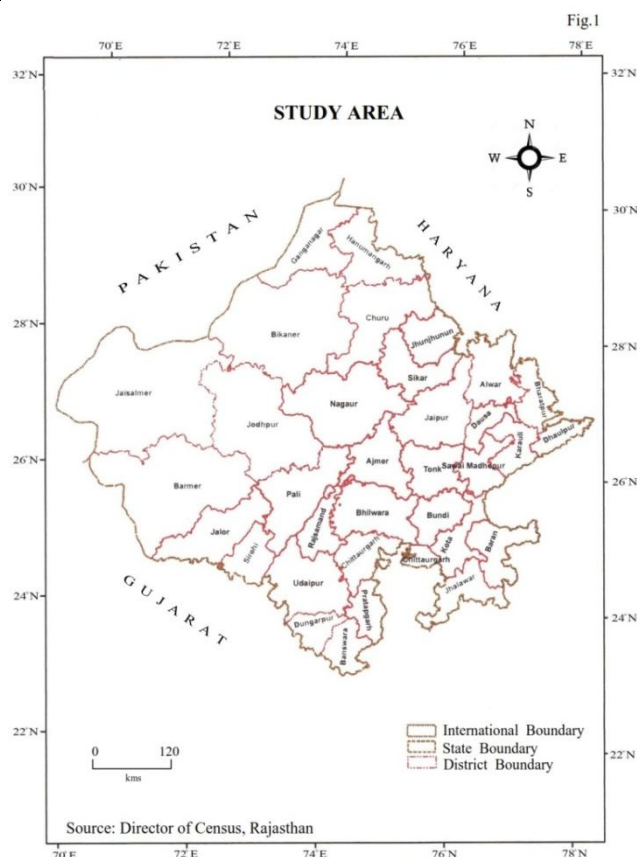
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### **Introduction:**

Cropping pattern means the percentage of total cropped area under various crops in a specific area at a particular point of time. It is also defined as arrangement of growing crops in a region over space and time (Mandal & Bezbaruah, 2013). Farmer's decision about the selection of cropping pattern is largely governed by the factors of agro-ecological, socio-economic, infrastructural, institutional, etc. Chouhan (1987) also mentioned multiple factors which affect cropping pattern and these are; terrain, topography, slope, soils, availability of water for irrigation, use of pesticides, fertilizers and mechanization. Patodiya (2015) visualized that resource base is one of the multiple factors which largely control the cropping pattern and it includes the soil types and irrigational facilities. He found that over time analysis of agricultural development shows that the areas having developed irrigational facilities shifted from inferior to superior crops, diversified to specialised cropping pattern, etc. Apart from these factors, farmer's decision is also controlled by their exposure to risks arising from various sources and also their skills and attitudes towards the crops they grow. Two main risk factors which limit out the agricultural operations are production risk and price risk. Thus, cropping pattern in any region is the result of action, reaction and interaction among physical and human environment. It is also a dynamic concept, which vary over space & time and the factors which control the cropping pattern also have spatial and temporal variations in a region. In Rajasthan, cropping pattern is mainly determined by relief, temperature, rainfall, soil, water sources, etc. Rajasthan is a mosaic of Aravalli Hills, shifting sand dunes and fertile plains. These diversities have unique influence on cropping pattern of the study region. As a result, large variety of crops are grown throughout an agricultural year.

### **Study Area:**

Rajasthan is located in north-western part of India, extending from 23°3'N to 30°12' N latitudes to 69°30' E to 78°17' E longitudes and covers about 342,274 square kilometres area. It shares an international boundary with Pakistan in the west and national boundary with Punjab, Haryana, Uttar Pradesh, Madhya Pradesh and Gujarat. Rajasthan is a part of peninsular India with exception of the Thar desert of western Rajasthan which belongs to great plains. Here maximum temperature is recorded 51°C in Sri Ganganagar district. Average annual rainfall is 50 cms and coefficient of variability in annual rainfall is above 65 per cent. There are two climatic zones; arid & semi-arid and soils vary from sandy to clayey.



According to 2011 census, total population of Rajasthan is 68,548,347 persons with 35,550,997 males and 32,997,440 females and density of population is 200 persons per square kilometres. There are 33 districts in Rajasthan in 2014-15.

**Objectives:**

- (1) To identify the spatial patterns of individual crops.
- (2) To find out factors responsible for the present cropping pattern in Rajasthan.
- (3) To make conclusions.

**Hypothesis:**

Cropping pattern of an area is often the product of physical and man-made environment.

**Sources of data and methodology:**

In present study secondary data is used which is collected from Agricultural Statistics of Rajasthan. Three year's averages are taken for 2014-15 i.e. 2013-14, 2014-15 and 2015-16. District is selected as unit of study. Simple percentages are used for deriving the results, tables & choropleth maps are prepared for representing the results.

**Discussion and Results:**

Cropping patterns of Rajasthan are discussed below;

**Overall cropping patterns of Rajasthan (2014-15):**

The synoptic view of fig. 1 and table. 1 show that bajra, guar, pulses, oilseeds and wheat are the major crops during 2014-15 and combinedly occupy 82.66 per cent area of the total cropped area of Rajasthan. Oilseeds are first ranking crop which cover 19.76 per cent area followed by guar with percentage of 19.00. The third major crop is bajra, which registers 16.35 per cent of the gross cropped area. In case of Pulses, the absolute area under its cultivation is 38,439,48 hectares which contains 15.01 per cent of the total cropped area. The next crop is Wheat which is an important cereal crop and comprises 12.54 per cent of the gross cropped area. Maize cultivation covers 3.52 per cent of the total cropped area and ranked sixth in the cropping system of Rajasthan.

Spices, jowar and cotton have 3.50 per cent, 2.44 per cent and 1.80 per cent of the total cropped area respectively. Whereas area under barley is 1.08 per cent. Remaining other crops such as rice, fruits, vegetables, sugarcane, etc. which have less than 1 per cent area under their cultivation each and are under the other crops head. By observing the overall cropping pattern of Rajasthan in 2014-15, it is concluded that food crops and fodder crops occupy the major part of the study region and are cultivated on commercial scale.

### Overall Cropping patterns: 2014-15

Table. 1

Crops	Percent of T.C.A
<b>Oilseeds</b>	19.53
<b>Guar</b>	19.00
<b>Bajra</b>	16.35
<b>Pulses</b>	15.01
<b>Wheat</b>	12.54
<b>Spices</b>	3.52
<b>Maize</b>	3.50
<b>Jowar</b>	2.45
<b>Fodder</b>	2.44
<b>Cotton</b>	1.80
<b>Barley</b>	1.08
<b>Rice</b>	0.71
<b>Others</b>	1.85

Source: Agricultural Statistics of Rajasthan

### Spatial Patterns of Oilseeds:

Traditionally, Oilseed crops are the mainstay of agricultural economy of India. It refers to the seeds of different plant species from which valuable oil is obtained. Oil mined from these crops is used as a raw material for manufacturing industries and is also an important part of diet. For this purpose, a wide variety of oilseed crops are grown namely mustard, soybean, sesame, groundnut, linseed, sunflower, etc. which are grown in different agro climatic regions and it is supported by Swain in his study (2013). For instance, rape seed and mustard blossoms healthy on loamy to sandy loam soils whereas, groundnut and sesame thrives well on sandy loam and loamy soils with good drainage. Rajasthan has rich agro-ecologically diversity and as a result ideally suitable for growing all oilseed crops (Jha, et al., 2012). In Rajasthan, oilseeds are grown throughout the year. Such as Soybean and groundnut are the main kharif crops, while, taramira and rapeseed-mustard are significant rabi crops (Kumar & Kumar, 2018).

Oilseeds are very important in the study region during 2014-15. They occupy 19.53 per cent area of the total cropped area and hold first rank in the cropping pattern of Rajasthan. Oilseeds are grown almost in all districts of the state but are noted highest of 53.66 per cent in S. Madhopur district and lowest of 3.48 per cent in Barmer district. Fig. 2 is prepared for showing their spatial distribution and it portrays following three categories;

#### Areas of high per cent share of oilseeds cultivation (> 20 per cent);

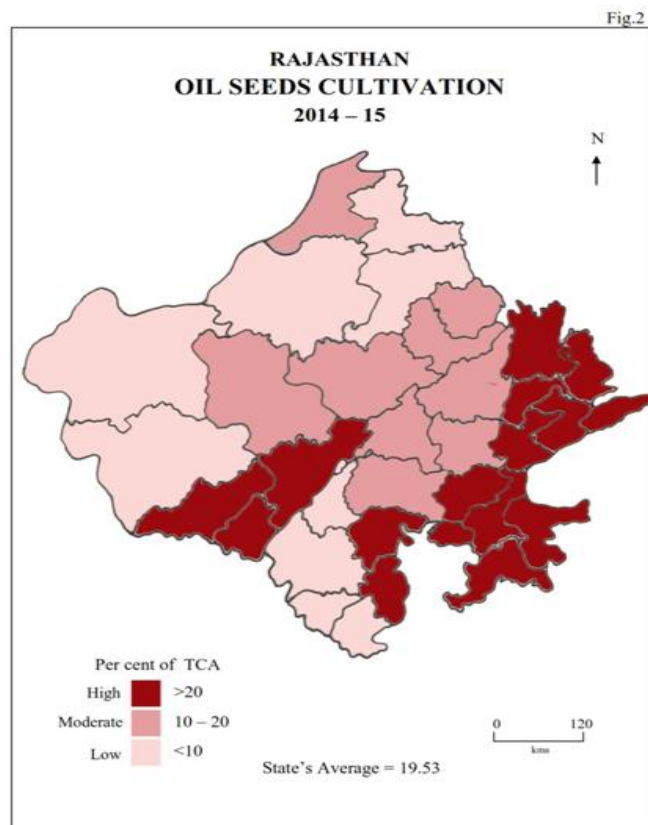
It covers 16 districts which comprises of 48.48 per cent of the total occurrences. It has two belts and first belt constitutes the eastern parts including the districts of Alwar, Bharatpur, Dausa, Karauli, S. Madhopur, Dhaulpur, Kota, Bundi, Jhalawar, Baran and Tonk. Here the per cent share of oilseeds cultivation varies between 53.66 per cent in S. Madhopur district to 22.77 per cent in Jalore district.

Reasons responsible for high share of cultivation are alluvial soils with mixture of stones because these areas fall in eastern Rajasthan plains with Hadoti plateau, moderate to high rainfall, moderate to high extent of irrigation, etc. Here, farmers prefer to grow oilseeds on low land areas and wheat on highlands, as a result, this belt has high concentration of both wheat and oilseeds cultivation in rabi season. Second belt is having the districts of Jalore, Pali and Sirohi owing to favourable geo-climatic conditions for oilseeds cultivation especially during rabi season.

#### Areas of medium share of oilseeds cultivation (10-20 per cent);

Eight districts form this category and constitute 24.24 per cent of the total occurrences. It is well scattered in central parts of the study region including one small patch of northern Rajasthan. It covers the districts of Ganganagar, Sikar, Jhunjhunu, Dausa, Jaipur, Bhilwara, Nagaur, Jodhpur and Ajmer. Except Ganganagar district, rest of the districts are having very low extent of irrigation, inadequate rainfall and sandy to

sandy loam soils, existence of Aravallis, and predominance of wheat, etc. which lead to moderate share of oilseeds crops. In district of Ganganagar, farmers prefer to grow more assured crops such as wheat and pulses which fetch assured and higher economic returns as compare to oilseeds, which resulted into moderate share of oilseeds.



Source: Agricultural Statistics of Rajasthan

#### Areas of low share of oilseeds cultivation (< 10 per cent);

This category of low share comprises two belts, lying in the north-western and southern parts of Rajasthan. First belt covers five districts namely; Barmer, Jaisalmer, Bikaner, Churu and Hanumangarh. These districts lay mostly west of the Aravallis, forming part of the Thar desert. Here, high temperature, low and scanty rainfall, coarse sandy to sandy loam soils, frequent occurrences of sand dunes, low extent of irrigation, predominance of drought prone crops, etc. are mainly responsible for low share of oilseeds cultivation. Second belt of this category includes four districts of Rajasmand, Udaipur, Dungarpur and Banswara. Here, owing to favourable geo-climatic conditions supplemented with developed irrigation and agricultural infrastructure, farmers prefer to grow crops of high and assured economic returns such as wheat during winters and maize & rice during summers in place of oilseeds. Hence, low share of oilseeds is noted.

#### Spatial Patterns of Guar:

It is a leguminous crop and also called cluster bean due to the arrangement of pods in clusters. It is a native crop of Indian Subcontinent and primarily cultivated in warm to hot arid zone of India because of its tolerance to warm and dry climatic conditions (Yadav & Shalendra, 2014). The ideal temperature for guar crop ranges between 30°C to 38°C though can survive even up to 45°C temperature and blossoms well on light textured sandy to sandy loam soils with 20 to 40 cm average annual rainfall. Sharma, et.al (2014) also mentioned that due to its significant qualities such as potentiality to survive in dry & warm climatic conditions, low input requirements, soil building properties, various industrial applications, etc. thus, these qualities helped it to gain a significant position in the cropping patterns of arid and semi-arid regions.

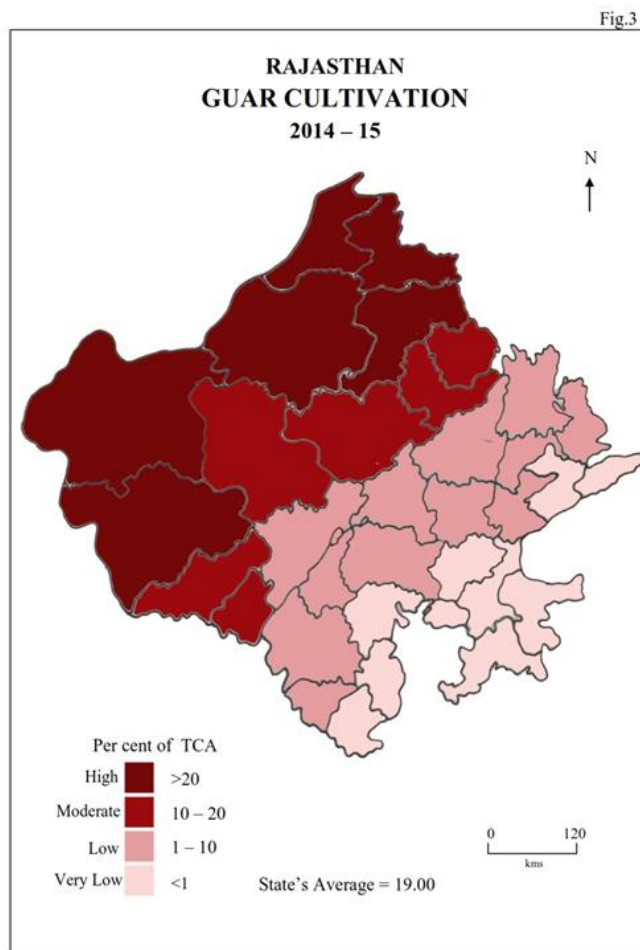
**Cropping patterns of Rajasthan: 2014-15**

**Table no. 2**

Districts	Jowar	Bajra	Maize	Wheat	Pulses	Spices	Oilseeds	fodders	Guar	Others
Ajmer	20.88	9.89	4.60	7.93	29.49	1.52	9.60	3.98	3.49	8.62
Jaipur	3.54	28.48	0.21	14.58	18.81	0.39	15.56	3.51	6.09	8.83
Dausa	1.30	35.99	0.11	25.78	4.30	0.11	23.01	3.27	3.90	2.23
Tonk	9	6.78	1.52	10.31	18.02	0.56	47.57	2.97	1.43	1.84
Sikar	0	39.03	0	13.57	12.74	1.47	11.29	0.25	15.04	6.61
Jhunjhunu	0	34.14	0	13.06	17.26	1.24	11.94	2.08	17.82	2.46
Nagaur	4.21	24.30	0	4.37	31.29	4.23	10.01	1.44	13.12	7.03
Alwar	3.09	28.89	0.49	24.50	1.59	0.09	27.56	2.71	5.96	5.12
Bharatpur	4.99	18	0	26.73	0.95	0.02	34.65	4.60	5.88	4.06
Dhaulpur	0.08	33.53	0	26.06	0.89	0.04	27.32	7.27	0.78	4.03
S.Madhopur	0.13	15	0.11	18.81	4.60	0.98	53.66	3.46	1.98	1.27
Karauli	0.08	38.38	0.02	25.60	3.22	0.03	30.90	0.09	0.70	0.98
Bikaner	0.01	4.85	0	5.82	21.63	1.42	9.95	1.38	53.26	1.68
Churru	0	20.46	0	2.20	36.99	0.99	5.87	0.38	32.14	0.97
Jaisalmer	0.25	8.78	0	1.27	14.40	3.55	7.56	1.89	59.73	2.57
Ganganagar	0	0.16	0	20.41	7.04	0.40	17.06	2.82	41.52	10.59
Hanumangarh	0	2.52	0	19.51	9.42	0.04	9.10	2.44	42.35	14.62
Jodhpur	3.39	26.80	0	4.16	15.33	9.58	18.31	1.89	15.86	4.68
Barmer	0.28	44.19	0	0.78	14.64	6.96	3.58	3.39	23.68	2.50
Jalore	0.73	33.81	0	4.11	13.04	10.20	22.77	2.43	10.74	2.17
Pali	13.76	7.55	1.90	7.09	23.04	3.01	26.52	4.18	8.23	4.62
Sikar	1.50	5.40	10.62	15.04	4.38	3.44	43.02	3.65	10.66	2.29
Kota	0.36	0.01	1.02	26.33	2.86	13.94	49.55	2.40	0.10	4.03
Baran	0.03	0.15	1.26	26.33	2.89	11.31	51.66	4.04	0.05	2.28
Bundi	0.02	0.30	6.54	32.46	13.99	1.02	34.09	3.82	0.32	8.01
Jhalawar	0.15	0	4.65	16.62	5.98	17.22	49.42	2.93	0.02	3.01
Banswara	0.08	0.02	35.79	24.30	8.62	0.10	9.98	8.29	0.06	12.76
Dungarpur	0.19	0.02	36.13	23.28	14.32	0.21	9.60	3.73	1.06	11.46
Udaipur	2.23	0.01	51.20	21.33	6.45	0.29	7.43	1.53	4.08	5.45
Partapgarh	0.01	0	15.34	17.59	9.99	4.37	43.09	4.38	0.03	2.81
Bhilwara	5.64	0.33	24.42	18.28	17.54	0.70	12.42	3.25	6.12	11.30
Chittaurgarh	1.98	0	19.16	23.77	2.29	4.26	32.83	5.77	0.32	8.12
Rajasmand	5.79	0.23	45.76	22.60	2.50	1.23	5.28	3.43	3.39	9.79
Rajasthan	2.44	16.35	3.50	12.54	15.01	3.52	19.53	2.44	19	4.96

Source: Agricultural Statistics of Rajasthan

Basically it is a kharif crop which is sown with the onset of monsoons in June/July months and harvested in October/November months. In Rajasthan guar is a significant crop in the arid and semi-arid parts, because of its potentiality to survive in such geo climatic conditions. Guar is widely spread in the study region with heterogeneous spatial pattern, covering 19.00 per cent area of the total cropped area. Its concentration is recorded lowest of 0.02 in Jhalawar district while



Source: Agricultural Statistics of Rajasthan

highest of 59.73 per cent in Jaisalmer district. To know the responsible reasons for its spatial pattern fig. 3 is mapped which depicts following four categories;

**Areas of high concentration (> 20 per cent):**

This category has one belt covering the extreme north-western part of Rajasthan and comprises 18.18 per cent of the total occurrences. There are 6 districts in this belt namely; Barmer, Jaisalmer, Bikaner, Ganganagar, Churu and Hanumangarh which mainly belong to arid climatic region. Here high temperature, low rainfall, moderate to low irrigational facilities, moderate to low developed agricultural infrastructure, etc. make it difficult to grow water intensive and semi-arid crops. Thus, farmers prefer to grow drought resistant and assured crops such as bajra and guar, but guar occupies high per cent share as compared to bajra because of its higher economic returns and consequently share of guar has more than 20 per cent.

**Areas of moderate concentration (10-20 per cent):**

It comprises one continuous belt and one small patch. This category lies between high and low categories of guar cultivation and has 6 districts namely; Sirohi, Pali, Jodhpur, Nagaur, Sikar and Jhunjhunu. Here, bajra and kharif oilseeds are grown as major crops, occupying more than 20 per cent area under their cultivation. Whereas guar has 10 to 20 per cent area under its cultivation and cultivated as secondary crop. Hence, moderate share of guar is noted.

**Areas of low concentration (1-10 per cent):**

12 districts out of 33 fall in this category which is found in a one uninterrupted belt and these districts are Dungarpur, Udaipur, Rajasmand, Pali, Ajmer, Bhilwara, Jaipur, Alwar, Dausa, Bharatpur, Tonk and S.Madhopur. This belt covers mainly the areas of comfortable temperature due to existence of Aravallis, high rainfall supplemented by high extent of irrigation and developed agricultural infrastructure. Here, owing to these above mentioned factors, farmers prefer to grow crops with high monetary and marketing value such as rice (on low lands) and maize (on high lands) especially in districts of Aravalli zone. While in remaining districts of this belt, farmers give more importance to cultivation of kharif oilseeds and bajra and consequently low concentration of guar crop is found.

**Very low concentration of guar crop (< 1 per cent):**

Remaining 9 districts covering the extreme south-eastern part of Rajasthan with some exceptions are included in this category. These districts are Banswara, Partapgarh, Chittaurgarh, Jhalawar, Kota, Baran, Bundi, Karauli and Dhaulpur which encompasses 27.27 per cent of the total occurrences. Owing to high temperature, high rainfall with high extent of irrigation and predominance of maize and kharif oil seeds, concentration of guar crop is noticed very low i.e. less than 1 per cent.

**Spatial Patterns of Bajra:**

Bajra is widely recognized as Pearl millet which belongs to *Gramineae* family and was originated in Africa. Later on about 4000 years ago, it was introduced in India. It is coarse grain crop, referred as inferior staple nourishment of economically poor people (Sharma & Pagaria, 2020). Bajra is prime source of food in arid and semi-arid regions and is not only used for humans, but an important source of fodder and forage for livestock. It is a Kharif crop which is generally seeded between May and September and reaped between October and February/March. It is further supplemented by Singh & Joshi, (1988) that onset of monsoon is the best time for its seeding. In dry regions lack of required moisture on seeding time becomes the restrictive factor for growing of a bumper crop. Bajra can bear drought to a greater extent, because of its forbearance to challenging growing conditions (Shah, et al, 2020). It also has an exceptional photosynthetic mechanism ensuring efficient transfer of energy from leaves to grains. Bajra crop has a potentiality to survive with 20-75 cm annual rainfall. The best temperature range for bajra crop is 20° c to 30° c and develops well in areas with high diurnal temperature range. It can be grown in variety of soils including light sandy soils, black, red soils, etc. (kumar, 2014). This crop cannot survive in water logging and acidic soils. In Rajasthan bajra is particular predominant cereal crop in arid and semi-arid regions of Rajasthan.

Area under bajra cultivation is 16.35 per cent of the total cropped area in 2014-15. This average figure of 16.35 per cent is not homogeneously distributed throughout the study region, it is noted lowest of 0.001 per cent in Partapgarh district and highest of 44.19 per cent in Barmer district. Figure. 4 is mapped to explain spatial variations in bajra cultivation and it portrays three categories which are discussed below;

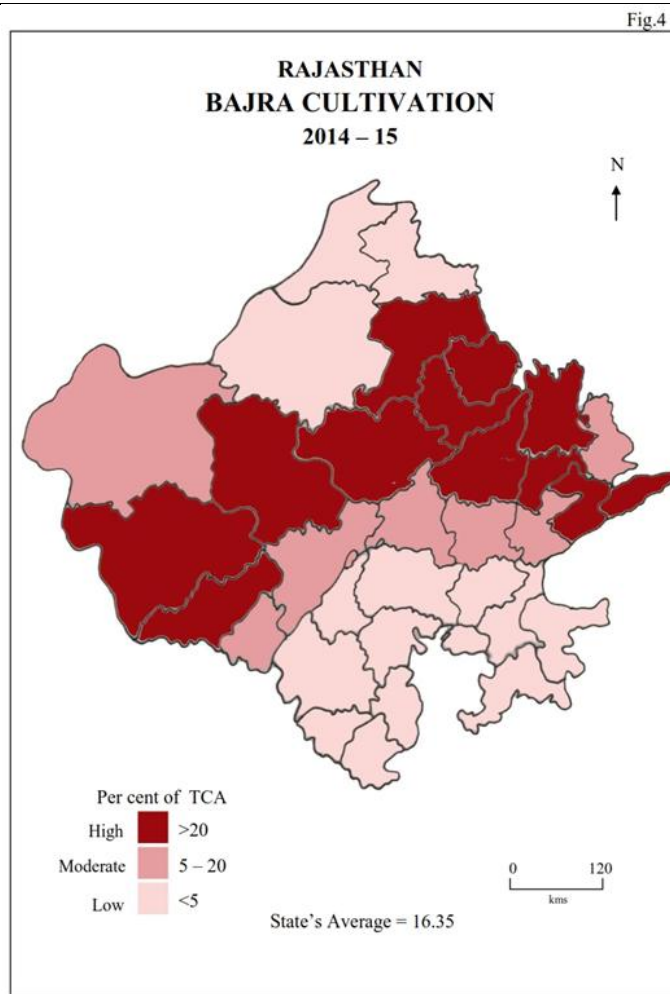
**Areas of high per cent share of bajra cultivation (> 20 per cent);**

Twelve districts form this category with 36.36 per cent of the total occurrences of Rajasthan. It has one continuous belt which runs from south-west to north-east comprising the districts of Jalore, Barmer, Jodhpur, Nagaur, Sikar, Churru, Jhunjhunu, Jaipur, Alwar, Dausa, Dhaulpur and Karauli. Due to arid to semi-arid climatic conditions, coarse sandy and sandy loam soils, low to moderate extent of irrigation, etc. farmers prefer to grow bajra crop. Moreover, these adverse climatic conditions do not allow the farmers to sow either rice or maize crop in kharif season which is also another reason for its high share in the cropping pattern.

**Areas of moderate per cent share of bajra cultivation (5 to 20 per cent);**

This category comprises one linear belt and two small patches. First belt includes five districts namely Sirohi, Pali, Ajmer, Tonk and S.Madhopur. Low to moderate rainfall, sandy loam soils with moderately developed irrigational facilities, presence of Aravallis, predominance of oilseeds, pulses and spices, etc. become responsible for moderate per cent share of bajra cultivation. In the case of Bharatpur district, farmers prefer to cultivate more area under oilseeds and pulses because of favourable geo-climatic conditions for these crops also. Whereas with respect of the remaining patch of this category i.e. Jaisalmer district scenario is opposite. Here, owing to arid climatic conditions with less developed irrigational facilities farmers prefer to grow guar in more area than bajra because of higher economic return from the farmer which leads to moderate share of bajra crop.





Source: Agricultural Statistics of Rajasthan

**Areas of low per cent share of bajra cultivation (< 5 per cent);**

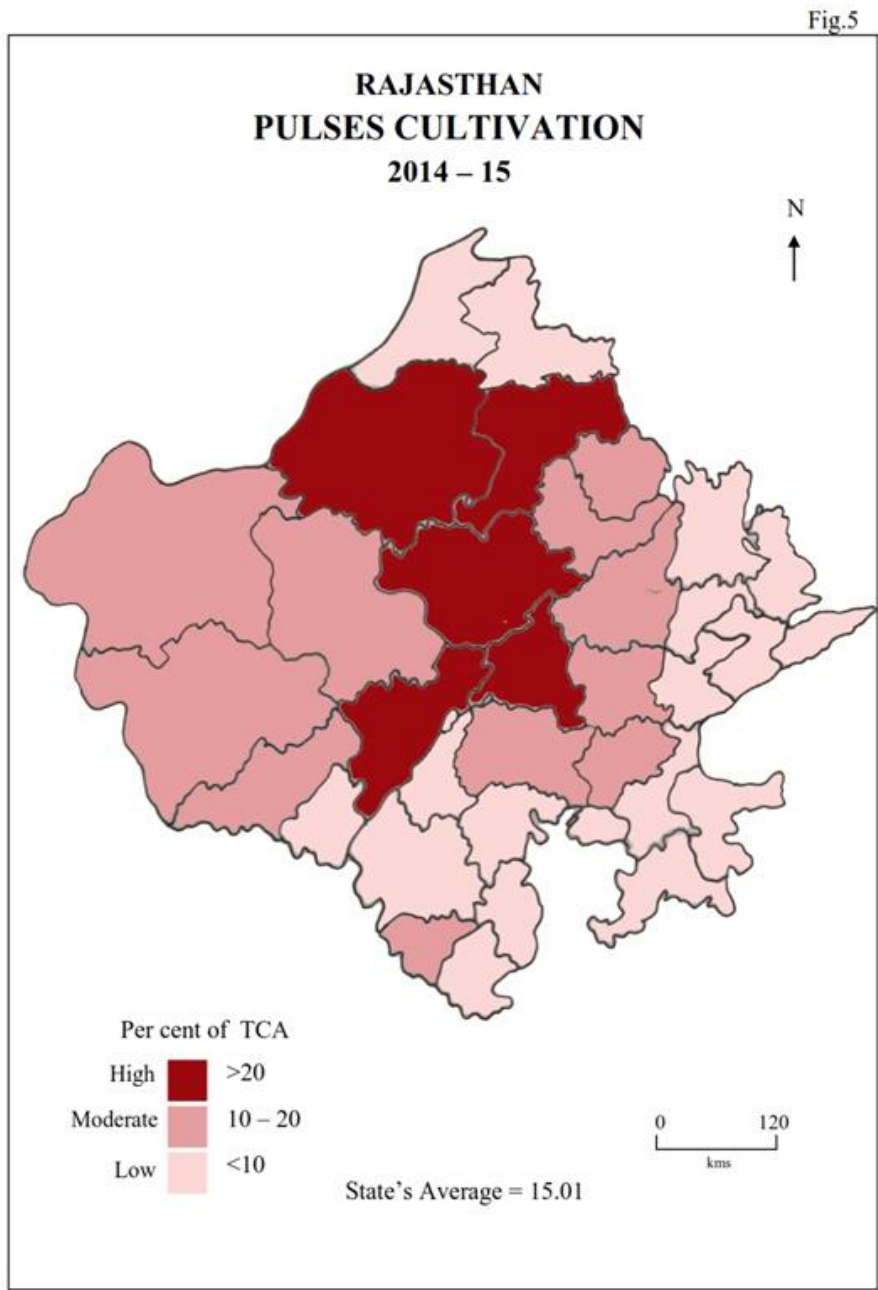
It has two belts accounting 42.42 per cent of the total occurrences. Firstbelt includes 11 districts namely; Rajasmand, Udaipur, Bhilwara, Bundi, Kota, Baran, Jhalawar, Dungarpur, Banswara, Baran and Chittaurgarh. Here per cent share of bajra cultivation is less than 5 per cent because of high rainfall. Owing to favourable climatic conditions for crops such as maize, rice, etc. which have high monetary value as compare to bajra also, farmers prefer to go with these crops in place of bajra. As a result, area under bajra cultivation is noted low in these districts. While, remaining belt of this category has three districts of Ganganagar, Hanumangarh and Bikaner. Here though geo-climatic conditions are favourable for bajra yet higher economic returns and assured marketing of guaris mainly responsible for low share of bajra cultivation as in case of first belt. Moreover, due to availability of irrigational facilities especially in northern parts of Ganganagar and Hanumangarh, Farmers cultivate cotton which is also responsible for low share of bajra cultivation.

**Spatial Patterns of Pulses:**

Pulses are the prime source of protein in human diet especially for vegetarian people and are also used to feed animals as fodder. Being leguminous crops, increase soil fertility and health by fixing nitrogen into soil. Depending upon physiographic conditions, pulses are grown as solo crop, inter crop and mixed crop in our country (Sharma and Bhushan,2019). Pulses are cultivated in both seasons (Kharif and Rabi). On the basis of sowing time period, all pulses can be grouped into two heads; Kharif pulses and Rabi pulses. Kharif pulses includes Arhar, Urd, Mung bean, Moth, tur, etc. which are sown on the arrival of monsoons from June to July and harvested in the month of October. These crops are cultivated in warm climate and under rainfed conditions mainly in semi-arid areas. While, rabi crops are gram, Chickpea, lentil, Urd, Mung, Rajmah, etc. which are seeded in the months of September to November and reaped in February to march/April. Rabi pulses thrives well in mild cold to warm climate(Singh,et.al,2017). In Rajasthan pulses are cultivated under rainfed conditions due to their capability to withstand abnormal weather conditions. The major pulses crops of Rajasthan are gram,



Moong, Moth, etc. There are 38,43,948 hectares under pulses cultivation which accounted for 15.01 per cent of the total cropped area, but it varies between 0.10 per cent in Banswara district and 36.99 per cent in Churru district. For explaining the distributional pattern of pulses cultivation in Rajasthan fig. 5 is mapped which shows three categories;



Source: Agricultural Statistics of Rajasthan

**Areas of high per cent share under pulses cultivation (> 20 per cent);**

5 out of 33 districts which form a continuous belt come under this category, comprising 15.15 per cent of the total occurrences. These districts are Bikaner, Churru, Nagaur, Pali and Ajmer. Here, major reasons for high share of pulses are very low amount of rainfall, high temperature, sandy soils, low extent of irrigation, etc. Moreover, these are traditionally pulses growing areas and pulses are mainly grown either solo crop or mixed with wheat in rabi season.

**Areas of medium per cent share under pulses cultivation (10 – 20 per cent);**

This category has one elongated belt and two patches encompassing 33.33 per cent of the total occurrences. The belt includes 6 districts namely; Jhunjhunu, Sikar, Jaipur, Tonk, Bundi and Bhilwara. Due to predominance of bajra in kharif season and wheat in rabi season pulses are grown as secondary crops. The patch of western Rajasthan covers four districts of Jaisalmer, Jodhpur, Barmer and Jalor. Here, due to low rainfall pulses are preferred in winter season which require low moisture but major crops of these districts are guar and bajra which are sown during monsoon season because summers receive more rainfall than winters. Thus, the share of rabi crops is comparatively low than summer crops. While in the case of remaining patch of Dungarpur district owing to favourable climatic conditions such as comfortable temperature, high rainfall, fertile soils, moderate extent of irrigation, developed agricultural infrastructure, etc. more concentration of farmers is on maize, rice in kharif season and wheat, barley in rabi season rather than pulses. Hence the share of pulses is noted moderate in this category.

**Areas of low per cent share under pulses cultivation (< 10 per cent);**

17 districts and 51.51 of total occurrences form this category. It is found in three belts and one patch. The first belt confines to eastern parts of the study region including the districts of Alwar, Bharatpur, Dausa, Karauli, S.Madhopur and Dhaulpur. Here, the share of pulses is low because of high rainfall, moderate extent of irrigation, predominance of maize, jowar, bajra in kharif season while wheat and oilseeds in rabi season. The second belt lays in southern parts covering districts of Sirohi, Rajasmand, Chittaurgarh, Udaipur, Partapgarh, Banswara, Kota, Baran and Jhalawar. These receive moderate to high rainfall, moderate to high fertile soils, moderate to high extent of irrigation. Owing to moderate to high rainfall these areas are not suitable for pulses and oilseeds thus, major crops are wheat and maize. Hence, the share of pulses cultivation is low. The third belt comprises extreme northern parts of Rajasthan having the districts of Ganganagar and Hanumangarh. These areas receive moderate rainfall, moderate extent of irrigation here wheat, cotton, guar are the predominant crops thus, farmers do not prefer pulses which resulted into their low share in the cropping pattern.

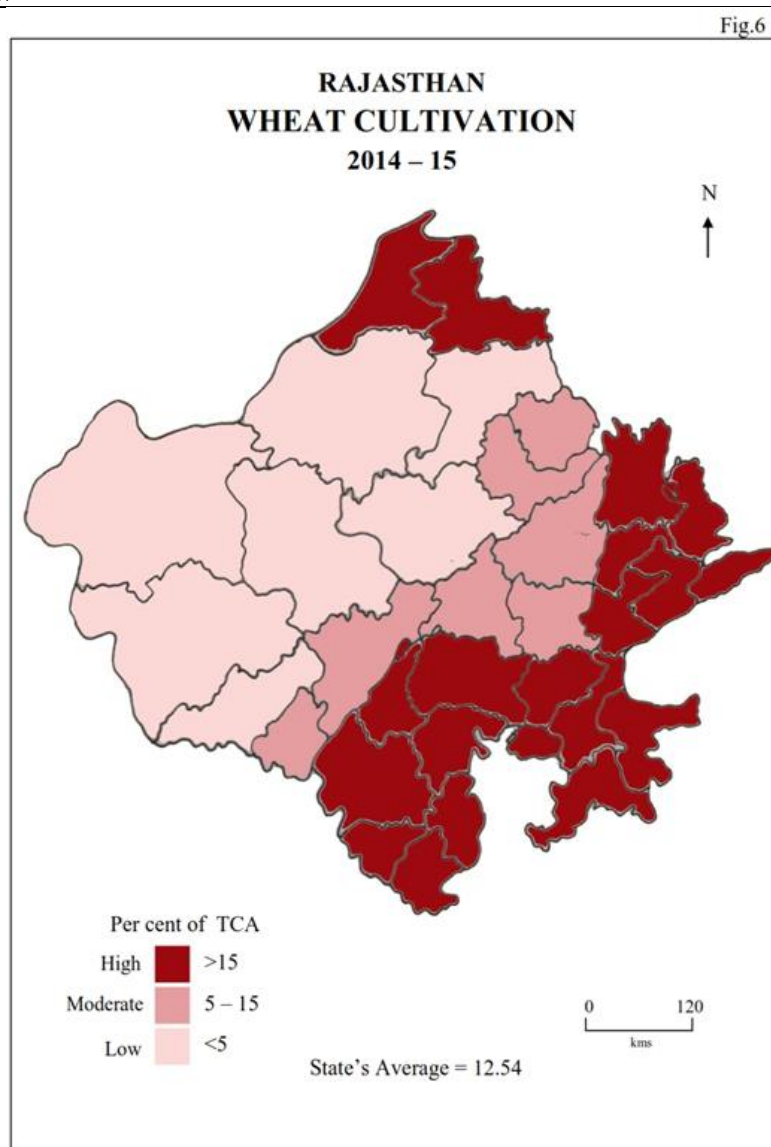
**Spatial Patterns of Wheat:**

Botanically, the most widely grown wheat plant is known as *Triticum Aestivum*. From archaeological records was cultivated in middle east about 10,000 years ago. It is the staple food in most of the countries of the world. From international trade point of view wheat is the leading food grain. But in India it is second most important cereal crop after rice. It is rabi crop in our country which is sown in the commencing of the month of October/November and harvested in the starting of March/April. The sowing and harvesting time varies in different areas because of geo-climatic conditions (Ramadas, et.al, 2018). An ideal temperature for wheat cultivation varies between 21°C to 26°C and it should be low at the seeding time and comparatively high at the reaping time. Wheat requires 50 to 75 cm of annual rainfall, though it can be cultivated in areas with less amount of annual rainfall with proper irrigation. Kumar (2014) augmented that 5 to 7 waterings are essential in areas with low amount of annual rainfall. It can be grown in clayey, loamy sand and sandy loam but it develops well in loamy soil. In Rajasthan, wheat cultivation is mainly restricted to areas with moderate rainfall or developed irrigational facilities.

Wheat has 12.54 per cent of the total cropped area under its cultivation in 2014-15, but it is not uniformly distributed in the study region. It is recorded as high as 34.09 per cent in Bundi district and as low as 0.79 per cent in Barmer district. To know factors responsible for great variations in the wheat cultivation in the study region fig. 6 and table. 2 are prepared which depict the following three categories;

**High category of wheat cultivation (>15 per cent);**

This category comprises 19 districts containing 57.57 per cent of the total occurrences. It has one elongated belt and one patch. The belt has 17 districts namely; Banswara, Dungarpur, Partapgarh, Udaipur, Rajasmand, Bhilwara, Bundi, Kota, Baran, Jhalawar, S.Madhopur, Karauli, Dausa, Dhaulpur, Bharatpur and Alwar. These districts are traditionally wheat growing areas, owing to ideal physio-socio-economic conditions such as relatively cool to warm temperature, moderate to high rainfall, moderate to high extent of irrigation, developing agricultural infrastructure, etc. While in northern patch of study region which has only two districts namely; Ganganagar and Hanumangarh, the reasons for high share of wheat cultivation are sandy to sandy loam soils, levelled sand dunes, moderate extent of irrigation, mechanised farming, large size of landholding, comparatively developed agricultural infrastructure, awareness among farmers, etc. all these factors have resulted into high share of wheat cultivation in this patch.



Source: Agricultural Statistics of Rajasthan

**Moderate category of wheat cultivation (5-15 per cent);**

Seven districts form this category with 21.21 of the total occurrences. This category has one linear belt lying in north - east to south – west direction and the districts included in this belt are Jhunjhunu, Sikar, Jaipur, Tonk, Ajmer, Pali and Sirohi. All these districts receive moderate rainfall varying between 40 to 60 cm, moderate extent of irrigation, loamy to sandy loam soils, occurrences of Aravallis, moderately developed infrastructure etc., which lead to moderate share of wheat cultivation.

**Low share of wheat cultivation (< 5 per cent);**

Remaining seven districts forming a compact belt with 21.21 per cent of the total occurrences fall in this category. Specifically, these districts are lying west of Aravallis, having semi- arid to arid climatic conditions, frequent occurrences of sand dunes, coarse sandy to fine sandy soils with low fertility, low extent of irrigation, low rainfall, traditionally bajra, guar, pulses and fodder growing predominant areas etc. which results into low proportion of wheat cultivation. These districts are Jaisalmer, Barmer, Jodhpur, Nagaur, Bikaner, Churu and Jalor.

**Spatial Patterns of Spices:**

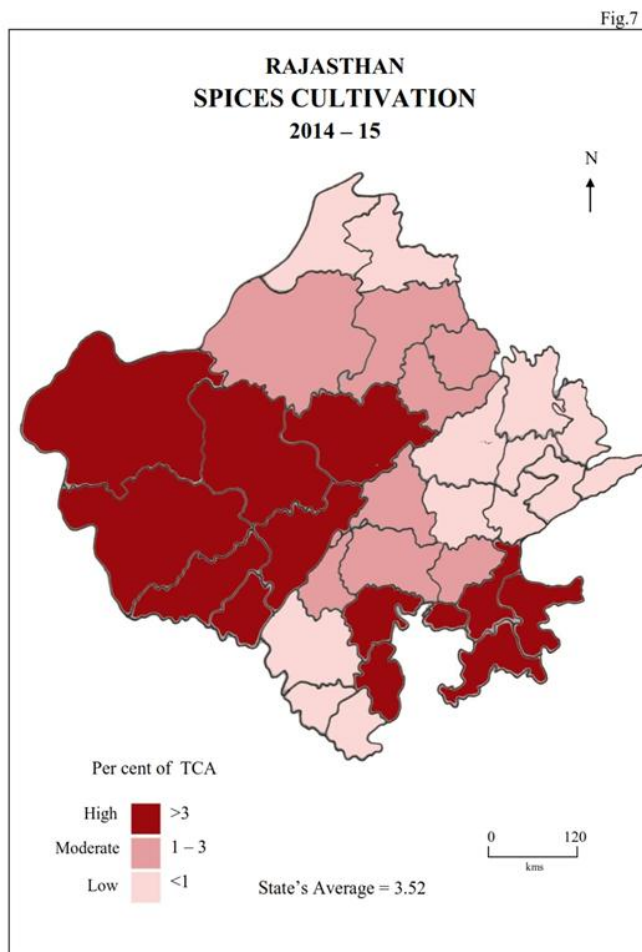
Annual herbs whose seeds and fruits are used in dried form referred as spices. Spices are the major part of Indian cuisine. In India flowers, fruits, leaves, roots, seeds of various plants are used as spices. For this

purpose, a large variety of spices are grown in India and it is also known as “Land of Spices” (Sachan,et.al.,2020). Basically, there are 63 varieties of pulses are grown which includes pepper, cardamom, chillies, cumin, fennel, fenugreek, etc. Spices are mainly cultivated in arid & semi-arid zone of India and mainly includes the states of Rajasthan and Gujarat. These are also referred as ‘Seed spices bowl’. In Rajasthan, these are grown under rain fed conditions. Spices require low amount of water and earns good profit. Hence in arid and semi-arid zone of Rajasthan spices are grown as compare to food crops.

Spices comprise of 3.52 per cent of the total cropped area of Rajasthan in 2014-15. It is recorded lowest of 0.10 per cent in Banswara district and highest of 17.22 per cent in Jhalawar district. To identify factors responsible for its heterogeneous spatial distribution, help is taken from fig. 7 which depicts following three categories;

**High category of spices cultivation (> 3 per cent):**

There are two belts in this category. First belt occupies extreme western parts of Rajasthan including districts of Jaisalmer, Barmer, Jodhpur, Jalore, Pali, Nagaur and Sirohi. Here, high temperature, low rainfall, coarse sandy to sandy soils, frequent occurrences of sand dunes, inadequate irrigational facilities, etc. enthruse the farmers to grow spices which are suitable for these adverse climatic conditions such as chillies, cumin, fenugreek, etc. Whereas second belt covers the extreme southern parts comprising the districts of Chittaurgarh, Kota, Jhalawar, Baran and Partapgarh. Owing to relatively high amount of rainfall, fertile soils, high extent of irrigation and traditionally spices growing areas, etc. lead to high proportion of the total cropped area under spices. Here, mainly garlic, ajwain, ginger, coriander, etc. are grown on commercial scale.



Source: Agricultural Statistics of Rajasthan

**Moderate category of spices cultivation (1-3 per cent):**

This category includes 8 districts namely; Bikaner, Churu, Jhunjhunu, Sikar, Ajmer, Bhilwara, Rajasmand and Bundi. These are also traditionally spices growing areas but owing to high share under bajra and fodder crops, the share of spices is noted moderate and their share varies between 1to 3 per cent.

**Low category of spices cultivation (< 1 per cent):**

Remaining 13 districts fall in low category, containing 39.39 per cent of the total occurrences. These districts are Ganganagar, Hanumangarh, Alwar, Dausa, Jaipur, Bharatpur, Tonk, Dhauipur, S.Madhopur, Karauli, Dungarpur, Banswara and Udaipur. In districts of Ganganagar and Hanumangarh due to predominance of guar, wheat, cotton, etc., area under spices is negligible. In rest of the districts of this category, the share of spices is low because of ideal geo-climatic conditions supplemented by irrigational and marketing facilities for maize, rice and oilseeds, the farmers give less preference to the cultivation of spices. As a result, significant area is given to maize, rice, oilseeds, etc. which leads to insignificant share of spices.

### **Spatial Patterns of Maize:**

Maize is third most important cereal crop in the world after wheat and rice. Firstly, it was domesticated in Latin America but later on in Indian cropping pattern it was introduced by Portuguese in 17<sup>th</sup> century. Basically, it is of two types; yellow maize and white maize. Traditionally, Yellow maize is used as a fodder crop for animals while white maize as a food crop for human consumption, even it is used as a raw material in food processing industries. Due to its predominant position it is referred as “queen of cereals” (Pillai, 2014). Maize is considered as most versatile crop because of its great potentiality to adapt climate change. Kumar et.al, (2013) described in their report that due to its versatile characteristics it is famous crop all over the world and is cultivated in tropical, sub-tropical and temperate regions. Gao, et.al, (2021) also mentioned that maize can be cultivated in all types of soils and agro-climatic conditions. It blossoms well in temperature ranging between 20° c and 27° c, moisture requirement from 50 to 100 cms, water should not stand in the field, soil with pH value between 7.5 to 8.5, etc. and generally 5 to 6 watering in low to moderate precipitation areas.

Maize occupies 3.50 per cent of the total cropped area in 2014-15 but varies greatly with highest per cent of 51.20 in Udaipur district and negligible in north- western parts of Rajasthan. Fig. 8 is mapped to show the spatial patterns of maize cultivation. It portrays three categories which are discussed below;

### **Areas of high per cent share under Maize cultivation (>10 per cent);**

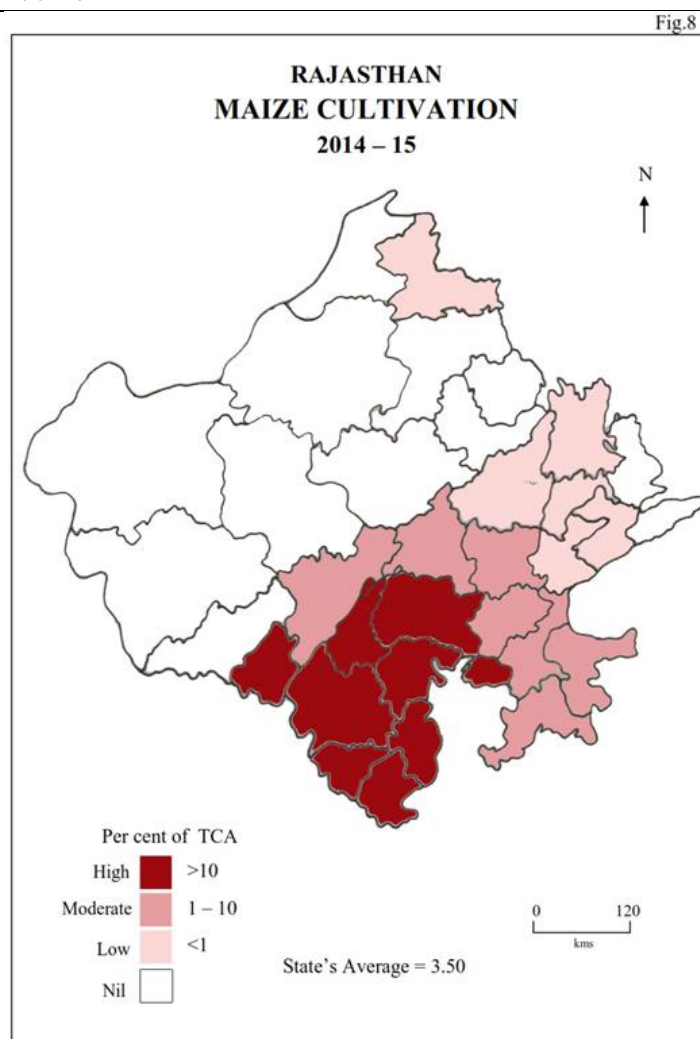
It comprises of 8 districts namely; Partapgarh, Udaipur, Chittaurgarh, Banswara, Dungarpur, Rajasmand, Sirohi and Bhilwara. This belt lies in extreme southern parts of the study region. Here, per cent share of maize cultivation is more than 10 percent. Main reasons for high share of maize cultivation are sandy loam to loamy soils, moderate to high rainfall, gentle gradient of terrain, moderate to high extent of irrigation, developed agricultural infrastructure, etc. which offer ideal conditions for maize. Moreover, farmers grow maize on gentle slopes and rice in flat lands. All this resulted into high per cent share under its cultivation.

### **Areas of Moderate per cent share under maize cultivation (1 - 10 per cent);**

Seven districts form this category which lay between high and low categories of maize cultivation. These districts are Pali, Ajmer, Tonk, Bundi, Baran, Kota and Jhalawar. Here share of maize is between 1-10 per cent. though these are traditionally maize growing areas yet maize is not a major crop because of competition from jowar, oilseeds and spices. The above mentioned factors are responsible for medium proportion of area under maize cultivation.

### **Areas of low per cent share under maize cultivation (< 1 per cent);**

Remaining 5 districts which account for 15.15 per cent of the total occurrences fall in low category. These districts are Jaipur, Alwar, Dausa, Karauli and S. Madhopur. In these districts area under maize cultivation is below 1 per cent of the total cropped area. These districts are largely confined to eastern Rajasthan. Here farmers prefer pulses, bajra and oilseeds cultivation owing to favourable geo-climatic conditions and as a result, area under its cultivation is noted low.



Source: Agricultural Statistics of Rajasthan

**Areas of no maize cultivation:**

Remaining 12 districts with 36.36 of the total occurrences. This category is large in respect of number of districts as well as in area. The districts fall in this category are Bikaner, Ganganagar, Jaisalmer, Jodhpur, Barmer, Jalor, Nagaur, Sikar, Jhunjhunu, Bharatpur and Dhaulpur. Except Bharatpur and Dhaulpur all the districts lie in the north –western parts of Rajasthan. Here owing to adverse climatic conditions with inadequate irrigational facilities maize cultivation is not feasible. Hence, noted no share of maize cultivation.

**Spatial Patterns of jowar:**

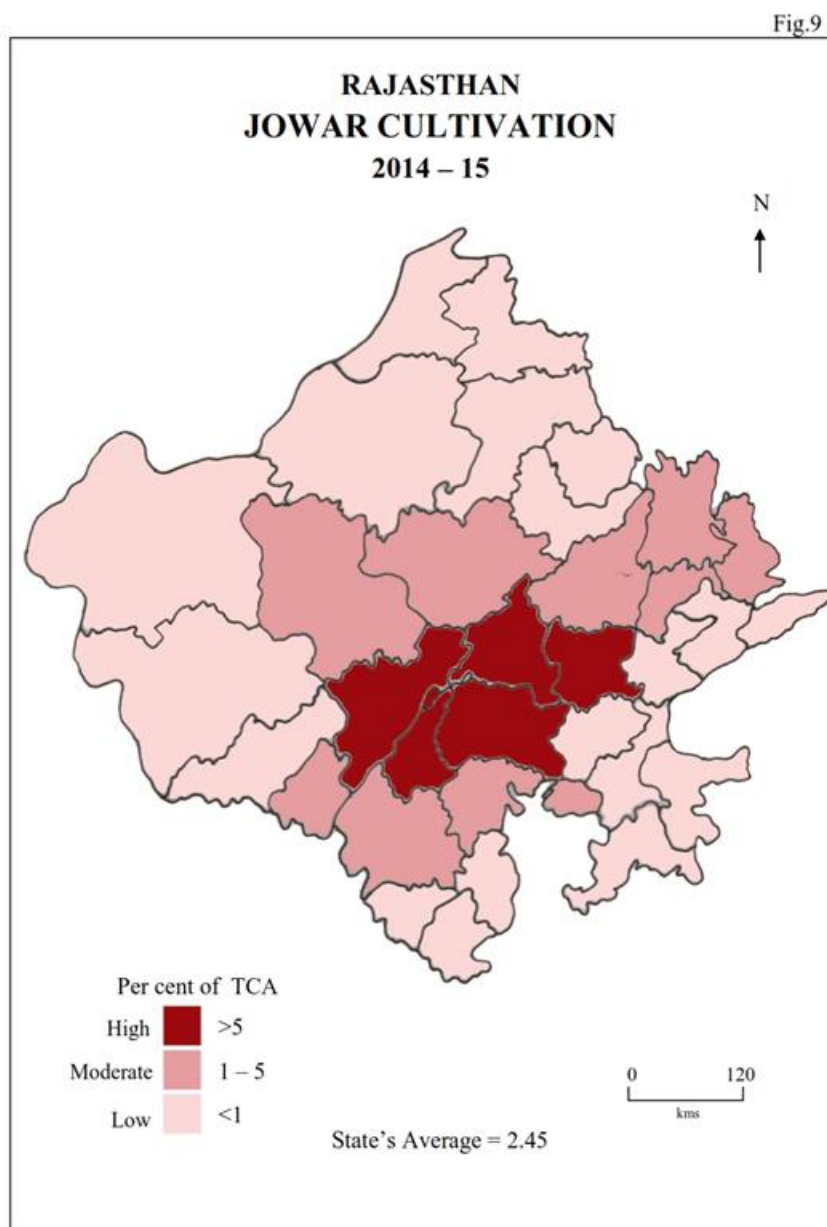
It is major crop of hot semi-arid region which has the potentiality to survive under adverse climatic conditions(Das,2015). It is used as both fodder and feed. Climatic conditions for its successful cultivation are temperature ranging from 15° c to 40° c and annual rainfall between 400 to 1000 mm, though jowar cannot survive under water logging conditions at any stage of growth. It can grow in variety of soils, but clayey loam is ideal soil for its cultivation and is grown throughout the year. In Rajasthan, it is a kharif season crop and sown during June to July.

During 2014-15 in Rajasthan, jowar has 2.44 per cent of the total cropped area under its cultivation. Its cultivation is highest of 20.88 per cent in Ajmer district while it is negligible particularly in north -western parts of the study region. Fig. 9 and table 1 yield three categories which are as follow;

**High category of jowar crop (> 5 per cent):**

It covers central parts of the study region comprising 5 districts namely; Pali, Ajmer, Tonk, Bhilwara and Rajasmand. Here share of jowar crop is over 5 per cent.





Source: Agricultural Statistics of Rajasthan

The responsible reasons for high per cent share of its cultivation are moderate to high rainfall, existence of Aravallis, moderately developed agricultural infrastructure, etc. which offer ideal growing conditions for its cultivation as compare to bajra and maize. Thus, farmers prefer to grow jowar as a main crop which leads to high per cent share of area under its cultivation.

**Moderate category of jowar crop (1-5 per cent):**

It has 9 districts which are dispersed into two belts and these surround the high category on two sides. Basically, high category separates moderate category into two belts: one towards north and second towards the south. The northern belt comprises districts of Jodhpur, Nagaur, Jaipur, Alwar, Bharatpur and Dausa. In this belt, the proportion of jowar decreases with decrease in rainfall, because as rainfall decreases area under bajra and guar cultivation starts increasing. The southern belt includes districts of Udaipur, Chittaurgarh and Sirohi. Here owing to high rainfall, irrigational facilities, etc. the proportion of maize and rice is high because these crops require more moisture than jowar, i.e. why the jowar cultivation captures moderate proportion. Hence, because of these different factors in these two belts have led to moderate share of jowar cultivation.



**Low category of Jowar crop (< 1 per cent):**

Remaining 19 districts are included in this category which cover the north-western, eastern and extreme southern parts of Rajasthan. There are three belts of low category. First belt has districts of Ganganagar, Hanumangarh, Bikaner, Churu, Jhunjhunu, Sikar, Jaisalmer, Barmer and Jalor. These districts belong to arid zone of Rajasthan and here bajra and guar crops are so successful because of their less water requirements than jowar, thus farmers do not prefer jowar but bring more area under guar and bajra which resulted into low share of jowar. Second belt has districts of Bundi, Jhalawar, Kota, S.Madhopur, Karauli, Dhaulpur and Baran. Owing to high rainfall complemented with developed agricultural infrastructure and irrigational facilities maize and oilseeds are the major crops of this belt. Because jowar needs comparatively less rainfall than maize, thus it cannot be grown as successfully as maize in kharif season and it resulted into its negligible share in the cropping pattern. While in case of third belt which covers three districts namely; Dungarpur, Partapgarh and Banswara, responsible reasons for low share of jowar are predominance of rice and maize crop due to high rainfall and high extent of irrigation. Therefore, farmers in this belt prefer to grow more profitable and suitable crops like maize and rice rather than jowar, hence, area under its cultivation is noted low.

**Fodder crops:**

Fodder crops are crops that are mainly grown to feed the animals. These include a large number of crops such as bajra, sorghum, maize, cowpea, guar, barley, etc. There are some of the fodder crops which are valued for fodder as well as food and are referred as 'dual purpose crops' (Sharma, 2012). For instance, bajra crop which is grown as a food grain and green fodder. In Rajasthan, fodder crops are cultivated in arid and semi-arid regions of Rajasthan to feed animals.

Area under fodder crops is 2.44 per cent during the present investigation period in Rajasthan, though it is not significant yet widely scattered in the study region with maximum share of 8.29 per cent in Banswara district and lowest share of 0.25 per cent in Sikar district. To do the in-depth study of spatial variations of fodder crops fig. 10 is mapped which is separated into three categories and these are given below;

**Category of high share of fodder crops (> 3 per cent):**

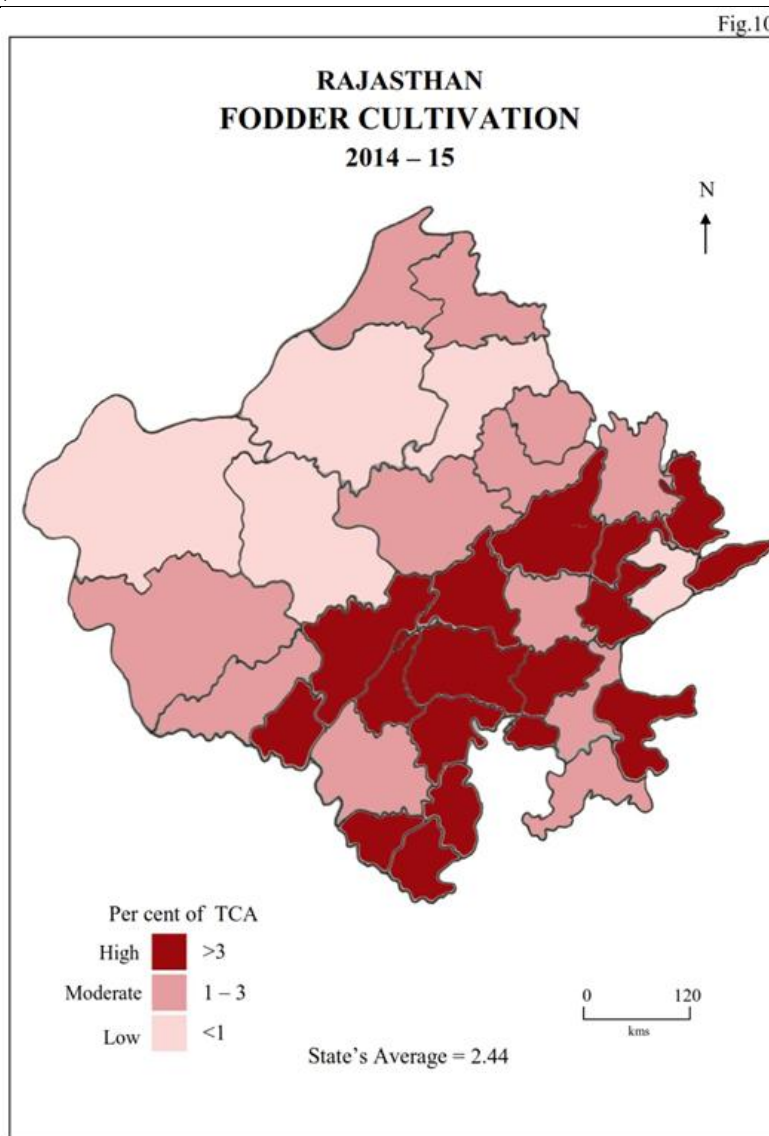
This category comprises of 16 districts namely Sirohi, Pali, Ajmer, Jaipur, Bhilwara, Rajasmand, Chittaurgarh, Partapgarh, Dungarpur, Banswara, Bundi, Baran, Dausa, Bharatpur and Dhaulpur. Here the per cent share of fodder varies from 3.51 in Jaipur to 8.29 per cent in Dhaulpur districts. The reasons for high share of fodder crops are stall feeding of the livestock, more per cent share of cows and buffalos, irrigational facilities, etc.

**Moderate share of fodder crops (1-3 per cent):**

Twelve out of 33 districts form this category. It has two belts and number of patches which are scattered in different parts of study region. First belt covers the districts of Jhunjhunu, Sikar and Nagaur. Here, some farmers grow fodder for stall feeding the animals. The second belt includes the districts of Ganganagar and Hanumangarh which are lying in the extreme northern parts here also stall feeding of animals is prevailing among the farmers where irrigation facilities are available and mostly these are bordering areas with Punjab and Haryana. There are four patches of this category which mostly lying in southern and eastern parts. Districts falling in these patches are Barmer, Jalor, Udaipur, Jhalawar, Baran, Tonk and Alwar.

**Low share of fodder crops (<1 per cent):**

Rest of the 5 districts fall in this category forming one compact belt and one small patch. Districts include in the belts are Jaisalmer, Bikaner, Churu and Jodhpur. Here due to arid climatic conditions cultivation of bajra and guar is feasible because of their tolerance to such adverse climatic conditions. Thus, farmers are using residue of these crops to feed the animals. Moreover, farmers are also economically not much stronger and as a result very less number of farmers grow fodder to feed their livestock and most of the farmers follow the grazing tradition. As a result, low proportion of the total cropped area is noted under fodder cultivation. The patch of this category which contains Karauli district is in extreme parts of the study region here only 0.09 per cent area is under its cultivation.



Source: Agricultural Statistics of Rajasthan

#### **Other crops:**

Crops involved under head of other crops are cotton, rice, barley, fruits, vegetables, sugarcane, sanhemp, mesta, tobacco, etc., and these combinedly cover the 5.57 per cent of the total cropped area in Rajasthan during 2014-15. These crops occupy very insignificant area under their cultivation, individually and are mainly grown for domestic purposes in whole Rajasthan with some exceptions. Among other crops, cotton being an insignificant crop of Rajasthan covering only 1.80 per cent area of its cultivation in 2014-15. The distributional patterns of it is highly variable because it varies from lowest of 0.0002 per cent in Dhaulpur district and highest of 11.46 per cent in Hanumangarh district. Next crop is barley, state average of barley cultivation is 1.08 per cent which shows it is minor crop of the study region. Rice is also holding an insignificant position in Rajasthan with exception of some extreme southern districts. It is negligible in north western Rajasthan where it occupies as high as 9.40 in Dungarpur district in southern Rajasthan. Under the other crops head the next are fruits & vegetables, which combinedly cover 0.77 per cent of the gross cropped area including the mango, oranges, melon, musk melon and tomatoes, potatoes, etc. Sugarcane comprises of only 0.05 per cent area of the total cropped area under its cultivation and is mainly concentrated in extreme southern parts of Rajasthan. It is grown as a minor crop in these districts. Remaining crops such as tobacco, sanhemp, mesta, etc. also have an insignificant area under their cultivation. Thus, the cultivation of other crops is done on small scale but is of local/ regional significance. Farmers grow these crops on small patches in their land holdings for their domestic consumption.

### **Conclusions:**

The study has deduced from the above discussion that Rajasthan has diversified cropping pattern owing to contrasts in physical environment and much proportion of the total cropped area in overall cropping pattern under rain fed crops. Fig. 1 reflects that oilseeds, guar, bajra, pulses, fodder crops, etc. are the main kharif crops and wheat is the main rabi crop of existing cropping pattern of the study region in 2014-15. Oilseeds are the first ranking crops of Rajasthan and mainly concentrated in eastern parts of the study region with over 20 per cent share in the cropping pattern. Their per cent share generally decrease from east to west with certain exceptions largely because of the geo-climatic conditions. Guar and Bajra are also the prominent crops occupying 19.00 per cent and 16.35 per cent, respectively. Spatial patterns of guar and bajra negatively correlated with patterns of rainfall and development of irrigation. Areas with deficient rainfall and less developed irrigational facilities, especially north-western parts have high proportion of area under guar and bajra. While rest of the state has moderate to less proportion of area under guar and bajra cultivation. The extreme northern and south-eastern parts with exception of Dungarpur district have low per cent share under pulses due to predominance of cotton, wheat, bajra and oilseeds, etc. While, remaining Rajasthan has moderate to high per cent share area under pulses cultivation. Areas with high amount of rainfall supplemented by developed agricultural infrastructure and irrigational facilities have high share of wheat cultivation. Whereas areas with inadequate rainfall and less developed irrigational facilities have low share of wheat cultivation. In rest of the districts which are lying between low and high categories, share of wheat cultivation is moderate. Maize cultivation has high per cent share in the cropping pattern in districts mainly confine to the extreme southern parts of the state with relatively high rainfall and developed agricultural infrastructure. While, rest of the districts owing to moderate to low rainfall with moderate to low development of irrigational facilities, etc. have registered moderate to negligible share of maize cultivation. Spices has 3.52 per cent share in the cropping pattern with highest of 17.22 per cent in Jhalawar district and lowest of 0.04 per cent in Dhaulpur district. Spatial patterns of bajra and jowar cultivation have negative relationship among them. In areas of high share of bajra cultivation, share of jowaris low to moderate. While in areas of low share of bajra cultivation, it occupies more area. Though jowar is a crop of dry area yet it requires more rainfall than bajra. Rice, cotton, fruits, vegetables, sugarcane, barley, etc. are the crops which have insignificant share in the cropping pattern and encompassing less than 1 per cent area under their cultivation, individually. These crops are grown mainly for domestic consumption with some exceptions. Thus, it has been concluded that Rajasthan has diversified cropping pattern with variety of crops.

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