Soil Population Density, Kernel Infection and Aflatoxin Contamination in Groundnut - A Survey of North Gujarat

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Abstract— *About 100 groundnut pod and soil samples were collected from different locations of North Gujarat and were tested for soil population of A. flavus, percent seed infection and aflatoxin contamination. The average soil population of A. flavus of Kachchh district (4.93 x 103 cfu g-1soil) was slightly higher than Banaskantha district (4.90 x 103 cfu g-1 soil). Minimum soil population of A. flavus was recorded with the variety J-11 grown as rainfed. Moreover, it was maximum when groundnut crops were grown after groundnut whereas; minimum after pulse crops; and a little difference between the irrigated and the rainfed samples were recorded.*

The average of seed infection was higher in the Banaskantha district than the Kachchh. Maximum seed infection was recorded in the variety GG-20 grown as irrigated; whereas minimum in the variety J-11 cultivated in rainfed. Maximum seed infection was recorded when groundnut was grown as previous crop, while minimum when pulses were grown as previous crops. Irrigated crops showed higher seed infection as compared to the rainfed crops.

None of the samples were found free from aflatoxin, but 51.00 per cent of the samples were within the safe limits. The average of Kachchh district was 14.22 ppb whereas in Banaskantha, it was 15.33 ppb .According to variety, the maximum aflatoxin (21.34 ppb) was recorded in the variety GG-2 cultivated in irrigated condition, while the variety J-11 cultivated in rainfed condition recorded minimum aflatoxin (4.55 ppb). Groundnut cultivated after groundnut recorded maximum, whereas it was minimum when pulses where grown as previous crops.

Keywords— Aflatoxin, Aspergillus flavus, Groundnut, Seed infection, Soil population, Survey Aflatoxin, Aspergillus flavus, Groundnut, Seed infection, Soil population, Survey.

I. INTRODUCTION

Groundnut is grown on a large scale in almost all the tropical and subtropical countries of the world. The most important groundnut growing countries are India, China, Nigeria, Sudan and USA. Globally, it is grown on about 24.7 million hectares with a total production of 33 million tones. India occupies the first place in regard to acreage and second in production. In India, it is grown on about 6.9 million hectares with a total production of 7.3 million tonnes (FAO, 2010). Its cultivation is mostly confined to the states of Gujarat, Andhra Pradesh, Karnataka, Tamilnadu and Maharashtra. The other important states where it is grown are Madhya Pradesh, Rajasthan, Uttar Pradesh and Punjab.

In Gujarat, groundnut is grown on about 1907 thousand hectares with a production of 2661 thousand tonnes and an average productivity of 1395 kg/ha. In North Gujarat, groundnut occupied an area of 159.6 thousand hectares which accounts for 8.37 % of the total groundnut grown in the state, with an average productivity of 1340 kg/ha. Area under it has been reported to increase year after year (DOA, 2009).

Groundnut crop suffers from many pathogens. Many workers have detected different mould fungi and their toxin production ability in stored grains, which deteriorate the stored products (Afzal et al., 1979 and Vedahayagam et al., 1989). Among them, Aspergillus flavus is the most serious disease causing mould fungus at pre- and post- harvest/storage of crop, and is the most common species in Africa and Asia (Clinton, 1960). The toxin of A. flavus species belongs to a highly toxic group of mycotoxins known as aflatoxin. A. flavus is present throughout the groundnut growing areas in the world. The fungus survives in the soil as a saprophyte. Though it is a saprophyte, groundnut seed, seedlings, and pods are subjected to the attack of this fungus. A. flavus causes the yellow mould disease especially on ungerminated seeds and seedlings of groundnut. Infection in seedling is characterized by necrotic lesions on the emerging plumule and cotyledons. This fungus also causes the disease – Aflarot, which is associated with the presence of toxins produced by A. flavus.

Clearly, scientists, farmers and development agencies must work together to find solutions to the problem. No information is available on the prevalence of different species of A. flavus across geographic location of North Gujarat. Thus, realizing the economic importance of the A. flavus and aflatoxin, present investigations were carried out.

II. MATERIALS AND METHODS

A survey was conducted during kharif 2010-11 in groundnut growing areas of Kachchh and Banaskantha districts of North Gujarat to assess the farmers' awareness about aflatoxin contamination by A. flavus and to estimate soil population density and kernel infection in groundnut. 100 pod and soil samples were collected from different locations according to growing areas representing the Kachchh and Banaskantha districts of North Gujarat. The stratified sampling procedure was followed to collect soil and pod samples from the field at harvest/ after harvest.

2.1 Soil Sampling

Soil samples were collected from 5 spots (50 g each) – one sample from each of the four corner and the fifth from the centre of a groundnut field. The samples were collected from 5-10 cm depth. All the 5 spot samples mixed to make a composite of 250 g.

2.2 Pod Sampling

Mature groundnut plants / newly harvested plants at 5 spots in the field were lifted. The pods from 8-10 plants were collected and pooled to make a bulk sample of one kg. Analysis for soil population of A. flavus and kernel infection were carried out as under.

2.3 Enumeration of *A. flavus* population in soil sample

The collected soil samples were sieved to fine powder and mixed thoroughly. From each samples, 10 g soil sample was taken in known amount of distilled sterile water to obtain 10-3 dilution factor. From this dilution, 1 ml suspension was spread on *Aspergillus Flavus* and *Parasiticus* Agar (AFPA) medium and spread uniformly with three replications, the plates were incubated at 27 ± 2oC for five days and colonies of A. flavus were counted. The population density was calculated as colony forming units (cfu) per gram of soil.

2.4 Assessment of kernel infection

For seed infection, randomly collected seeds (50 seeds per sample) were imbibed in sterilized distilled water for 20-30 minutes and then surface sterilized with 0.1 % $HgCl_2$ for 1 minute followed by three subsequent washes of sterile distilled water. The surface sterilized seeds from each sample were plated @ 10 seeds per plate containing PDA medium amended with Rose Bengal and streptomycin sulphate. The observation for seed infection was recorded after 8 days of incubation at 27 ± 2oC.

The aflatoxin content of each sample was determined by indirect competitive ELISA technique.

III. RESULTS AND DISCUSSION

About 100 groundnut pod and soil samples were collected from different locations according to growing areas representing the Kachchh and Banaskantha districts of North Gujarat during kharif 2009-2010 season to estimate the soil population density of *A. flavus*, seed infection and subsequent aflatoxin contamination. Stratified sampling procedure was followed to collect the soil and pod samples from the groundnut fields and analysis for soil population, seed infection and aflatoxin contamination were carried out as described earlier.

Among the highest groundnut growing talukas of Kachchh district, Abadasa, Mandvi, Nakhatrana and Bhachau covered 28.07, 23.80, 15.71 and 13.01 % of area, respectively. However, 74.63 % of groundnut growing area of Banaskantha district was covered only by Deesa taluka.

Analyzed samples were categorized in low, medium, high and very high categories for soil population and seed infection; whereas trace, moderate, high and very high for aflatoxin contamination based on their critical limits. The data of range, average and per cent distribution of samples in different categories according to taluka, variety, previous crop and irrigated/rainfed condition are presented in Table 1 to 11.

3.1 Soil Population

The overall range of soil population of *A. flavus* of all the samples ranged between 0.33 – 9.00 (x 10^3 cfu g^{-1} soil) with an average of 4.92 x 10^3 cfu g^{-1} soil. The average of Kachchh district (4.93 x 10^3 cfu g^{-1}soil) was slightly higher than Banaskantha district (4.90 x 10^3 cfu g^{-1} soil) with the range of 0.33 – 9.00 x 10^3 cfu g^{-1} soil and 3.00 – 6.67 x 10^3 cfu g^{-1} soil, respectively.

Taluka wise, the data presented in the Table 1 shows that the population of *A. flavus* varied highly across the taluka. Minimum average of soil populations were recorded in Rapar and Dhanera taluka (3.00 x 10^3 cfu g^{-1} soil) followed by Anjar (3.22 x 10^3 cfu g^{-1}soil), while maximum average was recorded in Vadgham (6.67 x 10^3 cfug^{-1} soil) followed by Palanpur (6.00 x 10^3 cfu g^{-1}soil) and Nakhatrana (5.92 x 10^3 cfu g^{-1} soil). The per cent distribution of samples revealed that 2.00, 31.00, 63.00 and 4.00 % samples fall under low, medium, high and

very high categories, respectively. Very high soil population of *A. flavus* was recorded from Bhuj (20.00 %) followed by Mandvi (10.53 %) and Nakhatrana (7.69 %).

TABLE 1

PER CENT DISTRIBUTION, RANGE AND AVERAGE OF SOIL POPULATION(X 103 CFU G-1SOIL) OF A. FLAVUS IN DIFFERENT TALUKAS OF KACHCHH AND BANASKANTHA DISTRICTS

Sr. No.	Taluka	No. of Sample	Area Ha.	% Area covered	Samples in each category (%)				Soil population (x 10^3 cfu g^{-1} soil)	
					Low (< 1)	Medium (1-4)	High (4-8)	Very High (> 8)	Range	Average
1	Bhuj	5	4029	6.15	0.00	40.00	40.00	20.00	2.00 - 8.33	4.87
2	Mandvi	19	15600	23.80	10.53	26.32	52.63	10.53	0.33 - 9.00	4.74
3	Mundra	3	2255	3.44	0.00	66.67	33.33	0.00	2.67 - 5.67	3.89
4	Anjar	3	2225	3.39	0.00	66.67	33.33	0.00	2.00 - 4.33	3.22
5	Bhachau	10	8530	13.01	0.00	50.00	50.00	0.00	2.00 - 6.33	4.17
6	Rapar	1	1210	1.85	0.00	100.00	0.00	0.00	-	3.00
7	Nakhatrana	13	10300	15.71	0.00	15.38	76.92	7.69	3.33 - 9.00	5.92
8	Lakhapat	4	3000	4.58	0.00	75.00	25.00	0.00	2.00 - 5.33	3.42
9	Abadasa	22	18400	28.07	0.00	18.18	81.82	0.00	1.67 - 8.00	5.61
Kachchh		80	65549	100.00	2.50	32.50	60.00	5.00	0.33 - 9.00	4.93
10	Deesa	15	14000	74.63	0.00	20.00	80.00	0.00	3.67 - 6.67	4.84
11	Palanpur	1	625	3.33	0.00	0.00	100.00	0.00	-	6.00
12	Danta	1	500	2.67	0.00	100.00	0.00	0.00	-	4.00
13	Vadgham	1	625	3.33	0.00	0.00	100.00	0.00	-	6.67
14	Dhanera	1	1200	6.40	0.00	100.00	0.00	0.00	-	3.00
15	Dantiwada	1	1150	6.13	0.00	0.00	100.00	0.00	-	5.67
Banaskantha		20	18760	100.00	0.00	25.00	75.00	0.00	3.00 - 6.67	4.90
Total		100	84309	100.00	2.00	31.00	63.00	4.00	0.33 - 9.00	4.92

According to variety, Table 2 revealed maximum average of *A. flavus* soil population (5.60 x 10^3 cfu g^{-1}soil) in the variety GG-2 grown as rainfed with the range of 2.67 -8.33 x 10^3 cfu g^{-1}soil, whereas minimum value (4.03 x 10^3 cfu g^{-1} soil) was recorded with J-11 grown as rainfed with the range of 0.33 -8.00 x 10^3 cfu g^{-1}soil. 18.18 % samples of the variety GG-5 grown as irrigated were under very high categories followed by, GG-2 grown as

rainfed (3.85 %) and GG-2 grown as irrigated (3.45 %); whereas only 8.70 % samples of variety J-11 grown as rainfed were under low category. Remaining all the samples were under medium to high categories.

TABLE 2

PER CENT DISTRIBUTION, RANGE AND AVERAGE OF SOIL POPULATION (X 103 CFU G-1 SOIL) OF A. FLAVUS IN DIFFERENT VARIETIES OF GROUNDNUT

Sr. No.	Variety	No. of Sample	Samples in each category (%)				Soil population (x10^3 cfu g^{-1}soil)	
			Low (< 1)	Medium (1-4)	High (4-8)	Very High (> 8)	Range	Average
1	GG-2 Irrigated	29	0.00	34.48	62.07	3.45	2.00-8.33	5.06
2	GG-2 Rainfed	26	0.00	15.38	80.77	3.85	2.67-8.33	5.60
3	GG-5 Irrigated	11	0.00	27.27	54.55	18.18	2.00-9.00	5.27
4	J-11 Rainfed	23	8.70	43.48	47.83	0.00	0.33-8.00	4.03
5	GG-20 Irrigated	11	0.00	36.36	63.64	0.00	3.00-5.67	4.48

In case of previous crop grown, data presented in the Table 3 shows that the maximum average of *A. flavus* soil population (5.64 x 10^3 cfu g^{-1}soil) when the groundnut crops were grown after groundnut with the range of 2.67 – 9.00 x 10^3 cfu g^{-1} soil. However, minimum value was reported with pulse crops with the average and range of 3.97 x 10^3 cfu g^{-1} soil and 0.67 – 5.33 x 10^3 cfu g^{-1} soil, respectively. Regarding per cent distribution, 11.11 % samples were grouped under very high category when groundnut was grown as previous crop. In the low category, 10.00 % samples with pulse crops, followed by 3.45 % with cereals as previous crops. Table 4 indicates a little difference in *A. flavus* soil population between the irrigated (6.67 – 63.33 x 10^3 cfu g^{-1} soil) and rainfed samples (3.33 – 66.67 x 10^3 cfu g^{-1} soil). The average values for these samples were 4.98 x 10^3 cfu g^{-1} soil and 4.86 x 10^3 cfu g^{-1} soil, respectively. 5.88 and 2.04 % respectively of the irrigated and rainfed samples were grouped under very high category. Whereas, in low category only 4.08 % samples belong to the rainfed growing condition were identified.

TABLE 3

PER CENT DISTRIBUTION, RANGE AND AVERAGE OF SOIL POPULATION (X 103 CFU G-1 SOIL) OF A. FLAVUS IN RESPONSE TO DIFFERENT PREVIOUS CROPS

Sr. No.	Previous Crops	No.of Sample	Samples in each category (%)				Soil population (x10^3 cfu g^{-1}soil)	
			Low (< 1)	Medium (1-4)	High (4-8)	Very High (> 8)	Range	Average
1	Groundnut	36	0.00	25.00	63.89	11.11	2.67-9.00	5.64
2	Other oilseed	17	0.00	23.53	76.47	0.00	2.33-7.00	4.90
3	Cash crop	8	0.00	50.00	50.00	0.00	2.00-6.00	4.00
4	Pulses	10	10.00	30.00	60.00	0.00	0.67-5.33	3.97
5	Cereals	29	3.45	37.93	58.62	0.00	0.33-8.00	4.63

TABLE 4
PER CENT DISTRIBUTION, RANGE AND AVERAGE OF SOIL POPULATION (X 103 CFU G-1SOIL) OF A. FLAVUS IN IRRIGATED AND RAINFED CONDITION

Sr. No.	Irrigated/ rainfed condition	No. of Sample	Samples in each category (%)				Soil population ($x10^3$ cfu g^{-1}soil)	
			Low (< 1)	Medium (1-4)	High (4-8)	Very High (> 8)	Range	Average
1	Irrigated	51	0.00	33.33	60.78	5.88	2.00-9.00	4.98
2	Rainfed	49	4.08	28.57	65.31	2.04	0.33-8.33	4.86

3.2 Seed infection (%)

Among 100 samples which have been analyzed, the seed infection ranged between 3.33 – 66.67 % with an average of 28.47 %. The ranges for Kachchh and Banaskantha districts were 3.33 – 66.67 % and 10.00 – 63.33 % with an average of 26.96 % and 34.50 %, respectively (Table 5). Overall, 27.00, 35.00, 27.00 and 11.00 % of samples were grouped under low, medium, high and very high seed infection categories, respectively.

TABLE 5: PER CENT DISTRIBUTION, RANGE AND AVERAGE OF SEED INFECTION (%) IN GROUNDNUT SEED BY A. FLAVUS IN DIFFERENT TALUKAS OF KACHCHH AND BANASKANTHA DISTRICTS

Sr. No.	Taluka	No. of Sample	Samples in each category (%)				Seed infection (%)	
			< 15 %	15-30 %	30-50 %	> 50 %	Range	Average
1	Bhuj	5	20.00	60.00	20.00	0.00	6.67-36.67	24.67
2	Mandvi	19	31.58	36.84	26.32	5.26	6.67-53.33	25.26
3	Mundra	3	33.33	66.67	0.00	0.00	6.67-26.67	18.89
4	Anjar	3	33.33	33.33	33.33	0.00	6.67-33.33	20.00
5	Bhachau	10	20.00	30.00	30.00	20.00	10.00-56.67	32.67
6	Rapar	1	100.00	0.00	0.00	0.00	-	13.33
7	Nakhatrana	13	23.08	38.46	30.77	7.69	6.67-63.33	31.03
8	Lakhapat	4	75.00	25.00	0.00	0.00	3.33-23.33	10.00
9	Abadasa	22	36.36	18.18	31.82	13.64	6.67-66.67	29.70
Kachchh		80	32.50	32.50	26.25	8.75	3.33-66.67	26.96
10	Deesa	15	6.67	46.67	33.33	13.33	10.00-56.67	32.44
11	Palanpur	1	0.00	100.00	0.00	0.00	-	20.00
12	Danta	1	0.00	0.00	0.00	100.00	-	53.33
13	Vadgham	1	0.00	100.00	0.00	0.00	-	20.00
14	Dhanera	1	0.00	0.00	100.00	0.00	-	46.67
15	Dantiwada	1	0.00	0.00	0.00	100.00	-	63.33
Banaskantha		20	5.00	45.00	30.00	20.00	10.00-63.33	34.50
Total		100	27.00	35.00	27.00	11.00	3.33-66.67	28.47

Taluka wise data presented in the Table 5 shows that the maximum average seed infection (63.33 %) was recorded in Dantiwada taluka, whereas minimum (10.00 %) in Lakhapat taluka. Average of seed infection of the dominant groundnut growing talukas *viz.*, Deesa, Bhachau, Nakhatrana, Abadasa and Mandvi of both the districts were 32.44, 32.67, 31.03, 29.70 and 25.26 % falling respectively in the range of 10.00 – 56.67, 10.00 – 56.67, 6.67 – 63.33, 6.67 – 66.67 and 6.67 – 53.33 %. Out of 100 samples, 11.00, 27.00, 35.00 and 27.00 % samples fall under very high, high, medium and low categories of seed infection, respectively. The samples from Dantiwada (100.00 %), Danta (100.00 %), Bhachau (20.00 %), Abadasa (13.64 %), Deesa (13.33 %) and Mandvi (5.26 %) taluka were grouped under very high category.

Maximum average seed infection (44.24 %) was recorded with variety GG-20 grown as irrigated followed by GG-5 grown as irrigated (37.58 %), whereas minimum average in the variety J-11 grown as rainfed (12.03 %)(Table 6). 36.36 % samples of the GG-20 variety grown as irrigated were grouped under very high category followed by, GG-5 grown as irrigated (18.18 %), GG-2 grown as rainfed (15.38 %) and GG-2 grown as irrigated (3.45 %). However, when the variety J-11 was grown as rainfed, 82.61 % of the samples grouped under low category.

TABLE 6

PER CENT DISTRIBUTION, RANGE AND AVERAGE OF SEED INFECTION (%) IN GROUNDNUT SEED BY A. FLAVUS IN DIFFERENT VARIETIES OF GROUNDNUT

Sr. No.	Variety	No.of Sample	Samples in each category (%)				Seed infection (%)	
			Low	Medium (15-30 %)	High (30-50 %)	Very High (>50 %)	Range	Average
1	GG-2 Irrigated	29	20.69	55.17	20.69	3.45	6.67-53.33	25.63
2	GG-2 Rainfed	26	7.69	34.62	42.31	15.38	6.67-66.67	35.64
3	GG-5 Irrigated	11	0.00	36.36	45.45	18.18	20.00-63.33	37.58
4	J-11 rainfed	23	82.61	17.39	0.00	0.00	3.33-30.00	12.03
5	GG-20 Irrigated	11	0.00	18.18	45.45	36.36	16.67-63.33	44.24

According to previous crop grown (Table 7), maximum seed infection of 33.43 % was recorded when groundnut was grown as a previous crop with the range of 10.00 – 66.67 %, while minimum average (14.67 %) with the range of 3.33 – 26.67 % were recorded when pulses were grown as a previous crops. 16.67, 11.76 and 10.34 % samples were categorized under very high seed infection group when groundnut, other oilseed and cereal crops were grown as previous crops, respectively. When pulses were grown as a previous crop, 60.00 % of the samples grouped under low seed infection category.

TABLE 7: PER CENT DISTRIBUTION, RANGE AND AVERAGE OF SEED INFECTION (%) IN GROUNDNUT SEED BY A. FLAVUS IN RESPONSE TO DIFFERENT PREVIOUS CROPS

Sr. No.	Previous Crops	No.of Sample	Samples in each category (%)				Seed infection (%)	
			Low (< 15 %)	Medium (15-30 %)	High (30-50 %)	Very High (> 50 %)	Range	Average
1	Groundnut	36	25.00	25.00	33.33	16.67	10.00-66.67	33.43
2	Other oilseed	17	5.88	47.06	35.29	11.76	13.33-63.33	32.75
3	Cash crop	8	12.50	50.00	37.50	0.00	6.67-46.67	29.58
4	Pulses	10	60.00	40.00	0.00	0.00	3.33-26.67	14.67
5	Cereals	29	34.48	34.48	20.69	10.34	13.33-56.67	24.25

Irrigated crops reported higher seed infection (32.22 %) as compared to the rainfed crops (24.56 %) (Table 8). 13.73 % samples of irrigated crops were recorded under very high seed infection category. Whereas in rainfed condition 42.86 % samples were reported to be under low seed infection category.

TABLE 8
PER CENT DISTRIBUTION, RANGE AND AVERAGE OF SEED INFECTION (%) IN GROUNDNUT SEED BY A. FLAVUS IN IRRIGATED AND RAINFED CONDITION

Sr. No.	Irrigated/ rainfed condition	No. of Sample	Samples in each category (%)				Seed infection (%)	
			Low (< 15 %)	Medium (15-30 %)	High (30-50 %)	Very High (>50 %)	Range	Average
1	Irrigated	51	11.76	43.14	31.37	13.73	6.67-63.33	32.22
2	Rainfed	49	42.86	26.53	22.45	8.16	3.33-66.67	24.56

3.3 Aflatoxin contamination

Among 100 samples analyzed for aflatoxin contamination, none of the samples were found free from aflatoxin but 51.00 % of the samples were within the safe limits (Table 9).The permissible limit for aflatoxin in foods under Prevention of Food Adulteration (PFA) Act is 30 ppb (Bhat and Rao, 1990). The maximum permissible level of aflatoxin in groundnut for human consumption was first set at 30 ppb in kernels, but it was revised to a level of 15 ppb (Mehan *et al.*, 1991). The average and range of all the 100 samples were 14.44 ppb and 0.81 – 36.53 ppb, respectively. The average of Kachchh district was 14.22 ppb with the range of 0.81 – 36.53 ppb; whereas in Banaskantha the average and range was 15.33 ppb and 3.25 – 28.32 ppb respectively. Aflatoxin levels were present in trace amount in 15.00 % and moderate amount in 36.00 % of the samples, but it was high in 43.00 % and very high in 6.00 % of the samples.

Among the dominant groundnut growing talukas of Kachchh district, Mandvi, Abadasa and Nakhatrana taluka respectively reported 15.79, 9.09 and 7.69 % of the samples under very high category. Trace amounts of aflatoxins were recorded in samples from the Rapar (100.00 %), Lakhapat (75.00 %), Bhuj (20.00 %), Mandvi (15.79 %), Nakhatrana (15.38 %), Abadasa (13.64 %) and Deesa (6.67 %), (Table 9).

According to variety, maximum aflatoxin content (21.34 ppb) was recorded in GG-2 grown as rainfed followed by GG-20 grown as irrigated (19.87 %), with the range of 6.04 – 36.13 ppb and 8.28 – 28.32 ppb, respectively. While the variety J-11 grown as rainfed recorded minimum average of 4.55 ppb aflatoxin with the range of 0.81 – 8.23 ppb (Table 33, Fig. 28). 19.23 and 9.09 % samples respectively of the varieties GG-2 grown as rainfed and GG-5 grown as irrigated reported to have very high aflatoxin content.

Groundnut cultivated after groundnut recorded maximum aflatoxin content (average 17.91 ppb and range 2.12 – 36.53 ppb) followed by other oilseed crops, while minimum average of 7.72 ppb with the range of 1.07 – 17.24 ppb was recorded when pulses were grown as previous crops (Table 11). 16.67 % samples were categorized under very high aflatoxin content when groundnut was the previous crop, while trace amounts of aflatoxin were recorded in 40.00, 24.14, 12.50 and 8.33 % of the samples when pulses, cereals, cash crops, and groundnut were grown as previous crops, respectively.

In irrigated crops, aflatoxin content of 15.38 ppb (range: 3.25 – 36.53 ppb) was recorded which was higher compared to the rainfed crops with an average value of 13.46 ppb (range: 0.81 – 36.13 ppb) (Table 12). 10.20 % of sample recorded very high, while 24.49 % of samples recorded with trace amount of aflatoxin in case of rainfed crops. However, in irrigated crops most of the samples observed were under moderate to high categories of aflatoxin content.

The variation in soil population, seed infection and aflatoxin content across different groundnut samples collected from different location might be due to several reasons *viz.*, soil type, climatic condition, variety, cropping pattern and other agronomical practices. Mehan *et al.* (1995) noted that isolates from a vertisol field produced less aflatoxin than isolates from the red sandy loam and light sandy fields. Saleha-Nahdi (1996) reported that populations of *A. flavus* were higher in the pod zone than in the field soil, and it increased with maturation of the crops. They also noted that soil population of *A. flavus* was higher in rainfed fields than in irrigated fields and also higher in fields where groundnut had been grown in the previous year. Mehan *et al.* (1986) further noted that seed infection and contamination by *A. flavus* increased with increasing maturity of pods. However, early harvest and threshing resulted in consistently lower aflatoxin content (Rachaputi *et al.*, 2002). Timmannavar *et al.* (2003) reported highest percentage infection of *A. flavus* in groundnut cultivars with

bolder and heavy seeds as compared to smaller seed size with less test weight. They also noted that harvesting at normal date recorded lower infection of *A. flavus* compared to one week early or late harvesting. Rossetto *et al.* (2003) concluded that delayed harvesting increased *A. flavus* contamination and aflatoxin production in the pods. Variety J-11 has also been reported as resistance source against seed infection and aflatoxin contamination by several workers (Nayak *et al.*, 1992; Rao *et al.*, 1995; Upadhyay *et al.*, 1997 and 2001; Khandar *et al.*, 2004 and Babu *et al.*, 2005).

TABLE 9

PER CENT DISTRIBUTION, RANGE AND AVERAGE OF AFLATOXIN CONTENT (PPB) IN GROUNDNUT SEEDS IN DIFFERENT TALUKAS OF KACHCHH AND BANASKANTHA DISTRICTS

Sr. No.	Taluka	No. of Sample	Samples in each category (%)				Aflatoxin content (ppb)	
			Trace (<5 ppb)	Moderate (5-15 ppb)	High (15-30 ppb)	Very high (>30 ppb)	Range	Average
1	Bhuj	5	20.00	20.00	60.00	0.00	3.78-18.91	12.71
2	Mandvi	19	15.79	42.11	26.32	15.79	1.11-36.13	14.90
3	Mundra	3	0.00	66.67	33.33	0.00	6.04-15.95	9.74
4	Anjar	3	0.00	66.67	33.33	0.00	5.64-25.35	13.36
5	Bhachau	10	10.00	40.00	50.00	0.00	3.87-24.45	15.14
6	Rapar	1	100.00	0.00	0.00	0.00	-	3.79
7	Nakhatrana	13	15.38	23.08	53.85	7.69	2.07-36.53	14.72
8	Lakhapat	4	75.00	25.00	0.00	0.00	0.81-7.82	2.96
9	Abadasa	22	13.64	31.82	45.45	9.09	2.36-34.80	16.49
Kachchh		80	17.50	35.00	40.00	7.50	0.81-36.53	14.22
10	Deesa	15	6.67	40.00	53.33	0.00	3.25-28.32	15.21
11	Palanpur	1	0.00	100.00	0.00	0.00	-	5.61
12	Danta	1	0.00	0.00	100.00	0.00	-	20.48
13	Vadgham	1	0.00	100.00	0.00	0.00	-	8.06
14	Dhanera	1	0.00	0.00	100.00	0.00	-	19.28
15	Dantiwada	1	0.00	0.00	100.00	0.00	-	24.91
Banaskantha		20	5.00	40.00	55.00	0.00	3.25-28.32	15.33
Total		100	15.00	36.00	43.00	6.00	0.81-36.53	14.44

TABLE 10

PER CENT DISTRIBUTION, RANGE AND AVERAGE OF AFLATOXIN (PPB) CONTENT IN GROUNDNUT SEEDS IN DIFFERENT VARIETIES OF GROUNDNUT

Sr. No.	Variety	No.of Sample	Samples in each category (%)				Aflatoxin content (ppb)	
			Trace (< 5 ppb)	Moderate (5-15 ppb)	High (15-30 ppb)	Very high (> 30 ppb)	Range	Average
1	GG-2 Irrigated	29	10.34	51.72	37.93	0.00	3.25-21.14	12.28
2	GG-2 Rainfed	26	0.00	19.23	61.54	19.23	6.04-36.13	21.34
3	GG-5 Irrigated	11	0.00	27.27	63.64	9.09	8.06-36.53	19.04
4	J-11 Rainfed	23	52.17	47.83	0.00	0.00	0.81-8.23	4.55
5	GG-20 Irrigated	11	0.00	18.18	81.82	0.00	8.28-28.32	19.87

TABLE 11

PER CENT DISTRIBUTION, RANGE AND AVERAGE OF AFLATOXIN CONTENT IN GROUNDNUT SEEDS IN RESPONSE TO DIFFERENT PREVIOUS CROPS

Sr. No.	Previous Crops	No. of Sample	Samples in each category (%)				Aflatoxin content (ppb)	
			Trace (<5 ppb)	Moderate (5-15 ppb)	High (15-30 ppb)	Very high (>30 ppb)	Range	Average
1	Groundnut	36	8.33	27.78	47.22	16.67	2.12-36.53	17.91
2	Other oilseed	17	0.00	47.06	52.94	0.00	5.61-25.35	15.84
3	Cash crop	8	12.50	50.00	37.50	0.00	3.78-23.51	13.76
4	Pulses	10	40.00	40.00	20.00	0.00	1.07-17.24	7.72
5	Cereals	29	24.14	34.48	41.38	0.00	0.81-28.32	11.80

TABLE 12

PER CENT DISTRIBUTION, RANGE AND AVERAGE OF AFLATOXIN CONTENT IN GROUNDNUT SEEDS IN IRRIGATED AND RAINFED CONDITION

Sr. No.	Irrigated/ rainfed condition	No. of Sample	Samples in each category (%)				Aflatoxin content (ppb)	
			Trace (< 5 ppb)	Moderate (5-15 ppb)	High (15-30 ppb)	Very high (> 30 ppb)	Range	Average
1	Irrigated	51	5.88	39.22	52.94	1.96	3.25-36.53	15.38
2	Rainfed	49	24.49	32.65	32.65	10.20	0.81-36.13	13.46

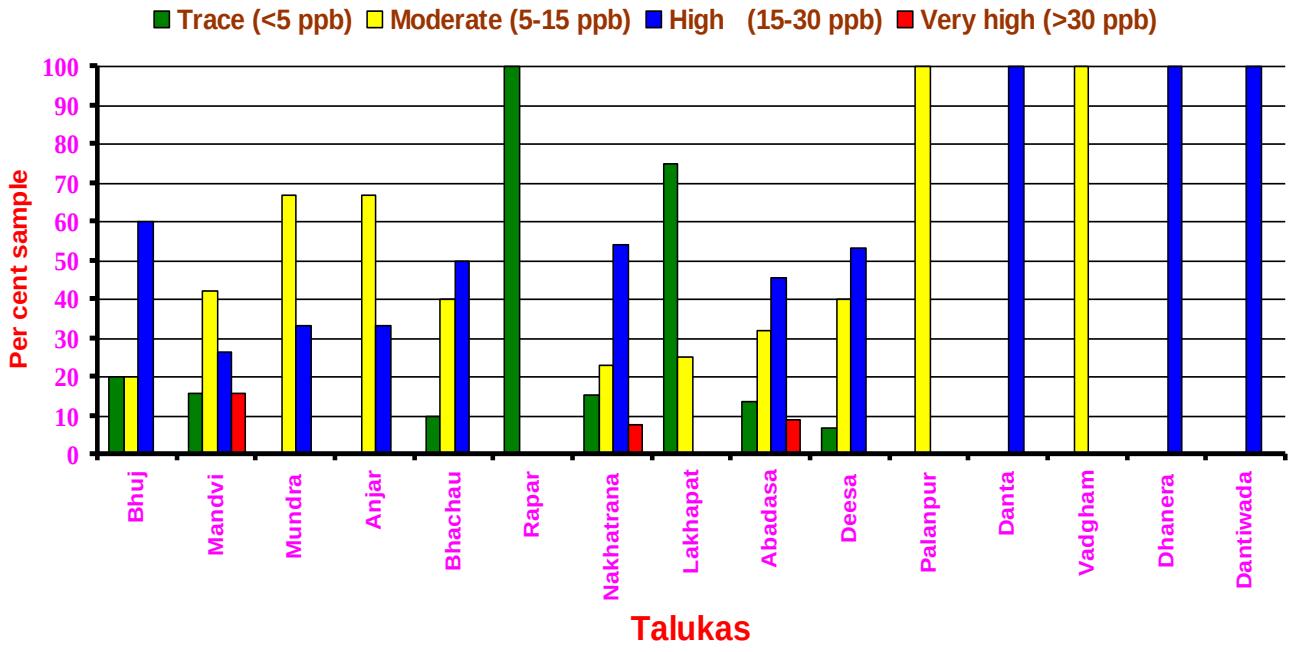

FIG. 1: AFLATOXIN CONTENT (PPB) ACCORDING TO DIFFERENT TALUKA OF KACHCHH AND BANASKANTHA DISTRICTS

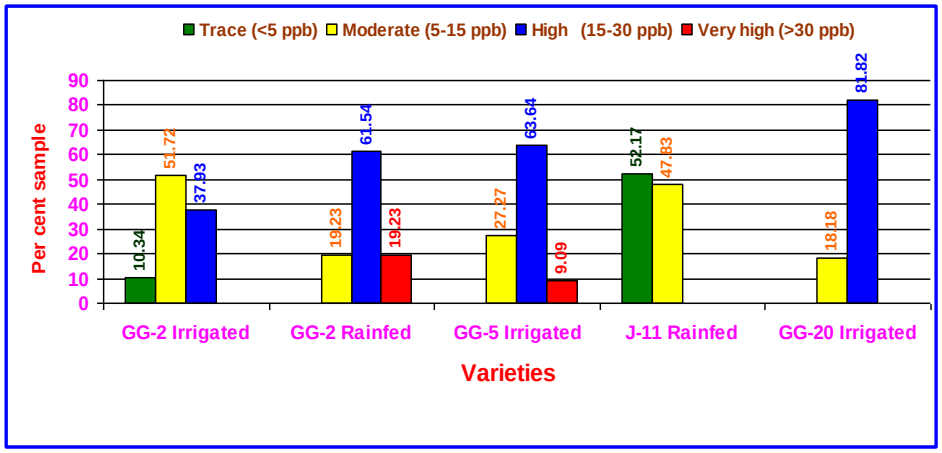

FIG. 2: AFLATOXIN LEVELS IN DIFFERENT VARIETIES OF GROUNDNUT

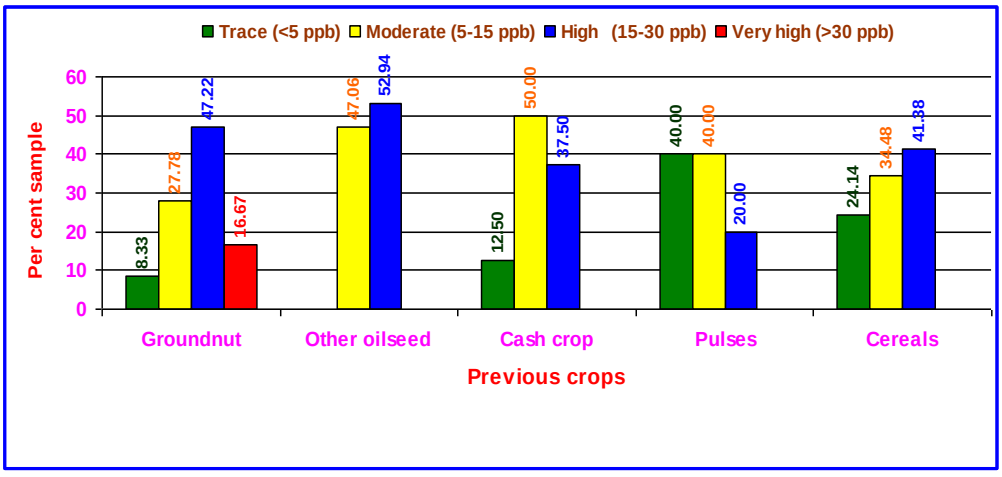

FIG. 3: AFLATOXIN LEVELS ACCORDING TO PREVIOUS CROPS GROWN

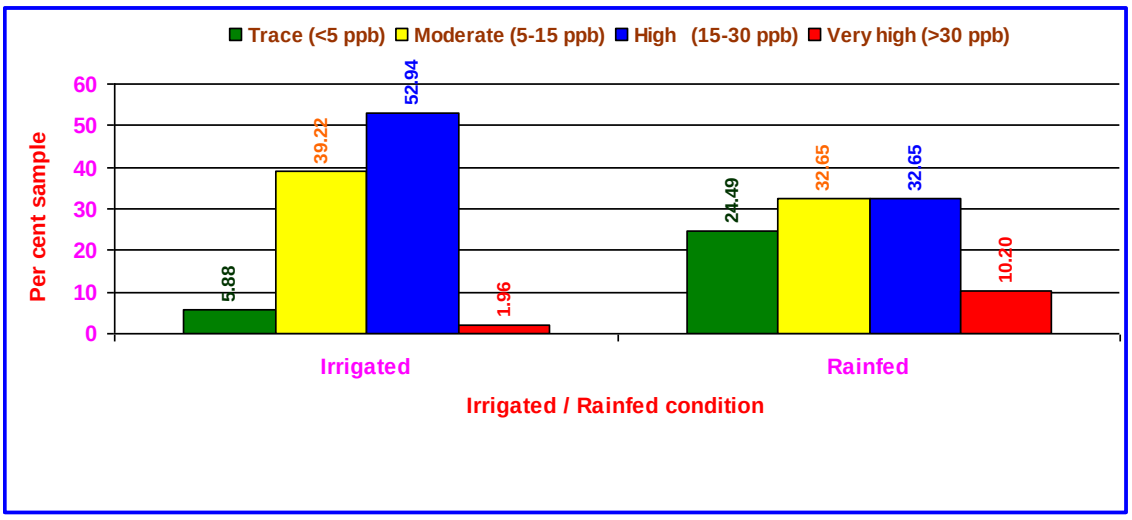

FIG. 4: AFLATOXIN LEVELS ACCORDING TO IRRIGATED/RAINFED CONDITION

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