CHAPTER 4
RESULTS

RESULTS

REMOTE SENSING STUDIES:

Degradation of land by waterlogging:

Satellite Remote Sensing data in the form of FCC transparencies, Photographes have been found to give good results in the delineation of waterlogged areas at the taluka and micro levels. The Quick look analysis of the images using the light table revealed that the major part of the study area ie Khambhat taluka was prone to waterlogging . In part of the area, this problem has been aggravated leading to soil salinity of immense severity .A general reduction in the vegetation was also noticed clearly indicating the severe land degradation.

VISUAL IMAGE INTERPRETATION:

Delineation of Waterlogged area in Taluka level

While using the Remote Sensing data, the choice of the correct season is very essential as a result the multi seasonal approach was attempted.

Multi seasonal approach:

A comparison of Visually interpreted images of pre and post monsoon of IRS-1A/LISS II FCC information helped in distinguishing the permanent waterlogged land by the presence of smooth dark blue tone in both the images from the moist surface soil, which can be distinguished by the coarse, dark brown with

bluish tinge (Fig. 9,10,11). Occurrence of dense vegetation during post monsoon season made it difficult to separate the moist land from the unaffected land. Though the multiseasonal approach could help us to distinguish two categories of waterlogged land namely, the severely affected permanent waterlogged land and moist surface land with sparse vagetation. While attempting the temporal analysis, this approach might not be cost effective and feasible. The third category of soil in this area, which registered a white tone due to surface salinity, was also found to belong to the seasonal category of waterlogged land during ground truth analysis.

Multi date analysis:

The Quick look analysis carried out at the taluka level clearly segregated the taluka into 3 different zones.

i) The south west zone, included permanent waterlogged soil of deep blue colour, prevailing in the villages, Fetepur, Galiana Veghatalav, Golana, Mitli, Pandad, Rohoni, Vadgam, Hasanpur, Tamsa etc.

ii) The central zone consisted of waterlogged lands and saline lands with the partial vegetation including Valli, Khaksar, Padra, Jafrabad, Gudel, Bhimtalav, Daheda, Ginaj, Gorad, Jichaka, Chikhalia, Amaliara, Moraj, Budhej, Kanpur, Mahiari, Sadh, Bhanderaj etc.

iii) The eastern zone, with normal cultivable land without much land degradation, included Undel, Kalamsar, Vadola, Vasna,

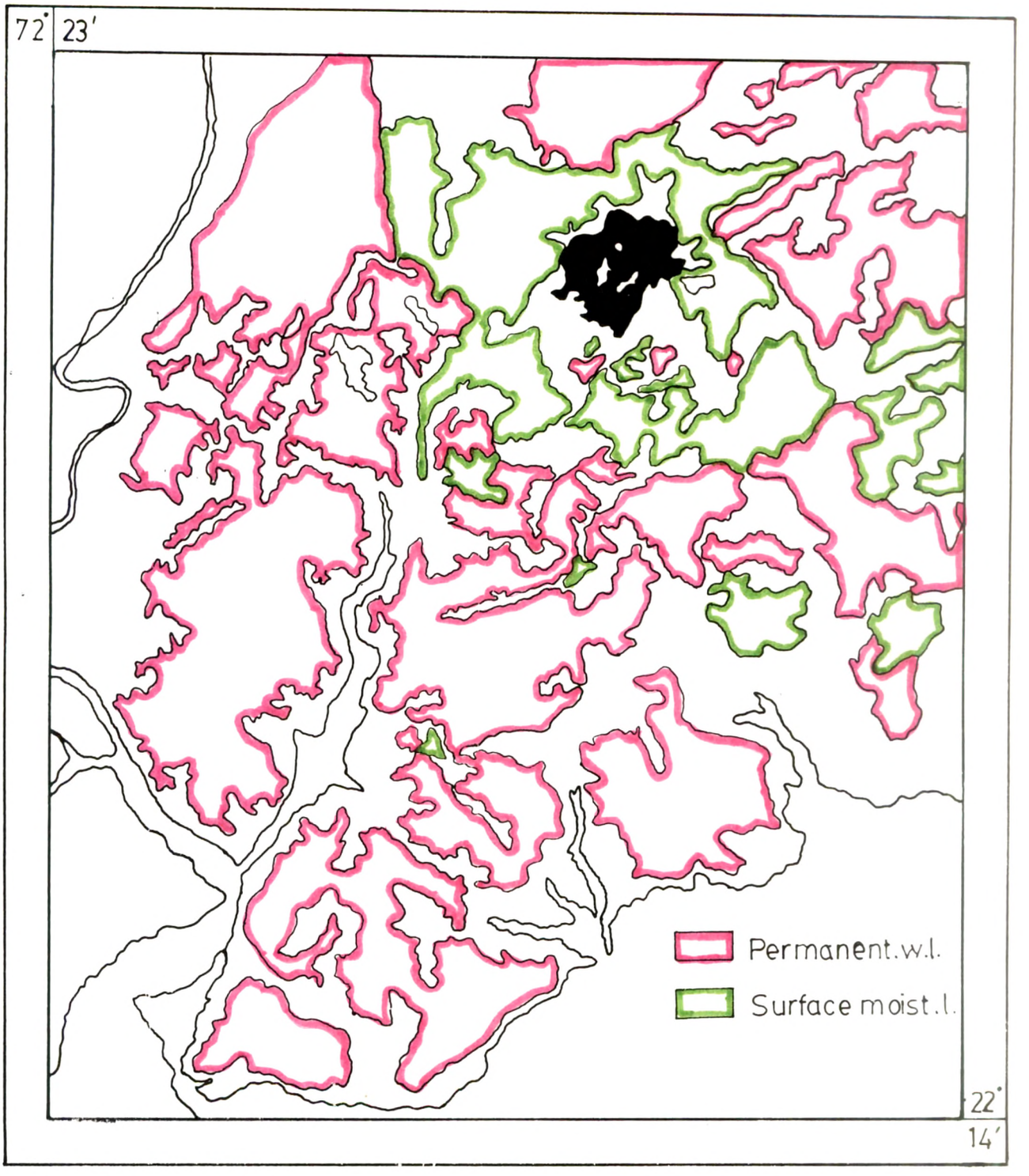


FIG. 9 Delineation of Waterlogged areas by using PREMONSOON data
(IRS IA LISS II MARCH 1989)

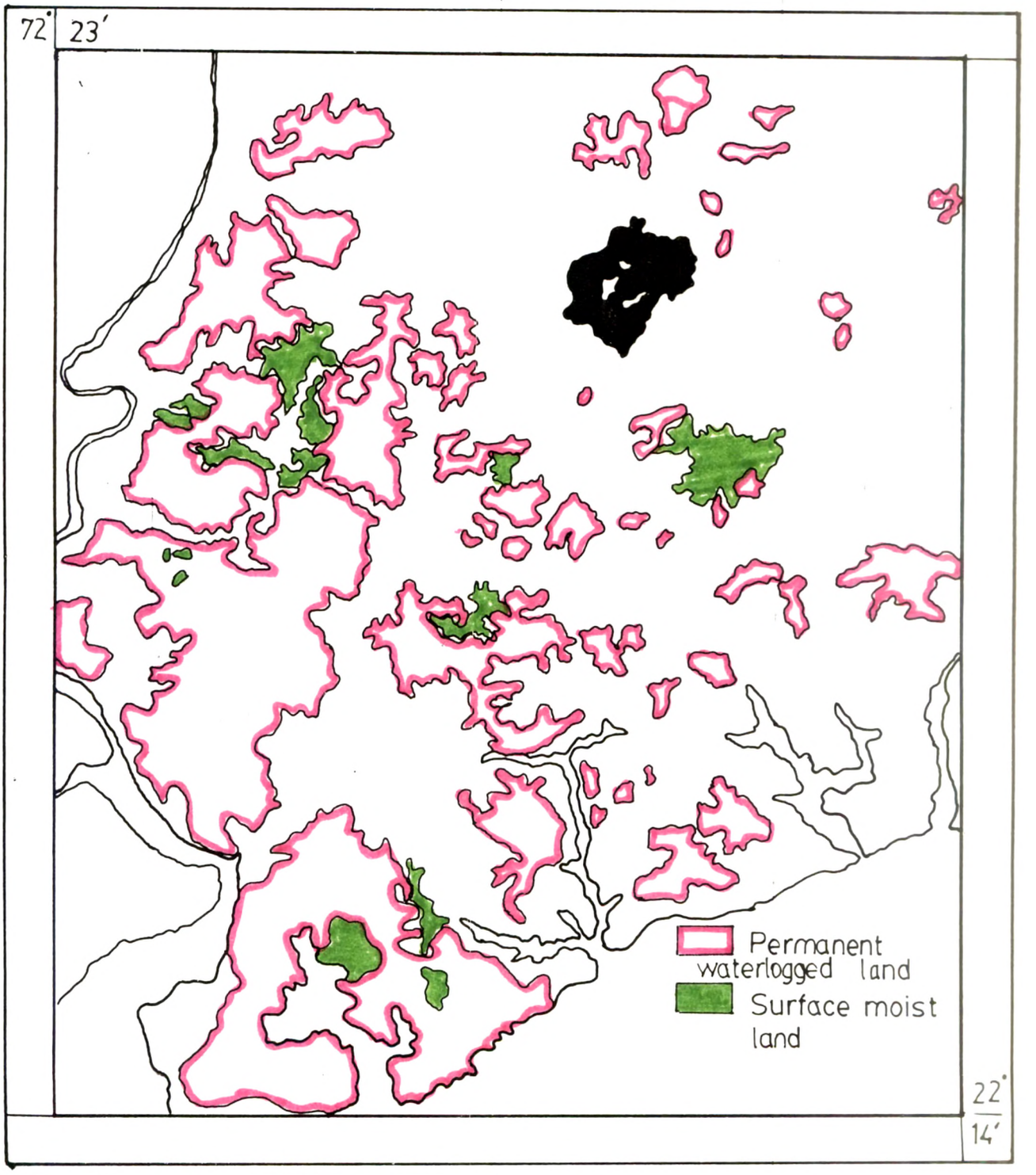


FIG 10 Delineation of Waterlogged areas by IRS/LISS II NOV 1989

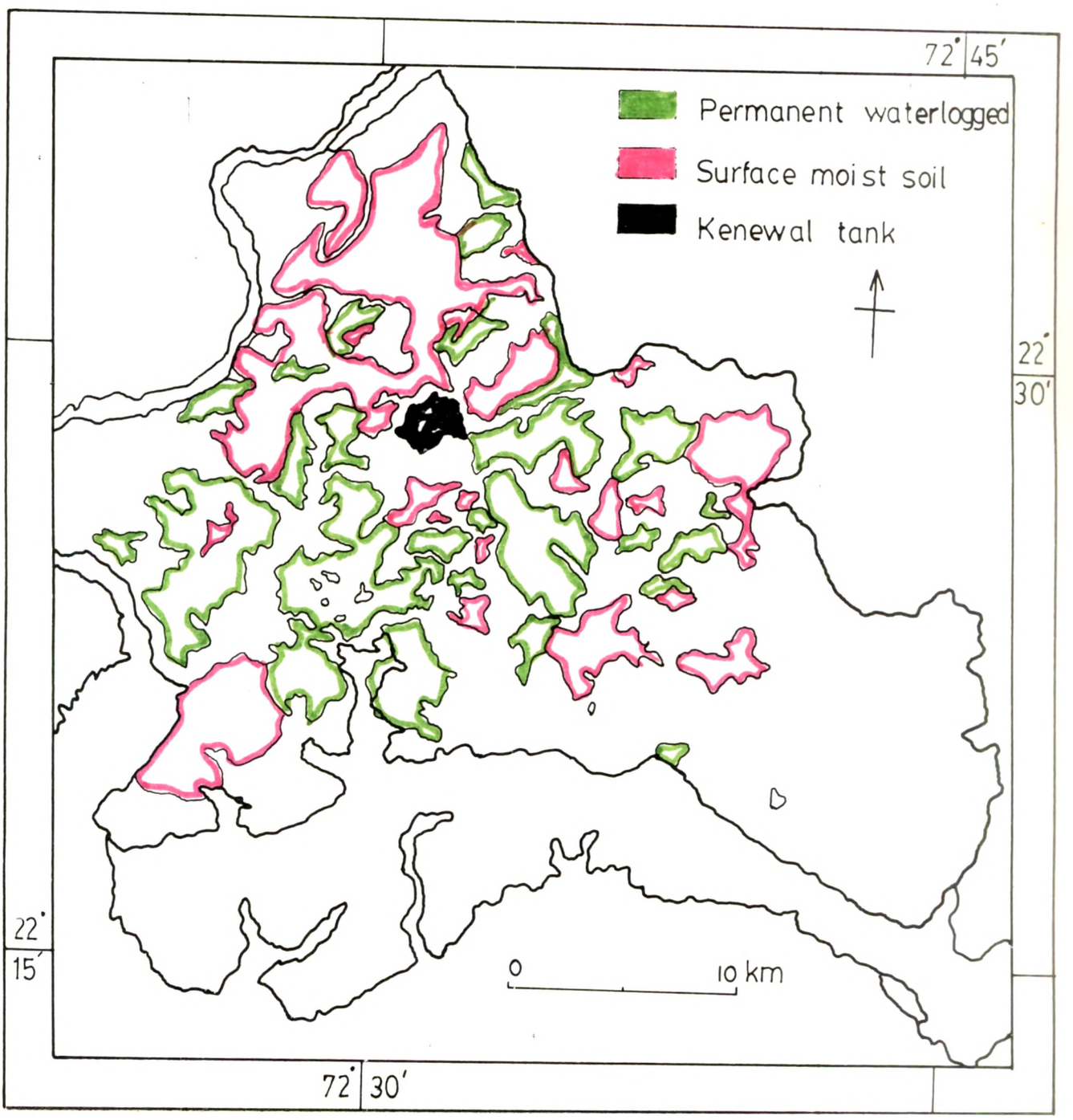


FIG 2. DELINEATION OF WATER LOGGED AREAS - LANDSAT/MSS 1983

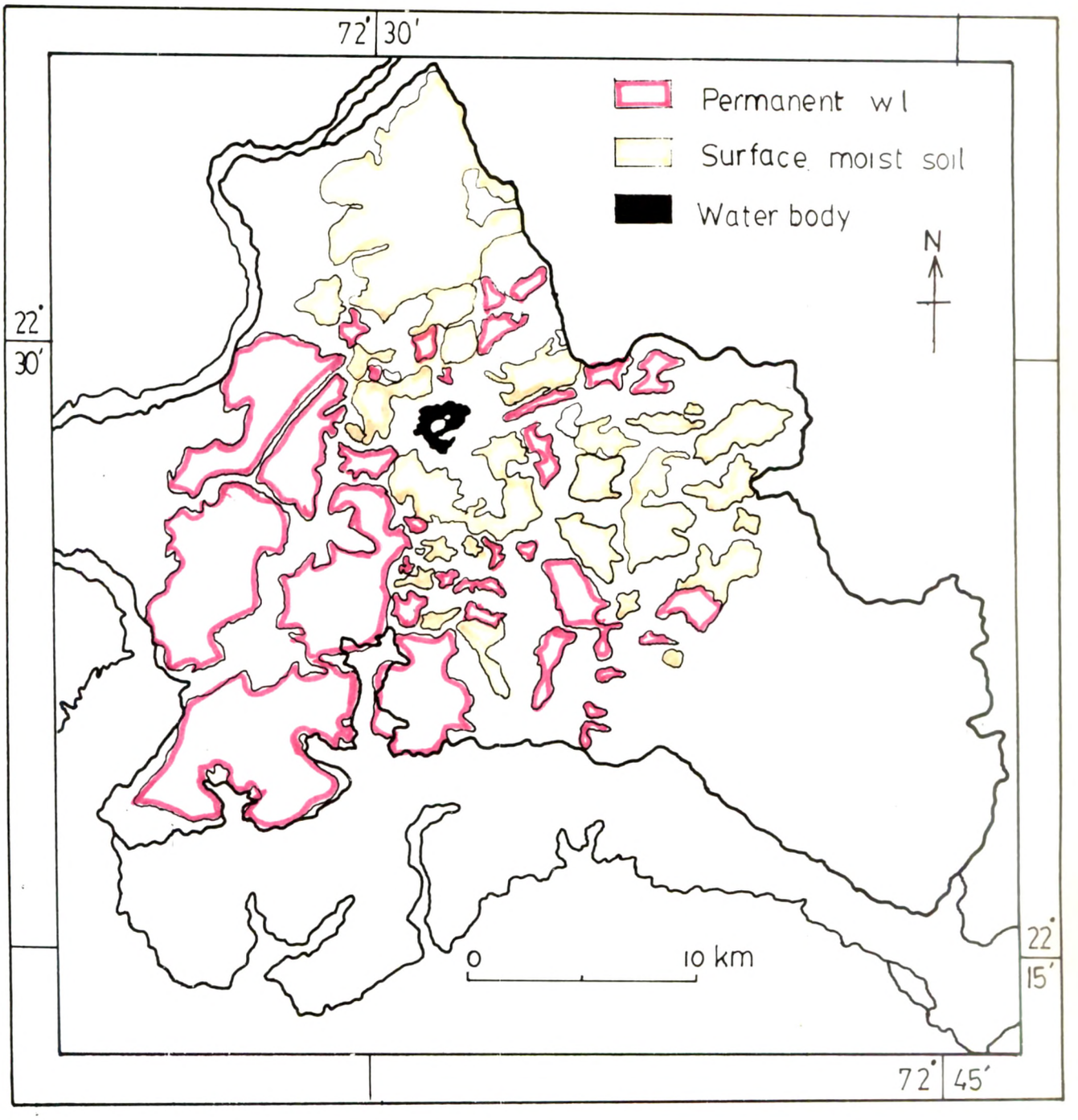


FIG.13. Delineation Of Waterlogged areas Using Landsat / TM 1986

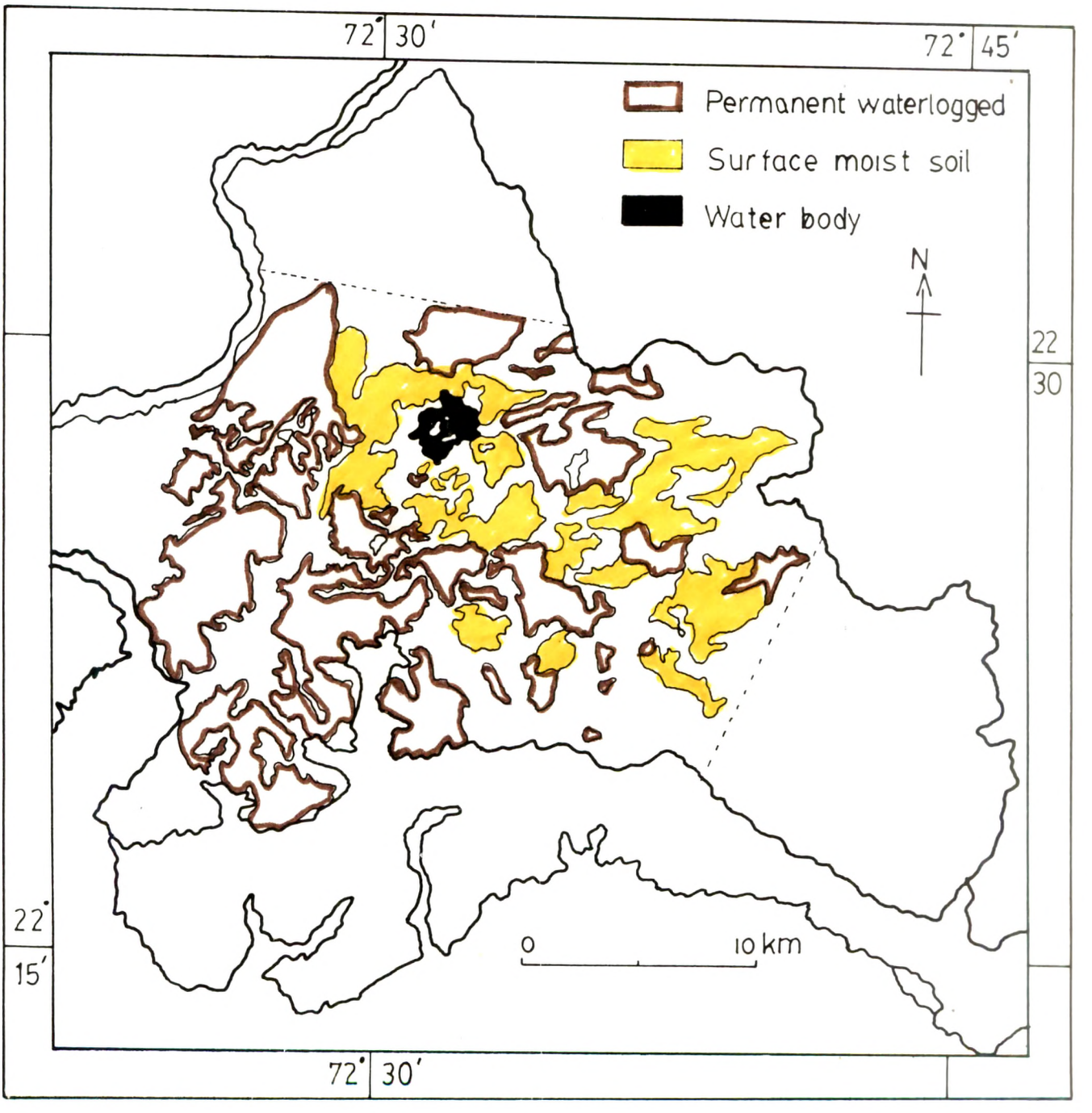


FIG.14. Delineation of Waterlogged areas using IRS 1A/ LISS II 1989

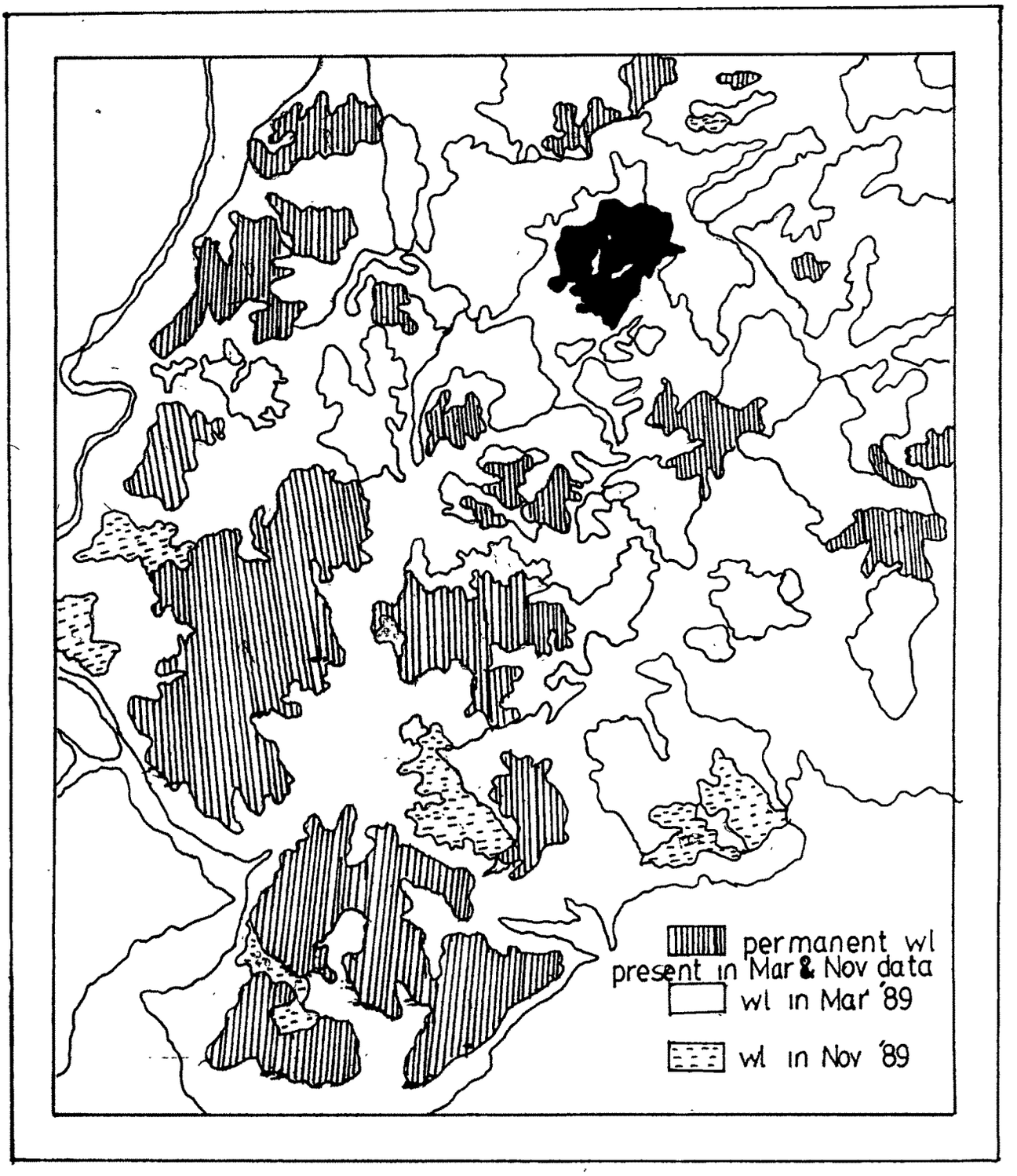


FIG 11 COMPOSITE MAPOF PRE & POST MONSOON DATA
Showing Permanent & Seasonal Waterlogged areas

Vatadra, Nandeli etc. (Fig. 12,13,14). (Plate 1)

The multidate analysis indicated clearly the increasing problem of waterlogging (Fig. 12,13,14). The surface moist soil observed in the south west zone in the year 1983 became permanently waterlogged by the year 1986 and 1989 in villages like Golana, Vaghatalav, Galliana, Varsada, Rohoni, Tarakpur, Panded, Vadgam, etc. The year 1986 was a severe drought year, Which is indicated by the shrinkage of the major waterbody ie Kanewal tank, in the photo interpreted data of 1986 as compared to the data of 1983 and '89. This could be the main reason for the permanently waterlogged areas of 1983 to get converted into the areas of surface moist soil supporting scanty vegetation in the villages like Padra, Budej, Bhimthalav, Gorad, Amaliara, Gudal etc. When excess of water was available in 1989, some of this surface moist category got converted into permanent waterlogged soil in Budej, Amaliara, Gorad etc. The above monitoring clearly indicated that the soil moisture could regulate the intensity of the waterlogging process and the water level of the water bodies and distributed systems played a great role in controlling this factor. Thus the multidate, analysis revealed that there was consistant increase in waterlogging in Khambhat taluka which ultimately resulted in saline degradation of the affected soils.

Quantification:

The waterlogged land was quantified using the photo interpreted maps of 1983 and 1986.(Table 4) There was as total

TABLE 4- Quantification of Water logged area from the Landsat FCC/MSS & TM

YEAR	Total area sq.km	Permanent Waterlogged area sq. km.	High soil moisture sq.km.
1983	353	181.5	171.5
1986	375.75	218.25	157.5

TABLE 5- Commision / Ommission Error

	Omission Errors		Commission		Correct	
	Total	%	Total	%	Total	%
Permanent waterlogged	0	0	0	0	21	100
Moist soil	1	7.7	1	7.7	12	92.3
Normal+salinity	1	6.2	4	20.0	15	93.7

* 99% accuracy at 85% confidence limit .

increase of 22.75 sq.km. in the waterlogged area of Khambhat taluka from the year 1983 to 1986. The total permanent waterlogged are exhibited on increase from 181.5 sq.km. in 1983 to 218.25 sq.km. in the year 1986, thus degrading 36.75 sq.km of land to severe permanent waterlogging within three years.However a reduction of 14 sq.km.and of high moist soil, was noticed during the year 1983 to 1986.(Table-4). Even though the quantification could not be carried out for the year 1989 due to the partial coverage of the study area in the image, there was a clear evident of sporadic spread of waterlogged areas year by year was observed in Khambhat taluka.The summery of commission and omission errors calculated for this quantified data indicated 100% accuracy at 85% confidence level. (Table-5)

Village level:

When the 1RS/1A-LISS-II information was expanded to 1:50,000 scale further categorisation of the waterlogged areas were possible.(Fig.15) The permanent waterlogged areas were differenciated into two sub categories,namely Dark blue and Medium blue based upon the tonal variation.The dark blue,which was found to be the permanent waterlogged land, while the light tone was found to be associated with salinity,as verified by the ground truth.Apart from these permanent waterlogged area, the soils with surface moisture was clearly delineated and were observed to have sparse vegetaion ,which was indicated in the image by a diffused, pink colour over blue tone.The villages Gorad,Amaliara,Padra etc, exhibited the second type of waterlogging. The permanent waterlogged area occured in the

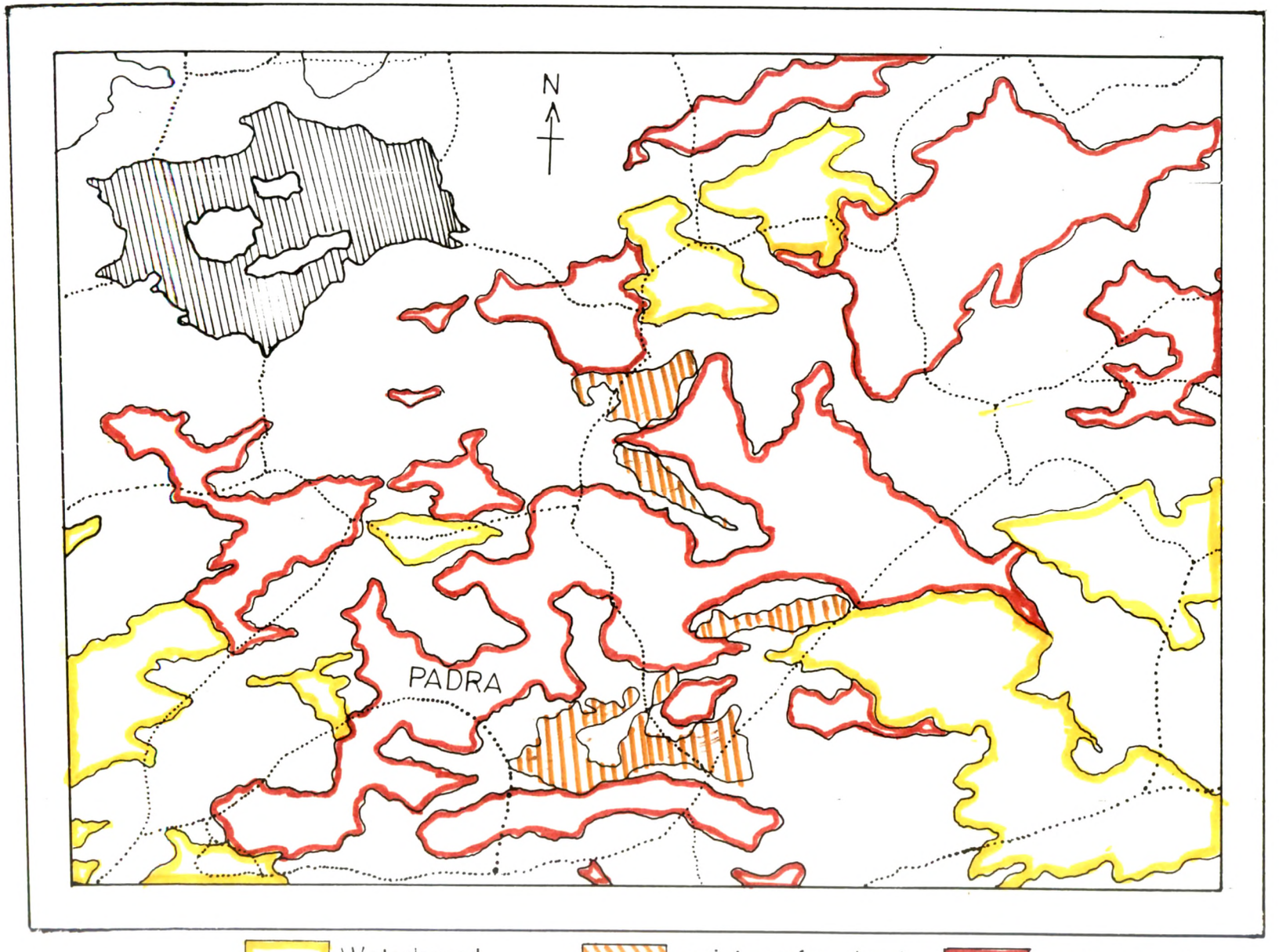


FIG .15. Delineation of Waterlogged areas in 1:50000 scale[IRS-1A LISS-II-1988]

villages like Khaksar,Padra, Jichaka, Kanpur, Mahiari, Bhudej etc and similarly the light blue tone was prevalent in all the villages studied in detail like Khakshar, Valli, Varsada, Rel, Padra, Jafrabad, Amaliara, Gorad, Chickalia, Moraj, Adruj, Malpur, Bhudej etc. Among these villages, all the categories of waterlogged land was observed in the villages Padra and Bhudej. An attempt carried out for identifying waterlogged areas with the survey number of plots, gave a general idea about the prevailing waterlogged areas in Padra village (Fig. 16; Table 6).

VEGETATIONAL STATUS

The vagetational status of Khambhat taluka was studied at 1:250,000 and 1:50,000 scale in photo interpreted map prepared by using the FCC images of Landsat/MSS acquired on May 1983, Landsat/TM of 1986, and 1RS-1A/LISS-II 1988 and 1989. The land degradation of the study area was clearly evidenced by the satellite data. During the visual interpretation the vegetation has been delineated in three categories based on their image characterestics, as

1. Dense vegetation with pink tone.
2. Sparse vegetation in waterlogged soil with diffuse red blue tone.
3. Vegetation in saline soil- with light pink on white tone.

The temperal analysis of vegetation using different years of 1983, 1986 and 1989, data indicated the sporadic extinction of

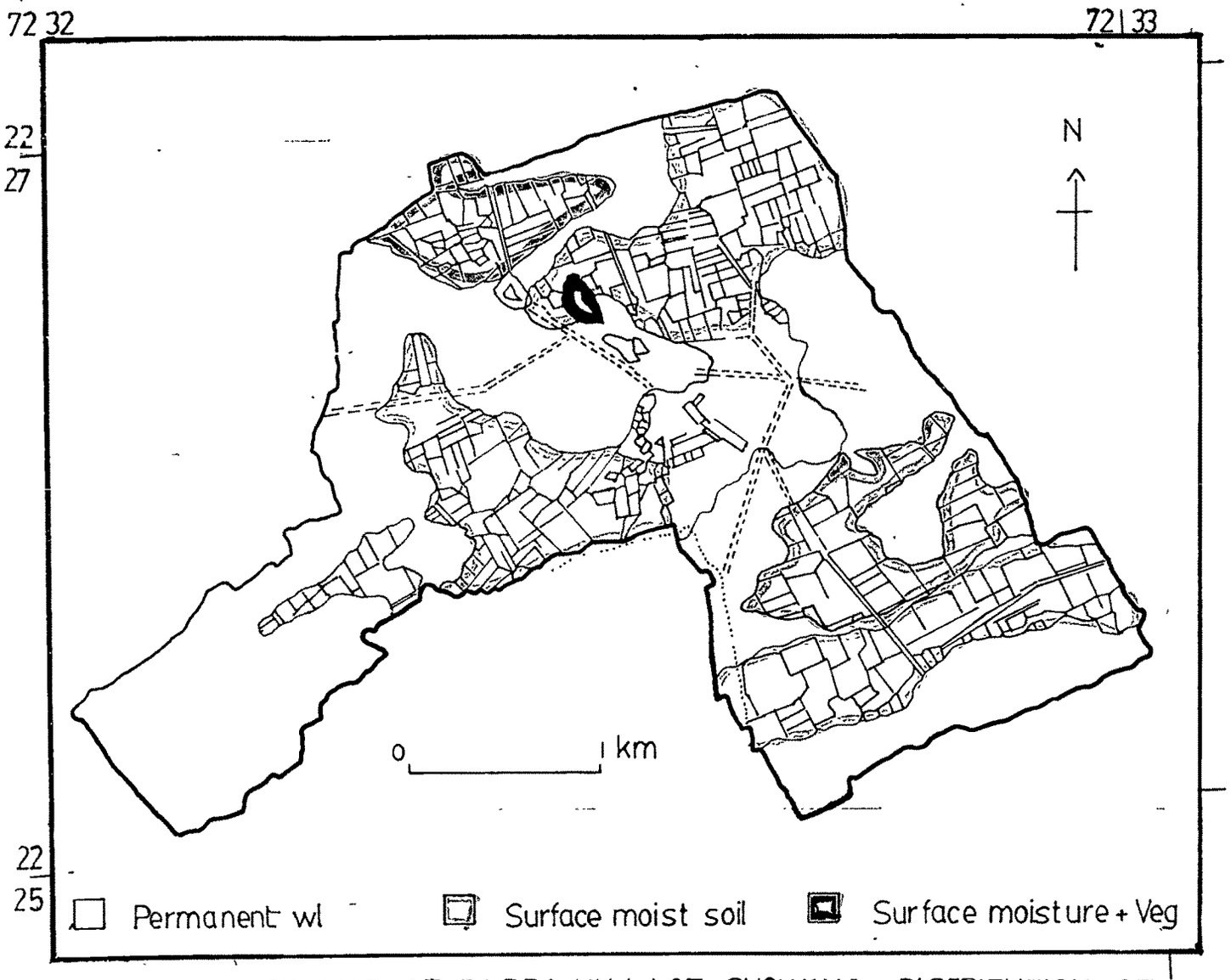


FIG.16. PLOTWISE MAP OF PADRA VILLAGE SHOWING DISTRIBUTION OF DIFFERENT CATEGORY OF WATERLOGGED AREAS IRS 1A LISS II 1988.

TABLE 6- Padra Village- Waterlogging area with survey numbers of plots identified from IRS -1A / LISS II

Permanent Water-logging	Surface soil moisture	Surface soil moisture with sparse vegetation
465		
466	1,2,3,4,5,12,13,15	152,159*,160,166,167 to 170
467	16,17,18,19,20,21,22,23,24	237,240,241,246 to 249
470	25,26,29,30,31,32,33,34,	251,252,254,255,259,268
471	35,36,37,38,39,44,45,46,47,51,	269,270,280 -287*
472	89,90,91,92,93,96,97,98,99,	294*295*,296
541	100,101,102,103,104,105,110-125,	624-654,669,671 to
542	130*,131*,146 to 151,153 to 158,	678,680,681,682,692 -
	159*,181 to 186,219,220	699.
544	222 to 236,250,251,260 to 267	
	290,291,299 to 316,320 326 to 328,	
546	330,331,332,334,335,336,337,	
547	339,340,341,343 to 348,350 to	
548	353,355,358,359 to 366,376	
	380 to 384,386,387,388,390	
	391*,392*,393,394*,420,421,422,	
	424,425,426,427,428,429,430 to	
	442,444, to 446,448,449,450 to	
	454*,531 - 533,574 to 577,580 -	
	583,660 661,665,666,667,668,697	
	to 700,701,702,703*,704,717 - 720,	
	723,725	

* Partially present

TABLE 7- Quantification of vegetation

Year	Total sq. km.	Dense veg. sq.km.	Sparse veg.in wl sq.km.	Sparse veg.in saline soil sq.km
1983	333.5	107	171.5	55
1986	311.5	114.5	157.5	39.5

vegetation in this taluka (Fig. 17,18,19) . Complete elimination of flora from the southern region of the taluka in the villages Fatepur, Vaghatalav, parts of Varsada, Golana, Vadgam, Tarakpur, Panded etc, and encroachment by the hazardous waterlogging and salinity, were observed. The increased level of sparse vegetaion were exhibited in the villages around Kenewal tank viz, Jichaka,Amaliara, Gorad, Budhej, Padra, Jafrabad, Chickhalia etc. during the year 1986 to 1989.

The seasonal study of 1989 using the pre and post monsoon season ie 1RS-1A/LISS II of March 1989, and November 1989, gave a real picture about the vegetational status of the area round the year (Fig. 19,20). Though the dense vagetation was observed profusely in eastern part of the area, in the pre monsoon season luxurient dense vegetation was recorded through out the taluka except in severely affected saline and waterlogging land, from the post monsoon remote sensing data.The area covered with sparse vegetation during March, was found to contain dense vegetation in post monsoon season.The vegetation in the saline area too increased in the post monsoon season. As a result of the monsoon activity in 1989, dense to sparse vegetation reappeared in patches in the villages of Fetepur, Gallina, Varsada, Golana, and Vadgam of the southern region, as interpreted from the post monsoon image.Village level study with 1:50,000 scale using the photointerpreted map of April 1989 1RS-1A image data revealed the negligible area for dense vegetaion,found in the villages in Khanpur, Jafrabad, Khaksar and Isanpur around kenewal tank. (Fig.21)

The vegetational status of the taluka was quantified for the year 1983 and 1986 by using visual interpretation of the summer data. A total area of 333.5 sq.km. in may 1983 and 311.5 sq.km.in March 1986 . Out of 1194.8 square kilometer of Khambhat taluka was found to be covered with vegetation, leaving the rest of the area bare. Out of this the sparse vegetational land was reduced gradually from the year 1983 to 1986. However, the differcence in dense vegetational cover from the 1983 to 1986 (Table-4) could be due to the presence of the crops in the cultivable lands in the eastern part of the taluka in the month of March 1986 as against that of May 1983 satellite coverage.

DIGITAL ANALYSIS

For the digital classification, the area covering 1340 sq.km which included 75% of Khambhat taluka was used. Based on the spectral responses and statistics of the different categories of waterlogged land, it was observed that the spectral separability was greater in band 2,3,4. The waterlogged areas appeared in light to dark blue tones in generated FCC with 2,3,4, because of the high absorption of radiation in soil, with a high moisture content and the standing shallow water in these areas. (Plate 6,7,8,9). This led further to classification and enhancement process.

Digitally waterlogged areas were catagorized into three namely, Permanent waterlogged, Surface waterlogged with salinity and Surface moisture soil with scanty vegetation. (Table 7A). Supervised classification of the vegetation, based on Greenness Vegetation Index (GVI) discreminated five classes as Dense,

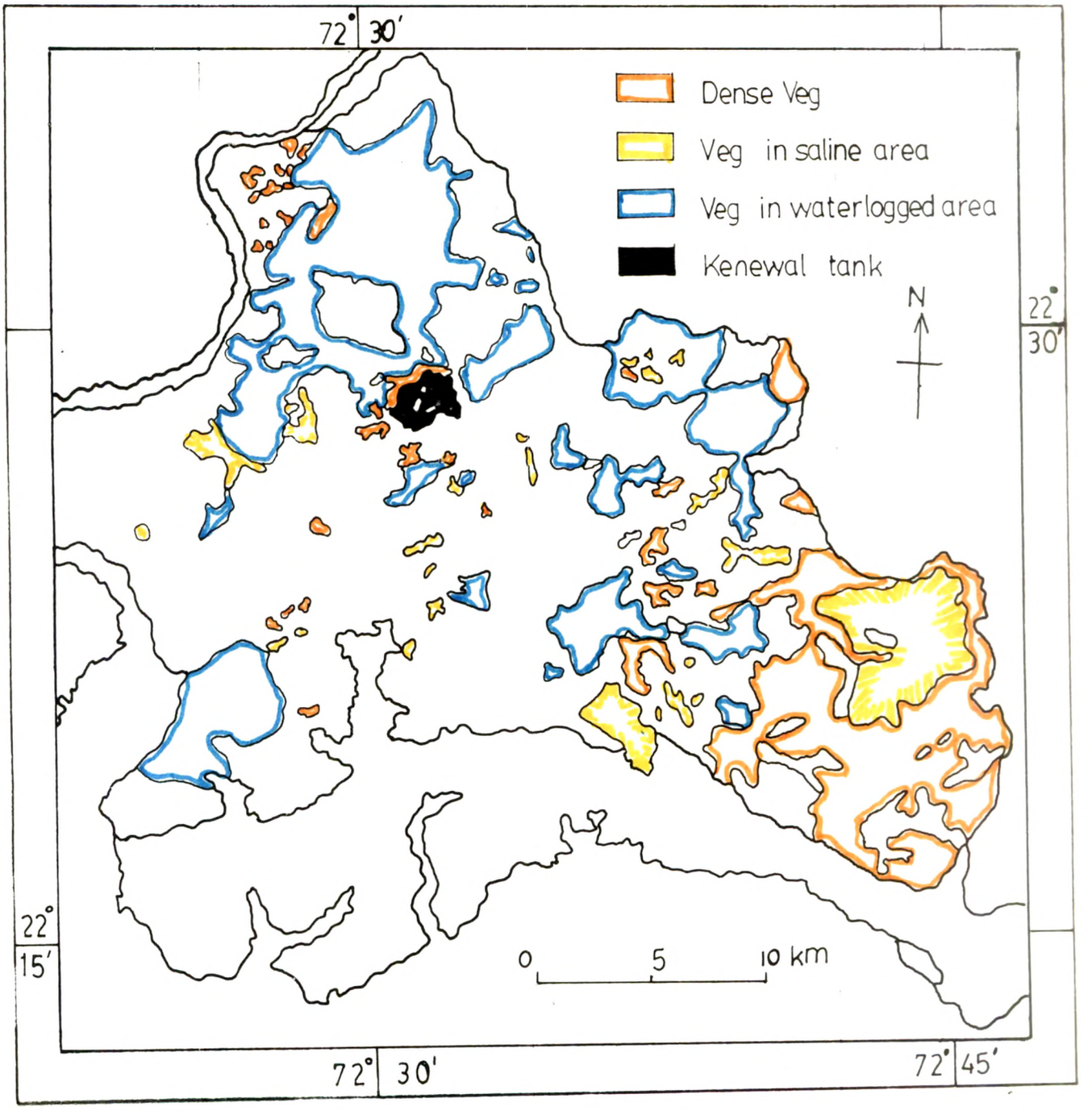


FIG-17-Vegetational status of KHAMBHAT Taluka from Landsat MSS '83

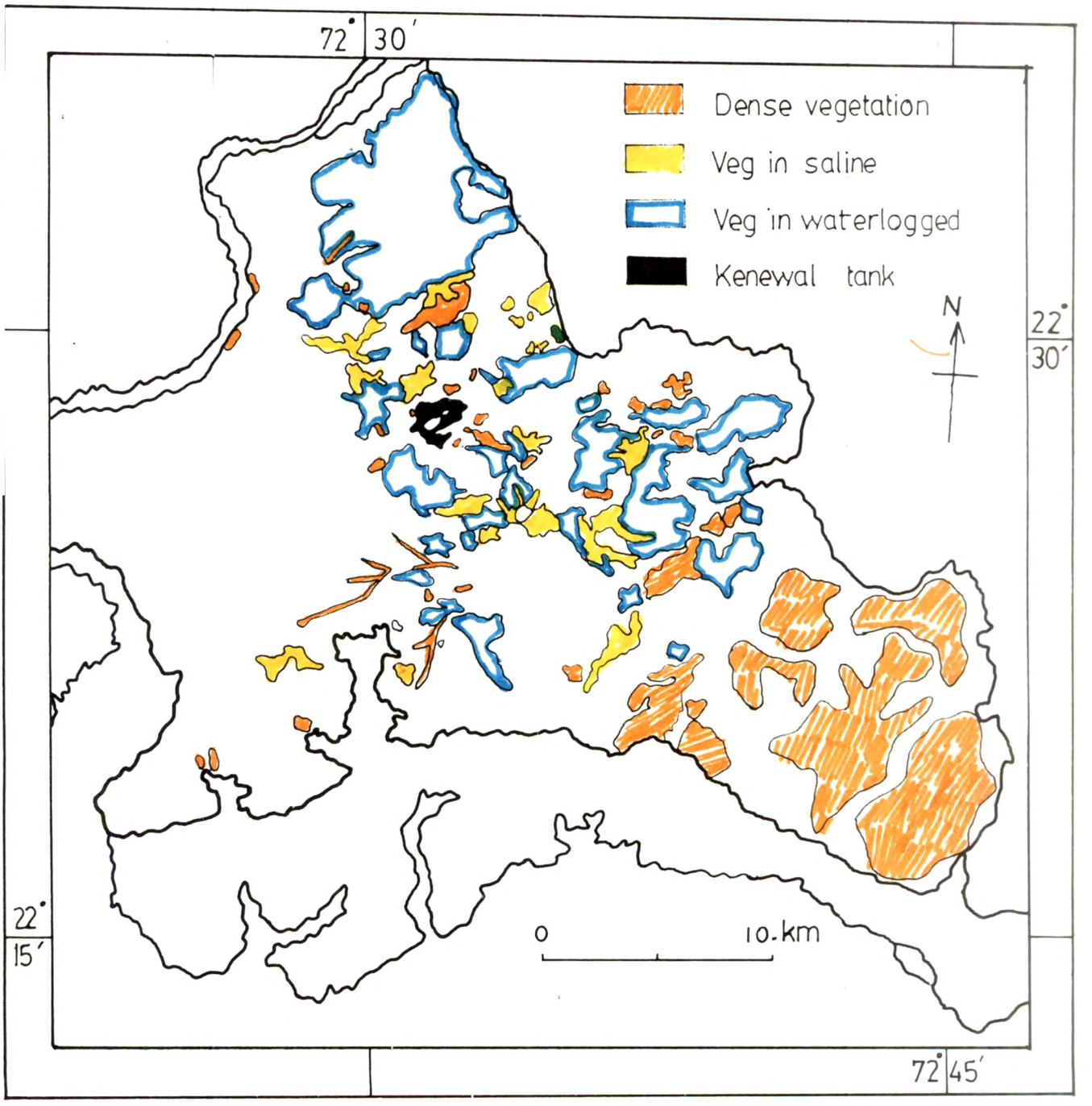


FIG.18. Vegetational status using LANDSAT TM 1986

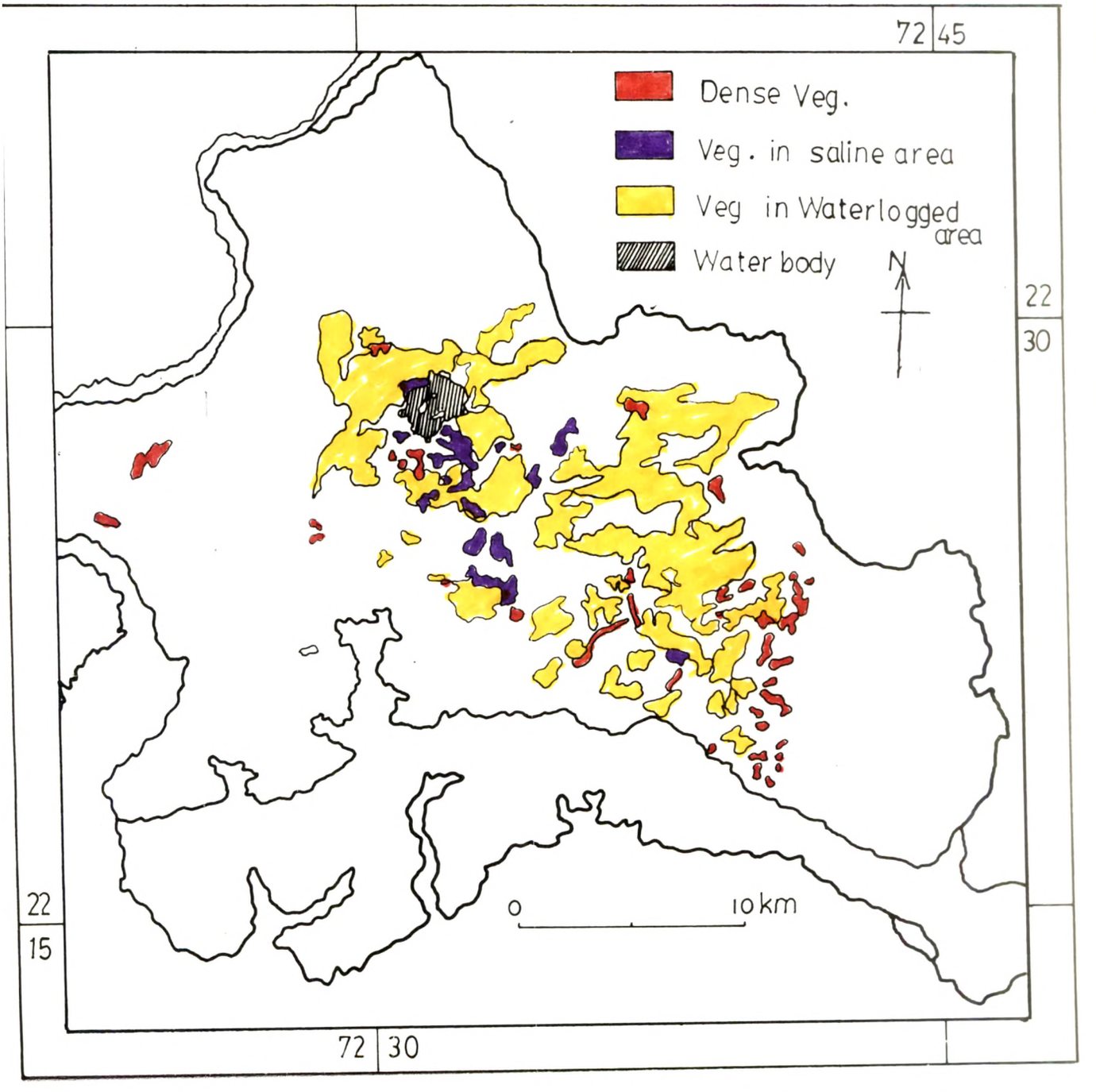


FIG.19. Vegetational status from IRS-1A/LISS II March 1989

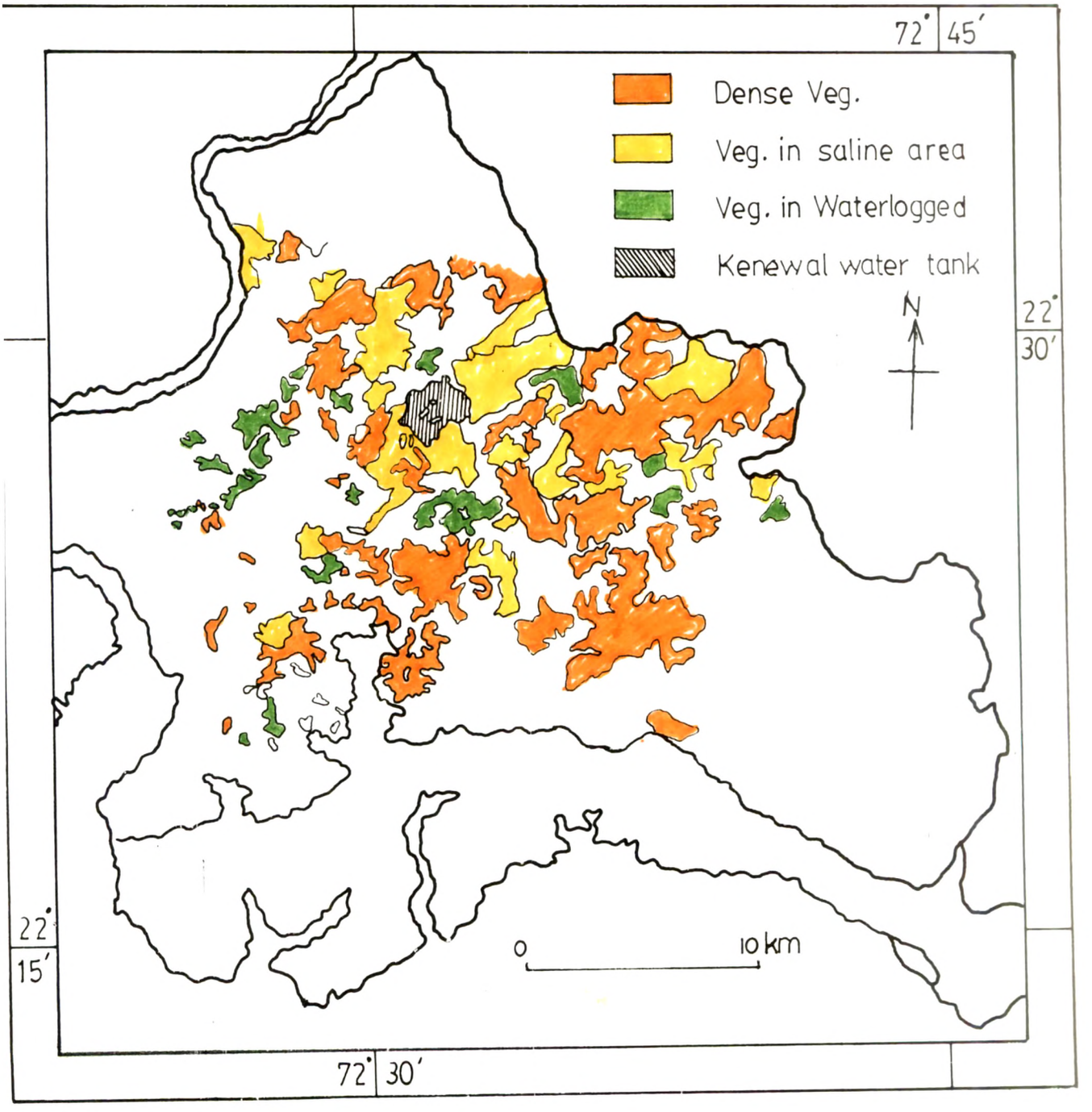


FIG.20. Vegetational status IRS-1A LISS II November 1989

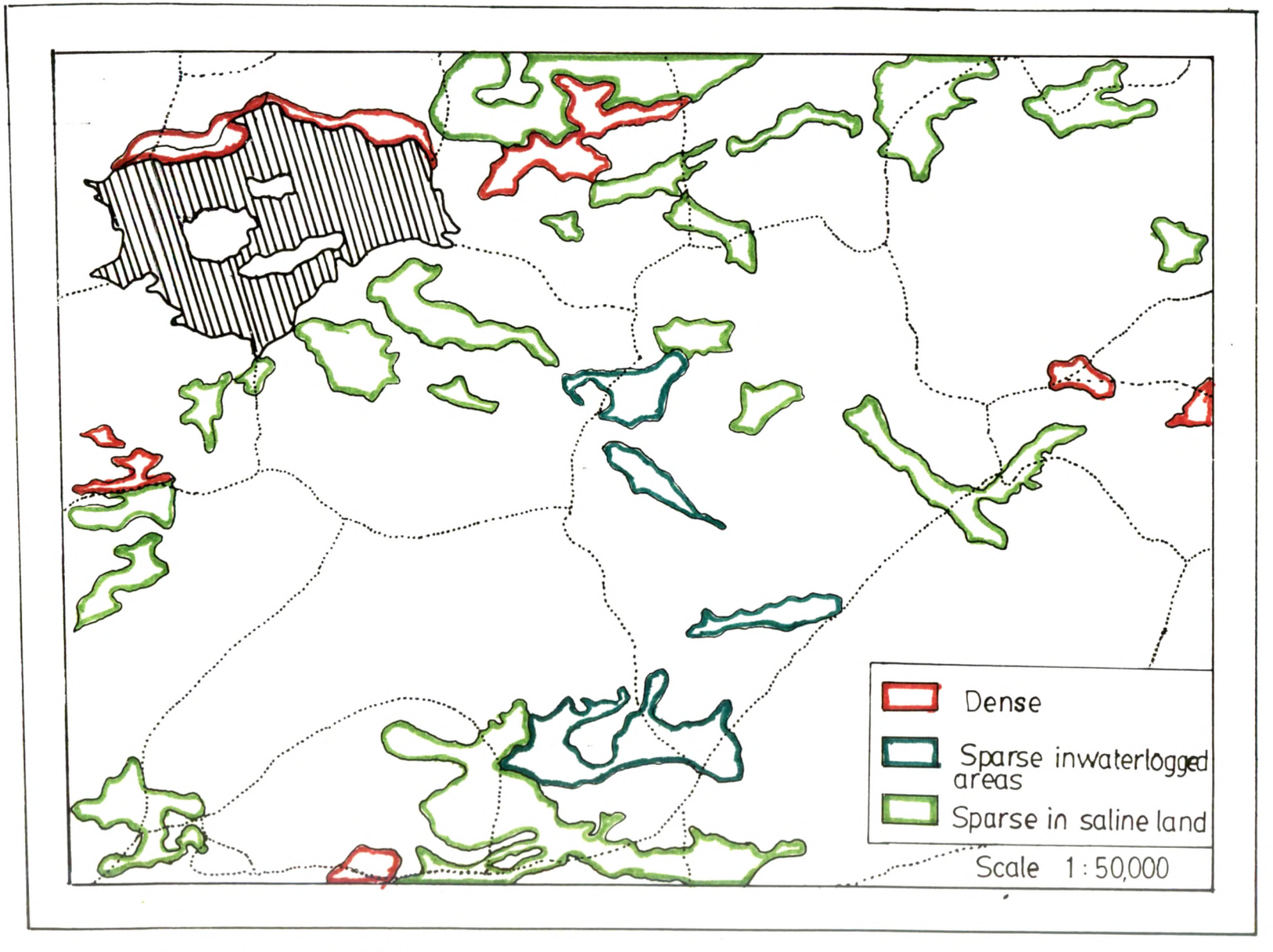


FIG.21. Detection of Vegetational Degradation at village level using IRS-1A-LISS II 1988

Plate 6,7,8,9 FCC of IRS -1A/LISS-II (2,3,4)

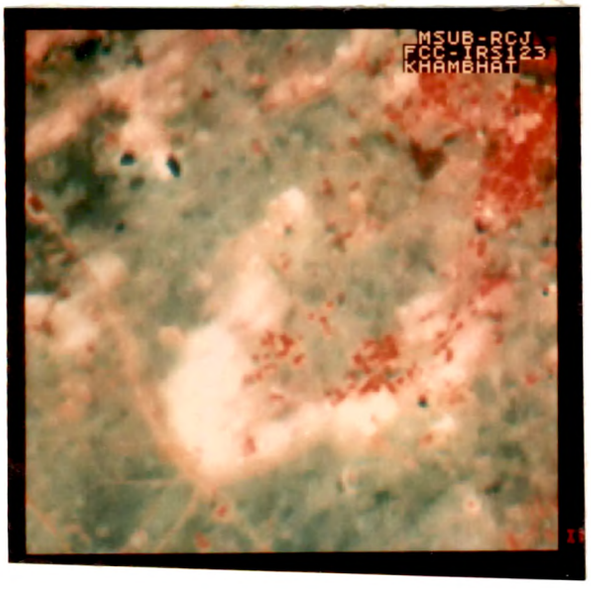


Plate 6

Plate 7

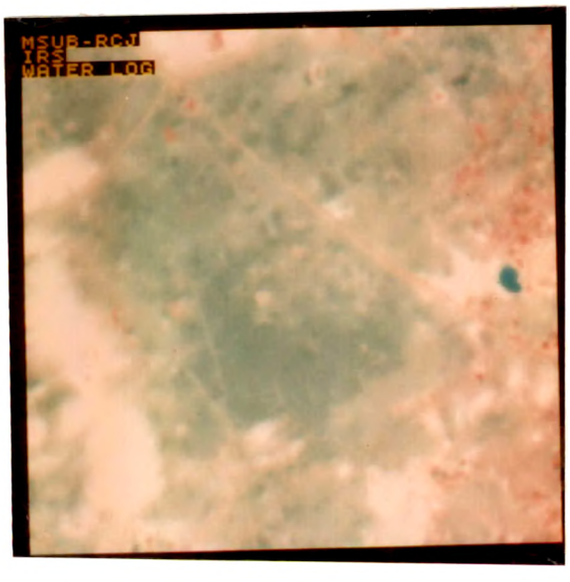


Plate 8

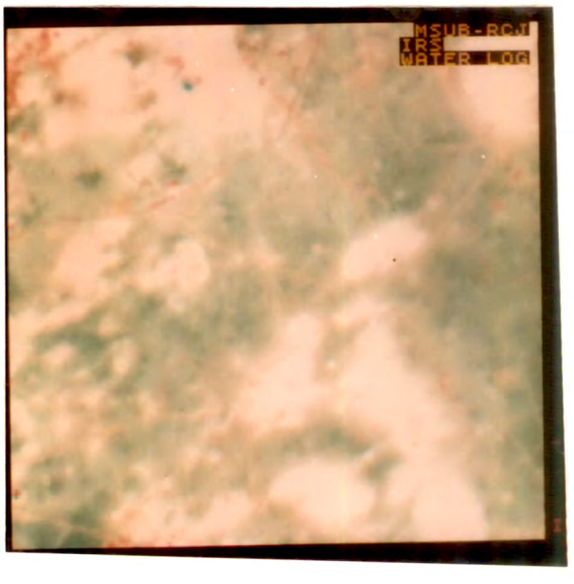


Plate 9

TABLE 7A - Supervised classification for Khambhat taluka

Category	Sq.Km.	ha
Surface waterlog (Dark blue tone)	35.60	3560.8
Waterlog + Veg. (Dark blue + pink)	108.90	10890.3
WL + salt affected (Light blue +white)	95.68	9568.0

Classification Algorithm : MXL (Supervised classification)

Data Used : CCT of IRS-1A/LISS II

Moderate, Less, Sparse and Nil. Vegetation, depicted by Red, Blue, Yellow, Pink and White color respectively. (Plate 10,11).

Attempt on different enhancement technique Soil Brightness Index yielded a very sharp separation of the wet soils in the order of flooded, wet soil and the wet land with sparse vegetation as dark blue, light blue and green in color respectively. However, mixing of dense vegetation with dark blue colour is occured in some areas. (Plate 12,13).

The ratioing technique with the band combination of band 1 and band 4 showed its superiority in identifying the waterbodies. The entire saline and waterlogged areas were dipicted in the form of yellow colour, which had been clearly separated from the vegetational and dry lands. However, discrimination between waterlogged areas and severe saline areas was not possible. In both simple and normalised ratio colour composite, saturated surface soil was exhibited as a red tinge over the yellow tone (Plate 14,15,16,17). Simple vegetation index (Band 4/Band 3) was also showed the sparse vegetation in both waterlogged and saline areas (Plate 18).

PHYTOSOCIALOGICAL STUDY

The phytosociological study conducted in the normal and as well as degraded waterlogged area to obtain the basic information on native species with a view to explore their utility in the effective management of the degraded waterlogged lands, yielded impressive results. Floristic analysis ofthe three communities existing in lands that are normal, surface moist and flooded, indicated only narrow decrease in the number of species from 21 to 17. (Table-8,9,10,11) (Plate -19). Floristic composition

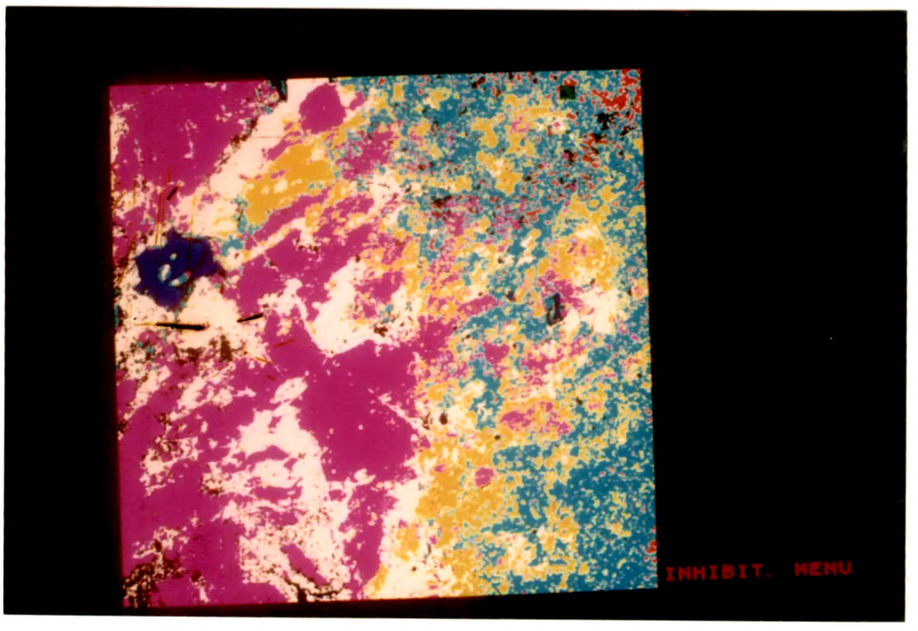


Plate 10 Supervised classification of vegetation showing different categories of vegetation.
Red -Dense; Light Blue - Medium; Yellow -low ;
Pink - Sparse; White-nil.

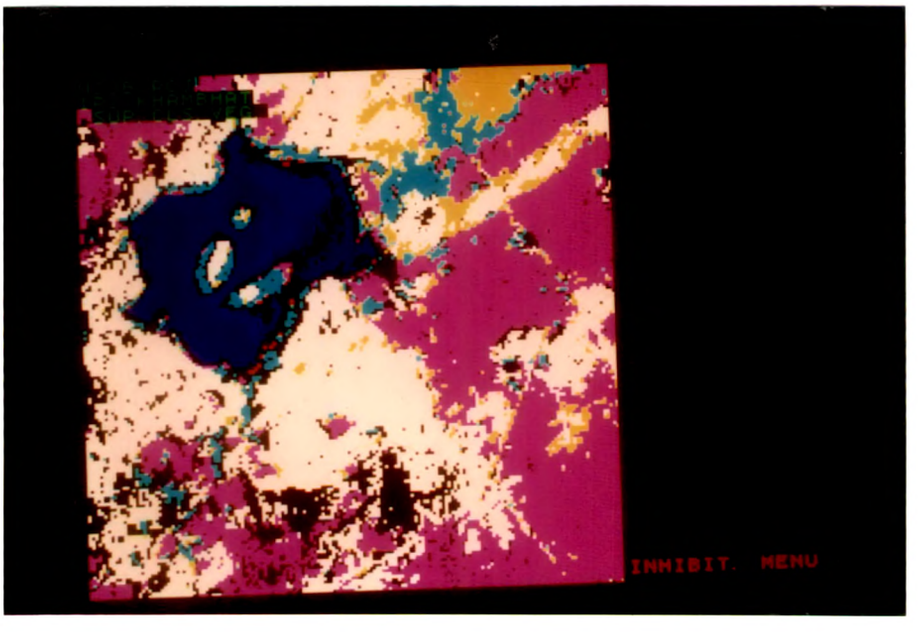


Plate 11 Supervised classification Zoomed.

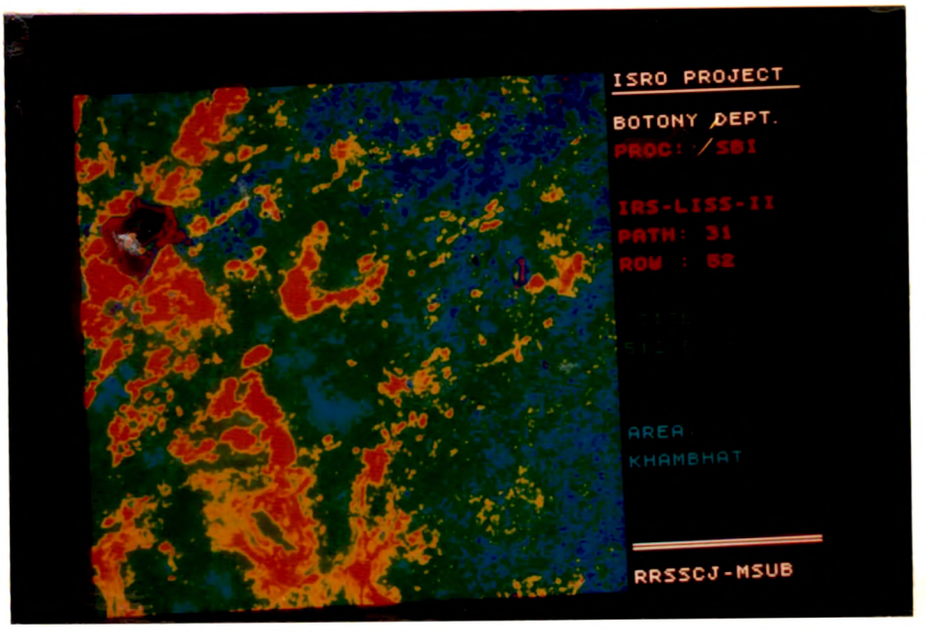


Plate 12 Soil Brightness Index exhibiting waterlogged areas in Dark blue, Light blue and green.

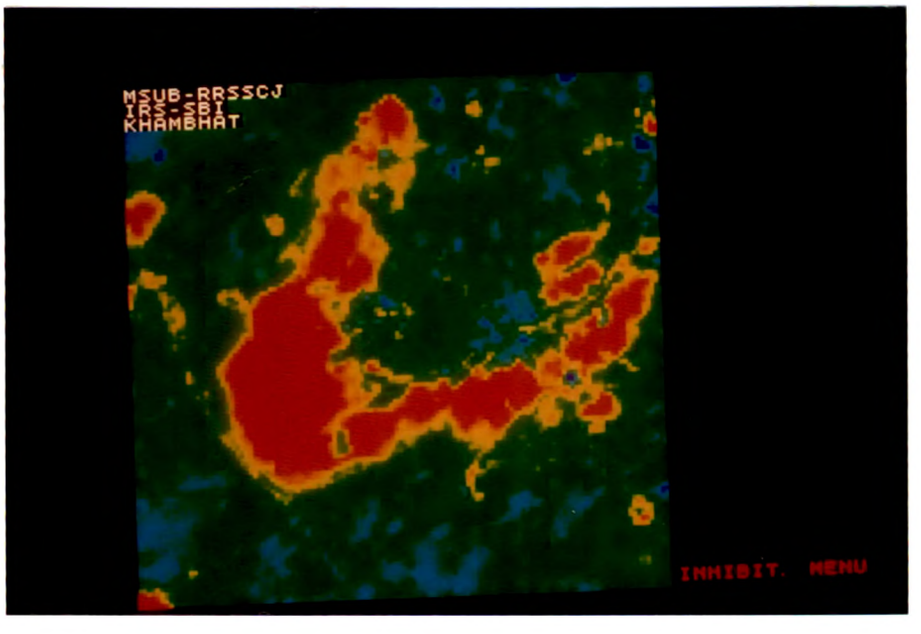


Plate 13 SBI-ZOOMED.
(Saline area exhibited in yellow and Red.)

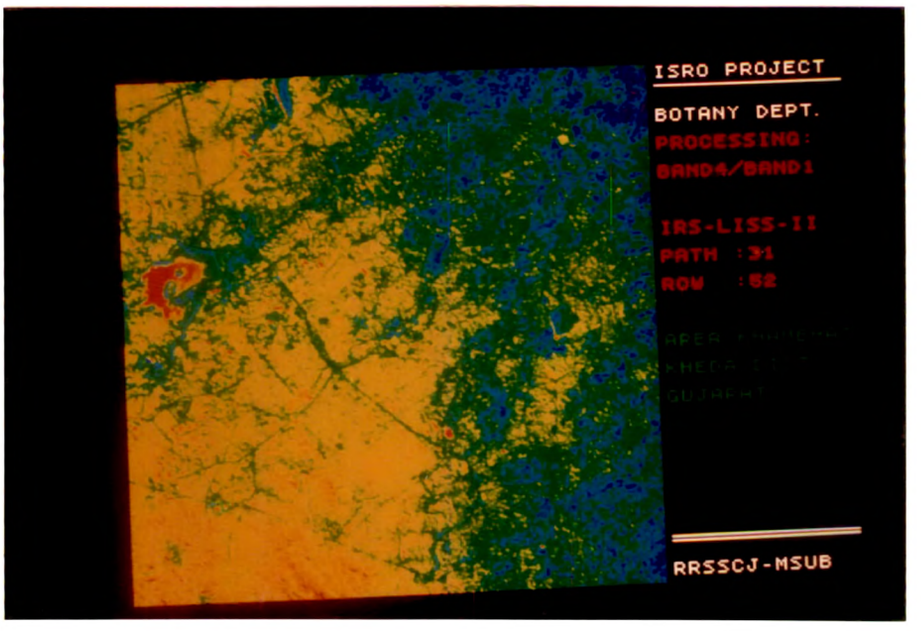


Plate 14 Ratioed output Band 1/4 exhibiting the water-logged and saline area in yellow colour.

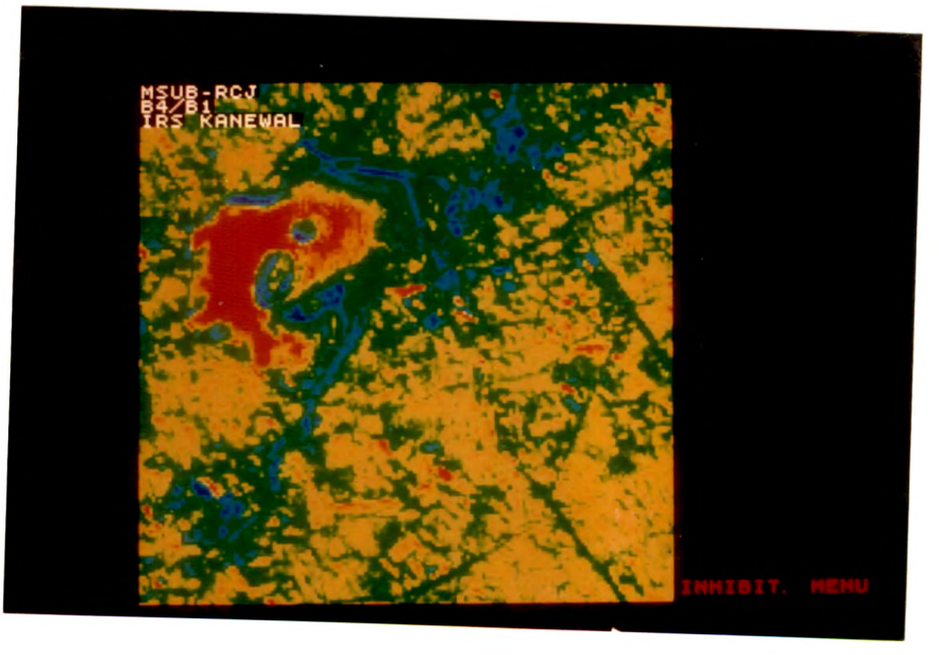


Plate 15 Zoomed ratioed output (1/4) image

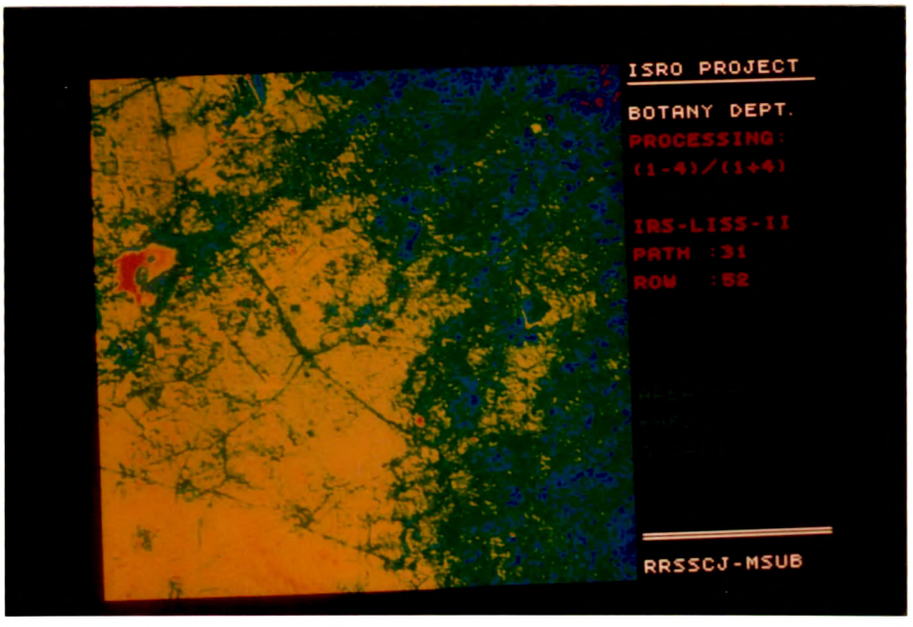


Plate 16 Ratioed colour composite (1-4/1+4) image

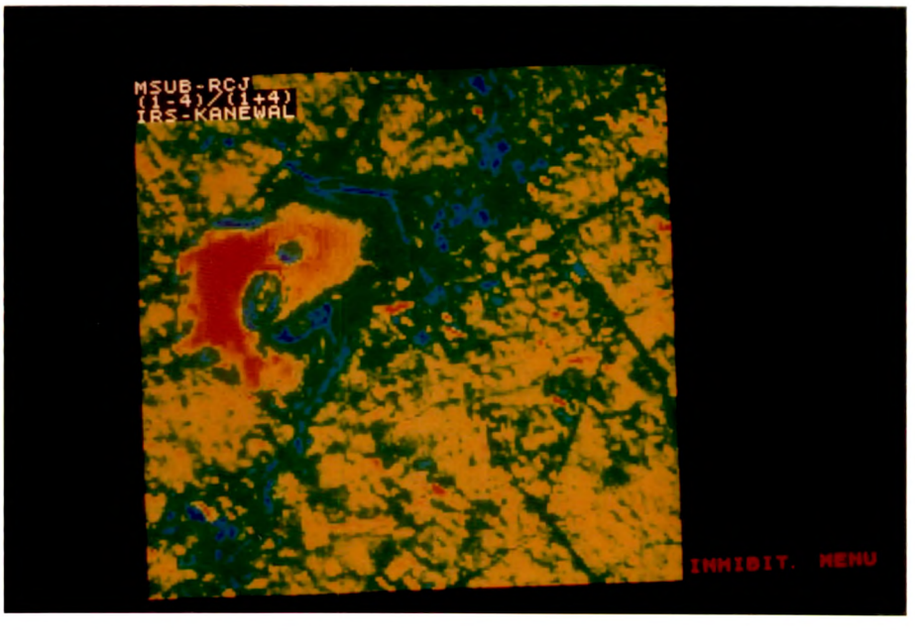


Plate 17 Ratioed image (1-4/1+4) Zoomed.

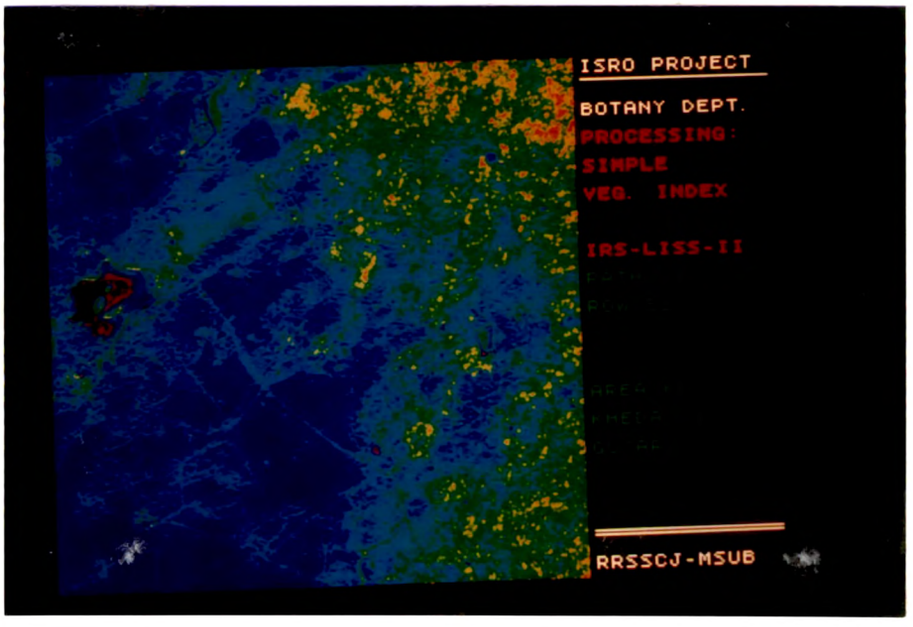


Plate 18 Simple vegetation Index (4/3) image showing levels of land degradation

Plate 19 Plant community in waterlogging areas of Khambhat taluka.

TABLE 8- Vegetational distribution in three types of community namely A: normal, B: Surface moist soil, C : flooded

No.	Name of the Species	IVI A	IVI B	IVI C	Frequency % A	Frequency % B	Frequency % C	Constancy %
1.	Acalypha indica	17.1	-	-	45	0.0	0.0	33
2.	Aeluropus lagopoides	-	52.3	-	0.0	45	0.00	33
3.	Aeruva lanata	5.3	-	-	15	0.0	0.0	33
4.	Alhagi pseudalagi	-	1.5	-	0.0	5	0.0	33
5.	Alternanthera pungens	9.3	-	2.05	20	0.0	5	66
6.	Alysicarpous monilifer	17.1	-	-	45	0.0	0.0	33
7.	Amarananthus spinosus	9.2	-	-	15	0.0	0.0	33
8.	Amaranthus viridis	4.8	-	-	15	10	-	66
9.	Ammania buccifera	8.8	6.7	-	25	20	0.0	66
10.	Blumia obliqua	6.7	28.1	-	20	25	0.0	66
11.	Centella asiatica	2.7	-	-	10	0.00	0.00	33
12.	Chara sps	-	-	10.2	0.00	0.00	10	33
13.	Chloris barbata	44.7	-	6.54	55	0.0	10	66
14.	Cleome gynandra	9	-	-	30	0.0	0.0	33
15.	Commelina benghalensis	9.7	-	3.1	25	0.0	5	66
16.	Cressa cretica	-	28.8	3.5	0.0	55	5	66
17.	Cynodon dactylon	54.8	13.1	48.2	65	15	15	100
18.	Cyprus sps	12.1	28	32.9	15	30	40	100
19.	Eclipta prostrata	-	3.6	-	0.0	10	0	33
20.	Euphorbia hirta	7.5	-	-	15	0.0	0.0	33
21.	Fimbrystylis	5.4	-	-	15	0.0	0.0	33

No.	Name of the Species	IVI A	IVI B	IVI C	Frequency % A	Frequency % B	Frequency % C	Constancy %
22.	Hygrophila auriculata	7.3	-	8.4	15	0.0	10	66
23.	Ipomea aquatica	-	-	11.2	0.0	0.0	15	33
24.	Ipomea carnea	-	-	2.6	0.0	0.0	5	33
25.	Ocimum canum	2.8	-	-	10	0.0	0.0	33
26.	Oryza sps	-	-	3.4	0.0	0.0	5	33
27.	Oryza sativa	-	-	4.3	0.0	0.0	5	33
28.	Panicum sps	7.4	2.2	37.4	15	5	45	100
29.	Prosopis chilensis	-	4.3	32.3	0.0	5	15	66
30.	Sagitaria sagitifolia	-	-	2.7	0.0	0.0	5	33
31.	Scirpus littoralis	-	37.4	34.7	0.0	20	30	66
32.	Sesbania bispinosa	-	1.7	-	0.0	5	0.0	33
33.	Stemodia viscosa	-	50.4	9.1	0.0	60	15	6
34.	Suaeda fruticosa	-	29.2	-	0.0	35	0.0	33
35.	Tamarix sps	-	2.6	4.5	0.0	5	10	33
36.	Trianthema portulacastrum	-	2.0	-	0.0	5	0.0	33
37.	Tridax procumbens	2.8	-	-	45	0.0	0.0	33
38.	Typha angustata	-	-	43.7	0.0	0.0	15	33
39.	Vernonia cinerea	29.5	-	-	60	0.0	0.0	33

no other authors

TABLE 9- Distribution of vegetation in normal land.

S.No.	Name of the species.	R.F.	Relative Density	Relative Dominance
1.	Acalypha indica	7.8	4.2	5.1
2.	Aerva lanata	2.6	1.7	1.0
3.	Alternanthera pungens	3.5	5.5	3.7
4.	Alysicarpous monilifer	7.8	5.5	3.8
5.	Amaranthus spinosa	2.6	2.7	3.9
6.	Amaranthus viridis	2.6	0.9	1.3
7.	Ammania buccifera	2.6	0.9	1.9
8.	Blumia obliqua	4.3	2.6	1.9
9.	Centella asiatica	1.7	0.52	0.51
10.	Chloris barbata	9.6	15.4	19.7
11.	Cleome gynandra	5.2	1.8	2.0
12.	Commelina benghalensis	4.3	3.2	2.2
13.	Cynodon dactylon	11.3	25.9	17.6
14.	Cyprus sps	2.6	4.6	4.9
15.	Euphorbia hirta	2.6	2.7	2.2
16.	Fimbrishtylis sps	2.6	1.5	1.3
17.	Hygrophila auriculata	2.6	2.2	2.5
18.	Ocimum canum	1.7	0.52	0.55
19.	Panicum sps	2.6	1.5	3.3
20.	Tridex procumbens	7.8	10.2	10.0
21.	Vernonia cinerea	10.4	8.1	11.0

TABLE 10- Vegetational distribution in moist surface land.

	Relative frequency	Relative density	Relative dominance
1. Aeluropus legopoides	12.7	17.2	22.4
2. Alhagi pseudalhagi	1.4	0.11	0.013
3. Amaranthus viridis	2.8	0.32	0.32
4. Ammania baccifera	5.6	0.75	0.38
5. Blumea sps	7.0	2.5	18.6
6. Cressa cretica	15.5	13.0	0.33
7. Cynodon dactylon	4.2	6.4	2.5
8. Cyperus sps	8.5	7.2	12.3
9. Eclipta prostrata	2.8	0.43	0.39
10. Panicum sps	1.4	0.32	0.45
11. Prosopis chilensis	0.4	0.11	4.3
12. Scripus littoralis	5.6	10.9	20.9
13. Sesbania bispinosa	1.4	0.11	0.17
14. Stemodia viscosa	16.9	33.5	0.005
15. Suaeda fruticosa	9.9	6.1	13.2
16. Tamarix sps	1.4	0.65	0.61
17. Trianthema portulacastrum	1.4	0.32	0.23

TABLE 11- Vegetational distribution in flooded land.

S.No.	Name of the speciés	Relative frequancy	Relative density	Relative Domifance
1.	Alternathera pungens	1.9	0.14	0.01
2.	Chara sps	3.8	6.1	0.25
3.	Chloris barbata	3.8	2.6	0.14
4.	Commelina benghalensis	1.9	1.1	0.08
5.	Cressa cretica	1.9	1.1	0.08
6.	Cynodon dactylon	5.7	13.1	20.4
7.	Cyprus sps	15.1	14	3.8
8.	Hygrophila auraculata	3.8	4.1	0.49
9.	Ipomea aquatica	5.7	4.7	0.75
10.	Ipomea carnea	1.9	0.57	0.11
11.	Oryza sativa	1.9	2.9	1.16
12.	Oryza sps.	1.9	2.1	0.26
13.	Panicum sps	17.0	16.7	3.74
14.	Prosopis cilensis	5.7	1.3	25.3
15.	Sagitaria sagitifolia	1.9	0.14	0.61
16.	Scripus littoralis	11.3	18.3	5.1
17.	Stamodia viscosa	5.7	3.4	0.00008
18.	Tamarix sps	3.8	0.57	0.09
19.	Typha angustata	5.7	9.4	28.6

indicated that the three grass species viz. Panicum antidotale Cynodon dactylon Pers and Cyprus rotundus L. Common in all three sites. Out of 39 species studied a total number 25 species i.e. 12 in normal, 6 in surface moist soil and 7 in flooded soil, were restricted to the particular site of study. Acalypha, Aeruva, Alycecarpous, Amaranthus, Centella, Cleome, Euphorbia, Fimbrystilis, Oscimum, Tridex, and Vernonia were found only in normal and Aeluropus, Alhagi Euclipta, Susbania, Suaeda, Trianthema, were in moist soil. (Table 8). In their frequency percentage calculated according to Raunkiers classes, the species Cynodon dactylon Pers Vernonia cinerea (L.) Less, Chloris barbata SW. showed higher percentage of frequency in the normal site. Similarly, Stemodia viscosa Roxb, Cressa cretica. L. in surface moist soil and Panicum antidotale, Cyprus rotundus L in flooded site exhibited the highest value of frequency percentage. The Frequency Diagram, prepared by using percentage of species under different Raunkier's classes, viz A,B,C,D,E for three communities followed A B C D in normal soil, A B = C in surface moist and A B C in the flooded site, against the normal frequency pattern of Raunkiaer i.e. A B C D E (fig.22).

The maximum value of Relative frequency, Relative Density and Relative Dominance was shown by Chloris barbata SW Cynodon dactyla Pers and Vernonia cinerea (L) Less in normal site. Stemodia Viscosa Roxb Cressa cretica L. Aleuropus lagopoides (Linn) Trin. and Suaeda fruticosa (Linn) Forsk (Table 9)exhibited the highest value of Relative frequency. Among these the first two showed the highest value in Relative Density. However, the

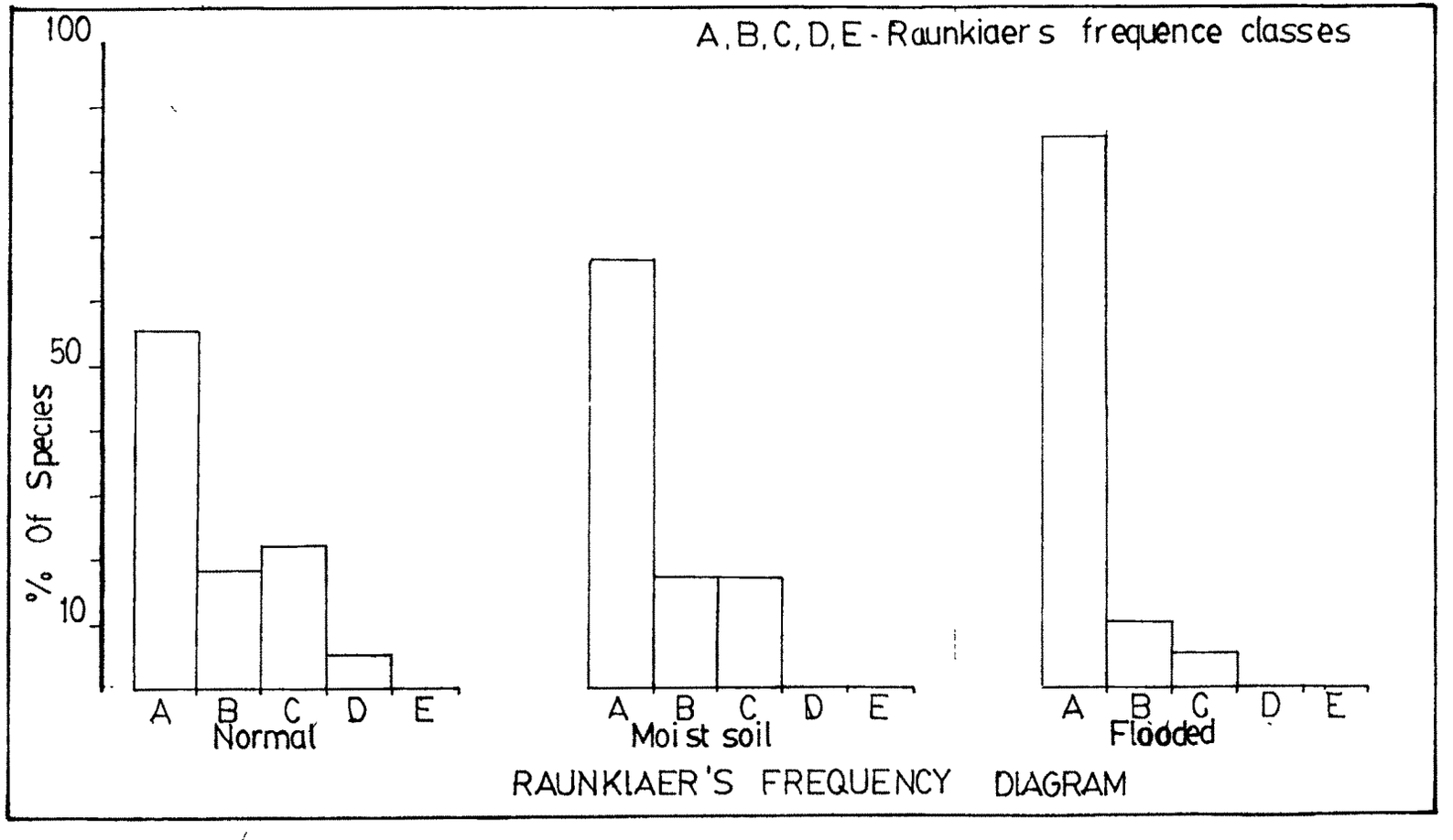

A, B, C, D, E - Raunkiaers frequence classes
100
50
10
% Of Species
A B C D E
Normal
A B C D E
Moist soil
A B C D E
Flooded
RAUNKIAER'S FREQUENCY DIAGRAM

FIG. 22.

Relative Dominance was shown by Scirpus litterolis Schrad. Var. Subulatus (Vahl) Chior. and leuropus lagopoides(Linn) Trin.in surface moist land. (Table 10).

In the case of flooded site, the highest values of RF, and Relative Dominance was exhibited by Panicum antidotale Scirpus litterolis and Cynodon dactylon Pers, Typha angustata. Bory & Chaub respectively (Table 11).

The maximum IVI value among the 21 species studied in normal site was shown by Chloris barbata SW., Cynodon dactylon Pers etc and Cynodon dactylon Pers, Typha angustata Bory and Chaub in flooded site, and Stemodia viscosa Roxb, Aleuropus lagopoides (Linn) Trin in surface moist soil had shown the maximum IVI values. The reduction and increases of IVI value was observed between the two communities depending upon the species. For example, the reduction of IVI value was observed in Chloris barbata Alternanthera sessilis (L.) R.Br., Commelina benghalensis. L. etc. from normal land to flooded site and Cressa critica L Scirpus litterolis from surface soil to flooded site etc. The increasing of IVI value were also observed in the case of Prosopis chilensis (Molina) Stuntz. and Scirpus litterolis where it increased from soil moisture to flooded site. (Table 8).

In all three sites the indices of similarity was lower than the dissimilarity between any two communities. The maximum similarity indices 0.44 was shown between the site of surface moisture and flooded site. The site A was dissimilar from the sites B & C. 84% dissimilarity was shown between the three sites (Table 12).

Diversity index of species ranged from 0.79 to 0.921 in

TABLE 12- Diversity indices of three different communities.

Indices	Normal(A)	Surface moisture (B)	Flooded(C)
Species Richness Index	6.92	5.39	6.32
Simpson's Index	0.079	0.21	0.15
Shannon Index	-0.0082	0.0023	-0.0074
Evenness Index	-0.006	-0.0019	-0.0058

Similarity Index	AB	BC	AC	ABC
	0.316	0.44	0.3	0.16
dissimilarity Index	0.684	0.56	0.7	0.84
Diversity Index	0.921	0.79	0.85	

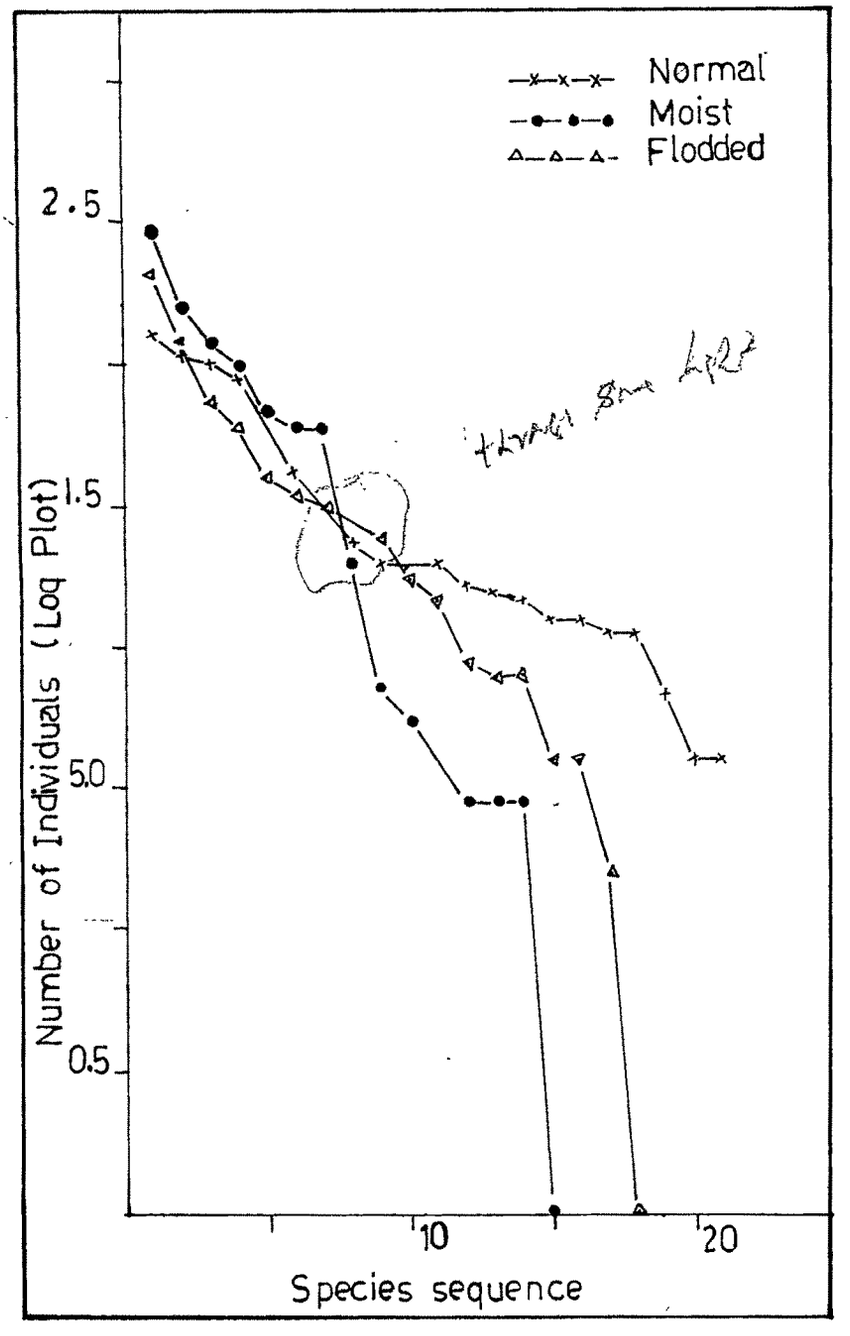


FIG 23 Species diversity curve

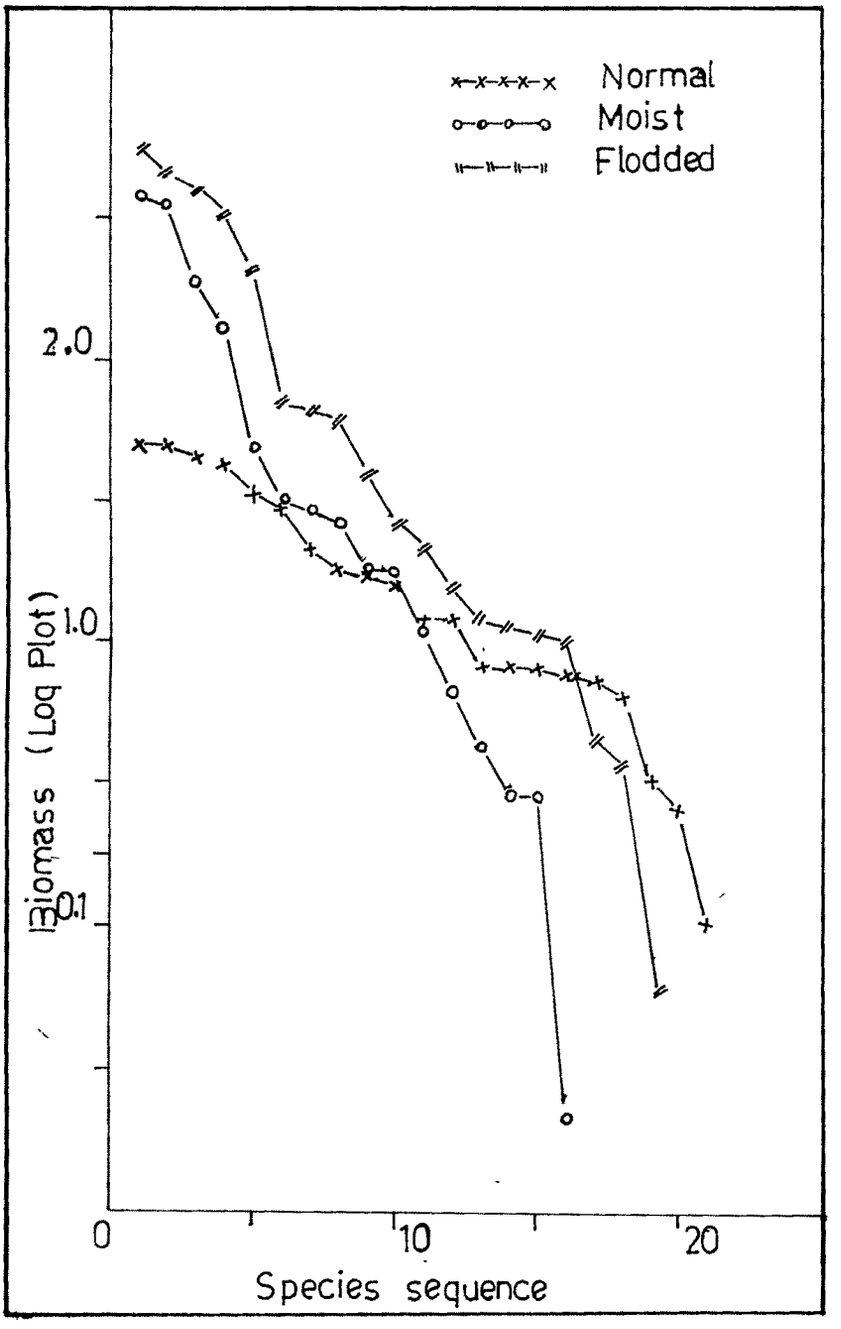


FIG 24 Species diversity curve-Biomass

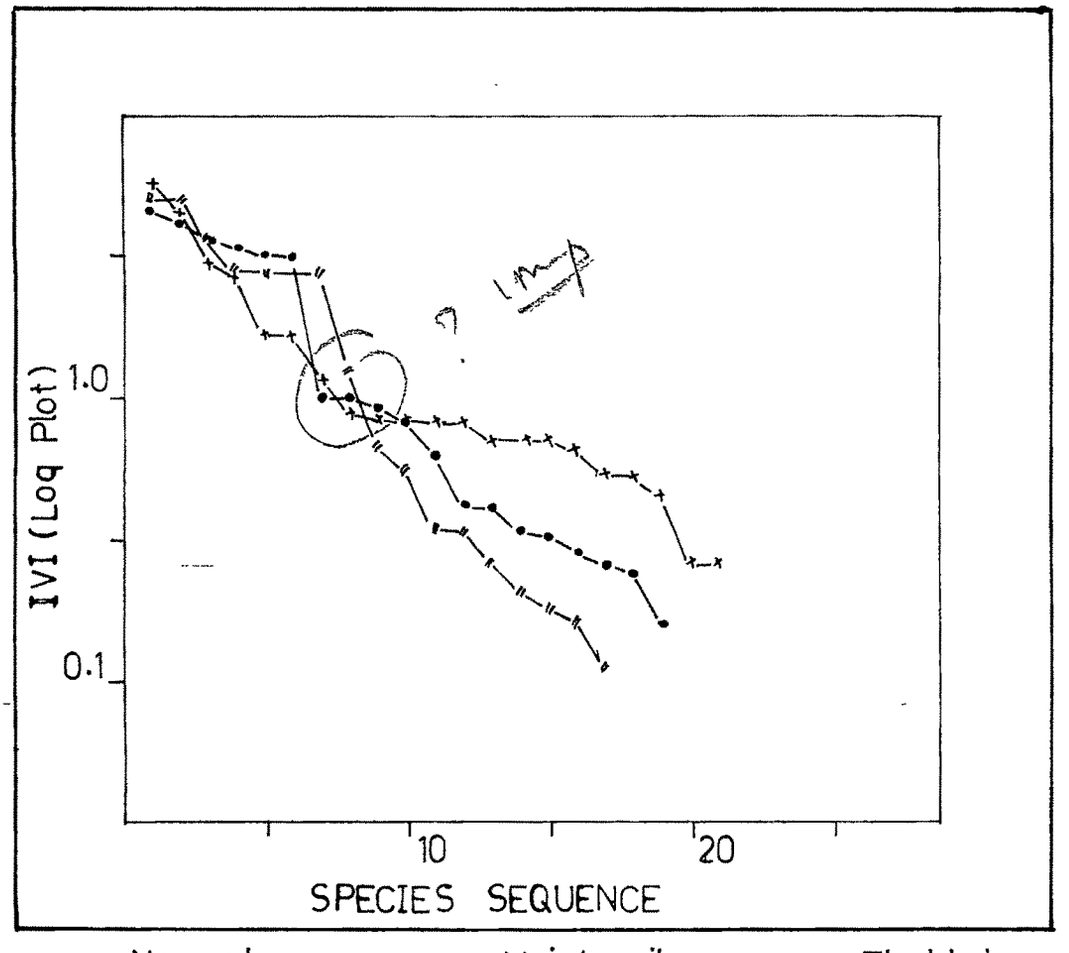


FIG 25 Species diversity curve - IVI

different sites (Table 12). There was a definite influence of waterlogging (either surface moisture or flooded) on species diversity. The surface soil moisture being conductive for maximum dominance.

The maximum richness index exhibited in normal land, and it reduced in flooded site and surface moist soil gradually.

Dominance of different species in relation to their availability of suitable niche and resource apportionment in a community have often interpreted from dominance diversity curves. The Dominance deversity curves ploted by using the important values like Number of individuals in a species (fig 23) Biomass (fig 24) IVI value (fig.25) was plotted on a log scale, against the species sequences, revealed that the curve of normal site was found to assume a normal form, while the curve of surface moist land, tended to assume a straight line from that of the flooded one, fitted best in the geo-metric series of niche-premption model. The difference between the normal site and others were distinct in the species diversity curve of species sequences of the number of species. It was also clear that the moist surface soil exerted more degree of stress than the others.

WATERLOGGING EFFECT AND ITS AMELIORATIVE MEASURES

Effect of waterlogging:

Germination:

Though the emergence of pearlmillet was not affected by waterlogging it had adversely effect on the coleoptile and

TABLE 13- % emergence of radicle under Waterlogging condition at different time intervals.

Treatment	% of Emergence at Time intervals		
	18 hrs.	40 hrs.	64 hrs
Control	83 (2.5)	91 (1.9)	92 (1.2)
Waterlogged	85 (1.6)	91 (2.4)	93 (1.9)

* (S.E Values are in Paranthesis)

TABLE 14- Effect of Waterlogging on the growth of 7 day old coleoptile and Radicle.

		Control	Waterlogging
Length (cm)	Coleoptile	5.7 (0.13)	3.5 (1.0)
	Radicle	10.1 (0.52)	7.1 (0.76)
Fresh weight in mg.	Coleoptile	0.21 (0.02)	0.14 (0.07)
	Radicle	0.08 (0.01)	0.003 (0.0008)
Dry Weight (mg)	Coleoptile	0.019 (0.0004)	0.008 (0.002)
	Radicle	0.011 (0.0002)	0.003 (0.0006)

(S.E Values are in paranthesis)

radicle growth as evidenced by the growth measurements on the 7th day (Table 13 and 14). The radicle was inhibited highly under waterlogged conditions. The length of the radicle was affected by 3o% and the fresh and dry matter accumulation of the root was affected by 93% to 73% respectively. Interestingly , even though the length of coloptile was affected by 21%, the fresh matter accumulation indicated inhibition of 33%. The dry weight of coleoptile was affected by 58% as against 73% inhibition as against 73% inhibition in the root system.The radicle in the waterlogged conditions were lacking the root hairs in contrast to the profuse root hair grown in the control. (Plate -20)

Growth:

The result of the experiments showed that the root zone waterlogging had a general tendency to decrease the growth of Pennisetum typhoides cultivars. GHB-32,MH-179 & BK- 560 as indicated by the experiments carried out in the Kharief season of the year 1988 and 1989. The height of the shoot- system was inhibited adversly.(Fig. 26 and 27) (Plate 21,22,23,24) However, the fresh and dry matter accumulation of the shoot system and leaves were also decreased, but not significantly (Table 15,16,17,18). Similarly the decrease in the leaf area index (LAI) of the experimental cultivars by waterlogging was not significant (Table 19) . Though the drymatter accumulation did not register a significant decrease; in waterlogging, the relative growth rate(RGR) of the peart millet was adversly affected. Both the cultivars (GHB-32,MH-179) had different pattern of growth, which

Plate 20 germination of P. typhoides

Plate 27

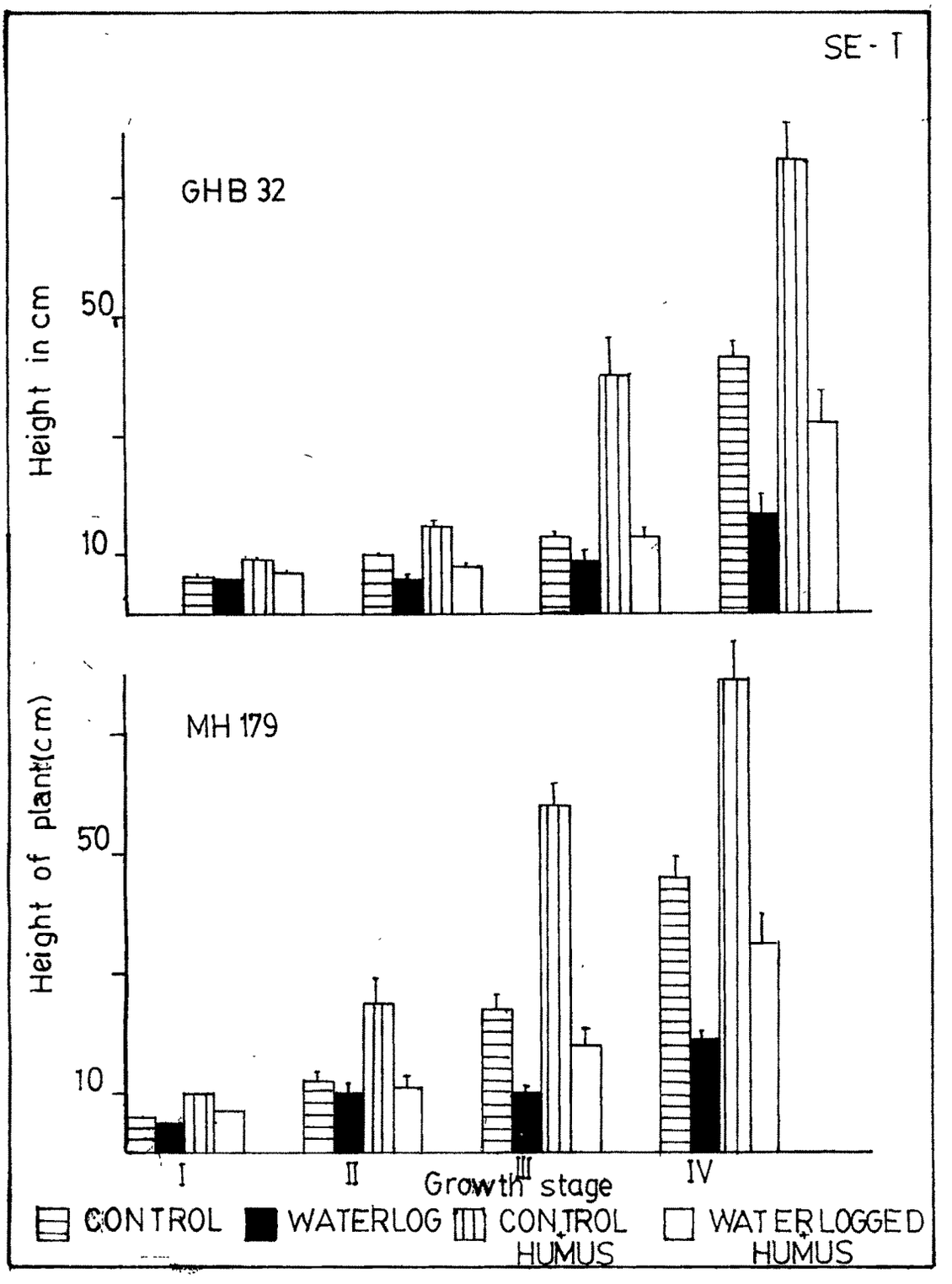


FIG.26. Height of P typhoides cv GHB 32 MH 179

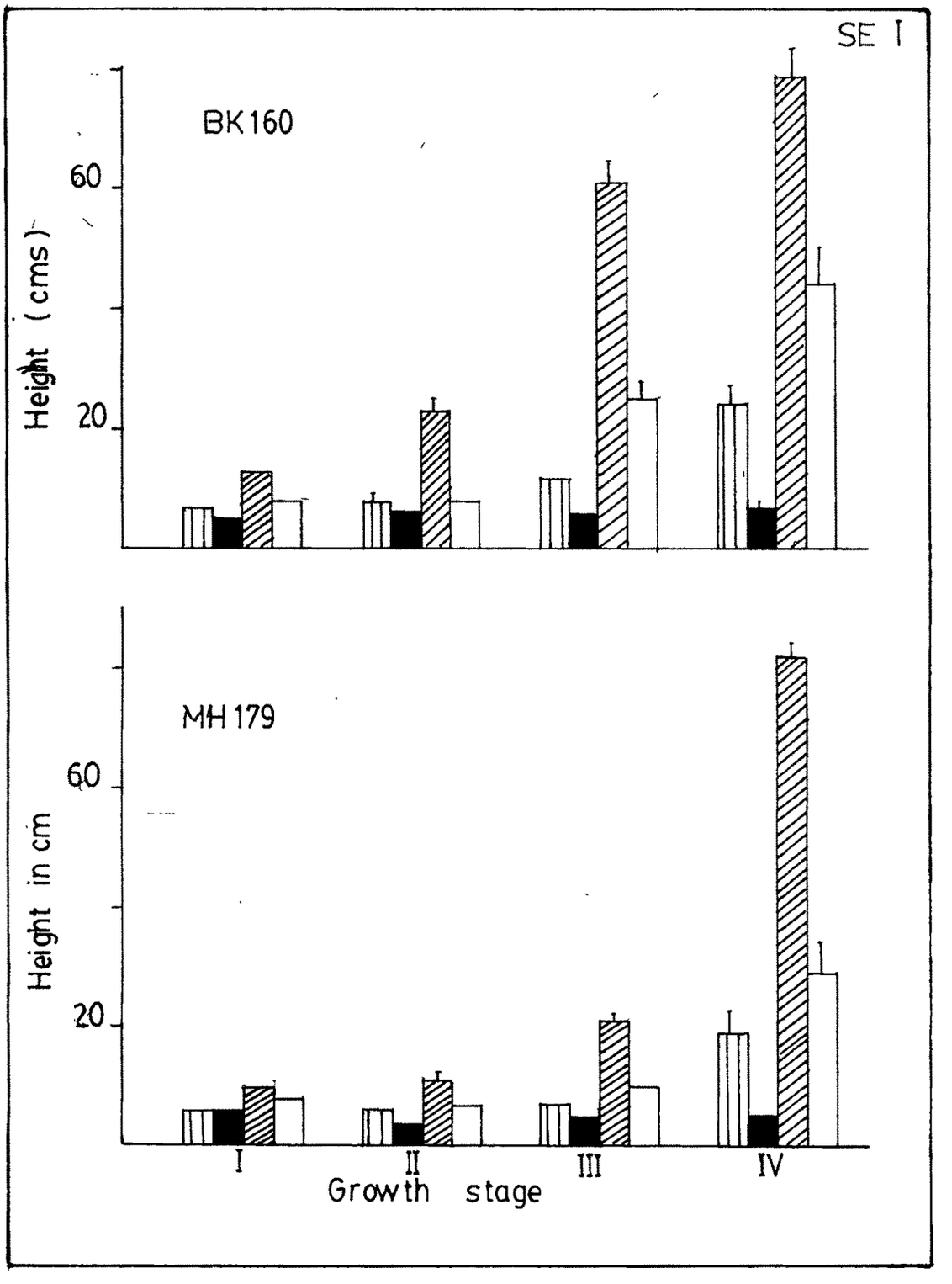


FIG. 27. Height of pearlmillet

ABLE 15- Change in the Fresh weight of Pennisetum typhoides cv GHB-32 and MH-179 of different parts like leaf, stem and aerial part, under Waterlogging stress.

resh wt.		GHB - 32				MH - 179				LSD.	
	Stage	H0W0	H0W1	H1W0	H1W1	H0W0	H0W1	H1W0	H1W1	5%	1%
	I	0.41	0.27	1.2	0.98	0.24	0.29	1.0	0.54	0.22	0.32
eaf	II	0.89	0.6	2.6	1.21	0.88	0.56	2.1	0.71	0.56	0.81
	III	1.2	0.45	3.9	1.4	0.92	0.35	2.8	0.69	0.56	0.81
	I	0.25	0.17	0.61	0.37	0.15	0.17	0.61	0.36	0.1	0.15
tem	II	0.63	0.38	1.8	0.7	0.7	0.53	2.1	0.69	0.42	0.62
	III	0.88	0.37	5.2	1.3	1.11	0.33	4.9	0.76	1.0	1.5
	I	0.66	0.44	1.6	1.2	0.39	0.46	1.6	0.89	0.37	0.54
hoot	II	1.52	0.98	4.4	1.7	1.58	1.1	4.2	1.4	0.87	1.26
	III	2.08	0.81	9.1	2.7	2.03	0.68	7.7	1.4	1.39	2.0

BLE 16- Effect of Waterlogging and additional humus on the fresh wt. of the plant at different growth stages(BK-560,MH-179)

	BK-560				MH-179				LSD	
	HOWO	HOW1	H1WO	H1W1	HOWO	HOW1	H1WO	H1W1	5%	1%
I	0.26	O.11	1.9	0.64	0.16	0.14	0.8	0.48	0.05	0.07
II	0.32	0.17	1.96	0.71	0.16	0.11	1.3	0.47	0.32	0.47
EAFIII	0.45	0.21	2.3	1.2	0.32	0.18	3.2	1.01	0.46	0.67
IV	0.34	0.15	2.31	0.68	0.41	0.12	2.8	0.8	0.51	0.74
I	0.18	0.O8	1.1	0.4	0.1	0.11	0.45	0.3	0.17	0.25
II	0.19	0.1	1.7	0.46	0.09	0.22	0.76	0.27	0.24	0.35
EM III	0.34	0.16	3.8	1.3	0.19	0.13	2.2	0.62	0.61	0.89
IV	0.53	0.15	6.89	1.5	0.57	0.12	7.2	1.3	1.2	1.7
I	0.43	0.19	3.03	1.04	0.27	0.25	1.3	0.79	0.42	0.62
II	0.51	0.27	3.6	1.16	0.25	0.32	2.1	0.75	0.51	0.74
OOT III	0.79	0.36	6.1	2.5	0.51	0.31	5.3	1.7	1.0	1.5
IV	0.87	0.3	9.2	2.2	1.08	0.25	10.1	2.09	1.5	2.2

TABLE 17- Changes in the dry matter accumulation at different stages of growth of pearl millet by addition of Humus under waterlogging condition

Dry weight of	Stage	GHB - 32				MH - 179				LSD.	
		H0W0	H0W1	H1W0	H1W1	H0W0	H0W1	H1W0	H1W1	5%	1%
Leaf	I	0.04	0.04	0.1	0.08	0.03	0.04	0.1	0.07	0.07	0.1
	II	0.18	0.06	0.45	0.15	0.17	0.07	0.35	0.14	0.07	0.1
	III	0.24	0.1	0.82	0.29	0.2	0.09	0.49	0.17	0.09	0.12
Stem	I	0.03	0.02	0.04	0.04	0.02	0.02	0.05	0.04	0.14	0.02
	II	0.07	0.04	0.19	0.08	0.05	0.08	0.38	0.2	0.05	0.07
	III	0.12	0.08	0.69	0.22	0.17	0.07	0.76	0.17	0.28	0.41
Shoot	I	0.07	0.06	0.14	0.13	0.05	0.06	0.15	0.1	0.03	0.04
	II	0.24	0.09	0.64	0.23	0.15	0.13	0.56	0.27	0.11	0.16
	III	0.36	0.18	1.5	0.5	0.37	0.16	1.2	0.34	0.22	0.32

E 18- Effect of Waterlogging and Ameliorative value of Humus content under waterlogging stress, on the dry matter accumulation of pearlmillet cultivar BK - 160 & MH - 179.

	BK - 160				MH - 179				LSD	
	H0W0	H0W1	H1W0	H1W1	H0W0	H0W1	H1W0	H1W1	5%	1%
I	0.04	0.02	0.24	0.09	0.02	0.03	0.12	0.07	0.03	0.04
II	0.06	0.03	0.34	0.2	0.04	0.02	0.24	0.06	0.07	0.1
III	0.09	0.04	0.42	0.22	0.06	0.04	0.5	0.18	0.08	0.12
IV	0.09	0.04	0.7	0.18	0.11	0.03	0.81	0.17	0.29	0.42
I	0.02	0.01	0.11	0.05	0.01	0.01	0.05	0.05	0.01	0.014
II	0.04	0.02	0.22	0.09	0.015	0.02	0.09	0.07	0.025	0.04
III	0.05	0.03	0.56	0.23	0.03	0.02	0.24	0.1	0.07	0.09
IV	0.10	0.03	1.5	0.34	0.07	0.05	1.3	0.29	0.32	0.47
I	0.06	0.03	0.35	0.14	0.04	0.04	0.17	0.11	0.03	0.05
T II	0.1	0.06	0.57	0.29	0.05	0.04	0.33	0.13	0.09	0.12
III	0.14	0.07	0.97	0.46	0.08	0.06	0.74	0.28	0.15	0.22
IV	0.2	0.07	2.25	0.5	0.18	0.08	2.1	0.46	1.0	1.5

BLE 19- Effect of waterlogging and addition of humus, on the Leaf Area Index at the different growth stages of pearl millet plant

	GHB32				MH179				LSD	
	HOWO	HOW1	H1WO	H1W1	HOWO	HOW1	H1WO	H1W1	5%	1%
	1.2	0.94	2.86	1.49	0.62	0.64	1.97	0.88	0.97	1.4
	1.0	0.65	3.4	1.7	0.96	0.7	3.1	0.75	1.5	2.1
I	1.17	0.73	3.8	1.5	1.0	0.49	2.5	0.75	1.2	1.8
	1.1	0.58	3.38	1.03	0.87	0.28	1.5	0.42	0.92	1.3

Plate 21

Plate 22

Plate 23

Plate 24

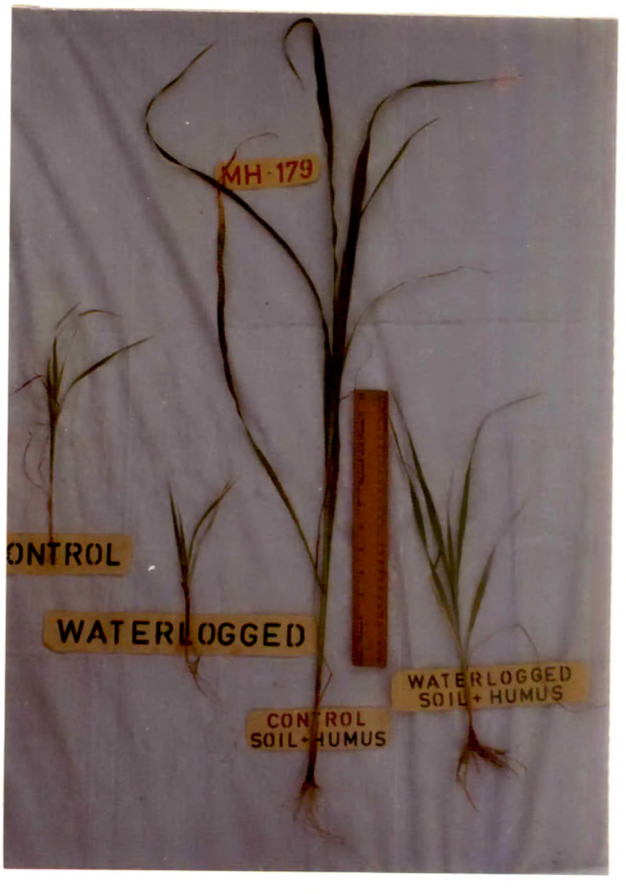


Plate 21,22, Ameliorative value of Humus on Pearl millet growing
23,24 under waterlogging conditions.

was inhibited significantly by waterlogging as indicated by the reduced RGR. (Fig.28) Similarly, this treatment changed the pattern of Net Assimilation Rate(NAR). Among cultivars MH-179 and BK-560, the second one exhibited slight increase in the NAR during the second growth stage,which declined during the last growth stage as a response to waterlogging stress,while MH-179 exhibited a decreased NAR during the active growth stages and much stimulated NAR before the harvest stage due to waterlogging treatment.(Fig.29) More over , the photosynthetic leaf area was also affected significantly by prolonged waterlogging treatment in the cultivars MH- 179 and BK-560 .(Fig.30) Waterlogging also affected adversly the pigment levels of the fully expanded leaf from the top. In both the types of soil the cultivars GHB-32 and MH-179, showed considerably more content of chlorophyll 'a' 'b' and carotenoids, in the waterlogging treatment and the reduction in chlo 'a' and 'b' under waterlogging was highly significant (P = 0.01) at all stages of growth (Table.20). Carotenoids were affected more at the latter growth stages under waterlogging stress. (Table.21)

The waterlogging had also an adverse effect on the fresh and Drymatter accumulation and pigment levels of Brassica juncea.Though the results recorded at nine days after imposing the waterlogging treatments had not indicated a very significant effect on the plant growth (Table.22), the plants could not survive in the continous waterlogging treatments. An interesting observation under the waterlogging stress of B. juncea was that the stem developed distinct ring at the water level that breaking of

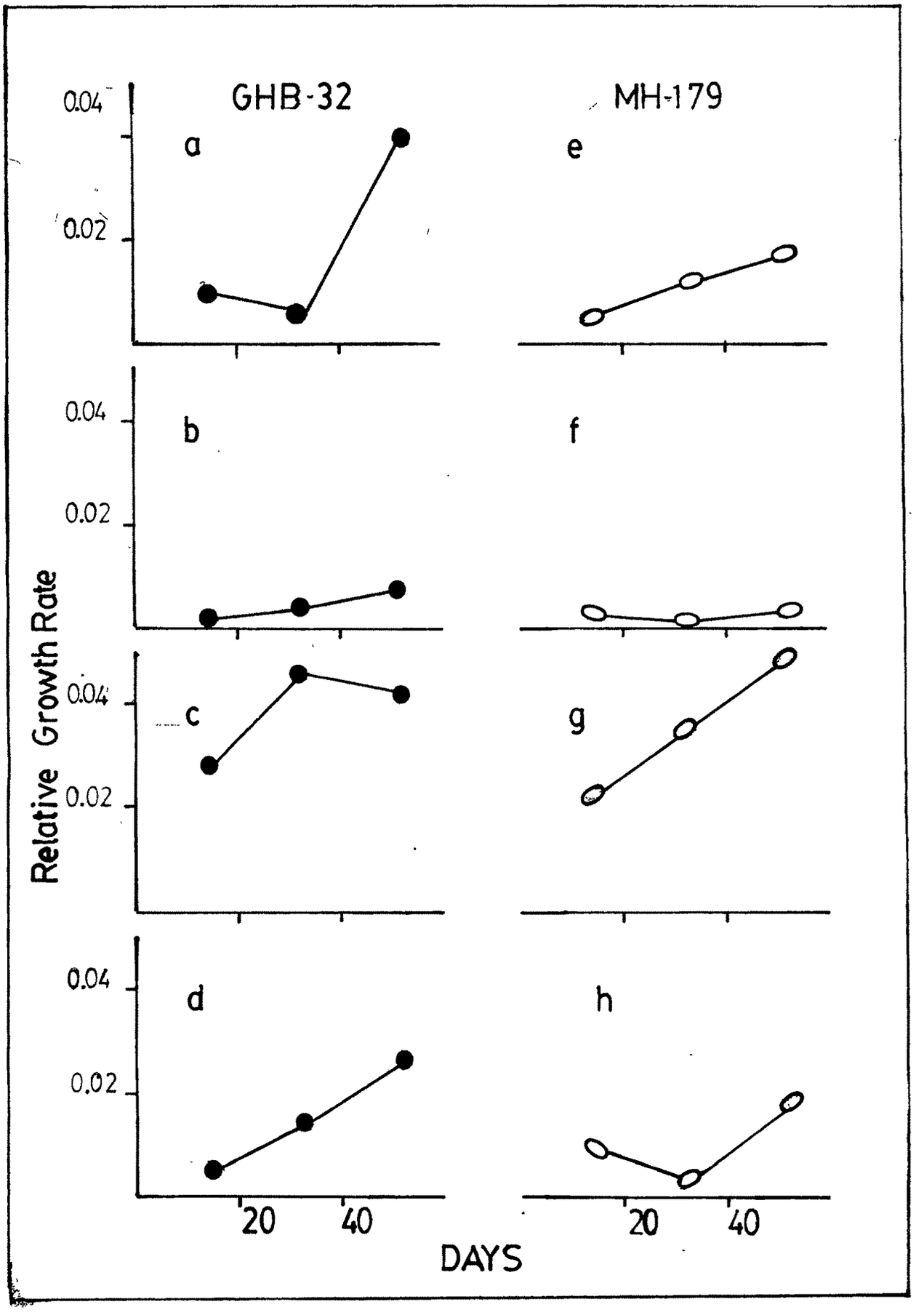

GHB-32
MH-179
a
b
c
d
e
f
g
h
0.04
0.02
Relative Growth Rate
20
40
DAYS

FIG. 28.

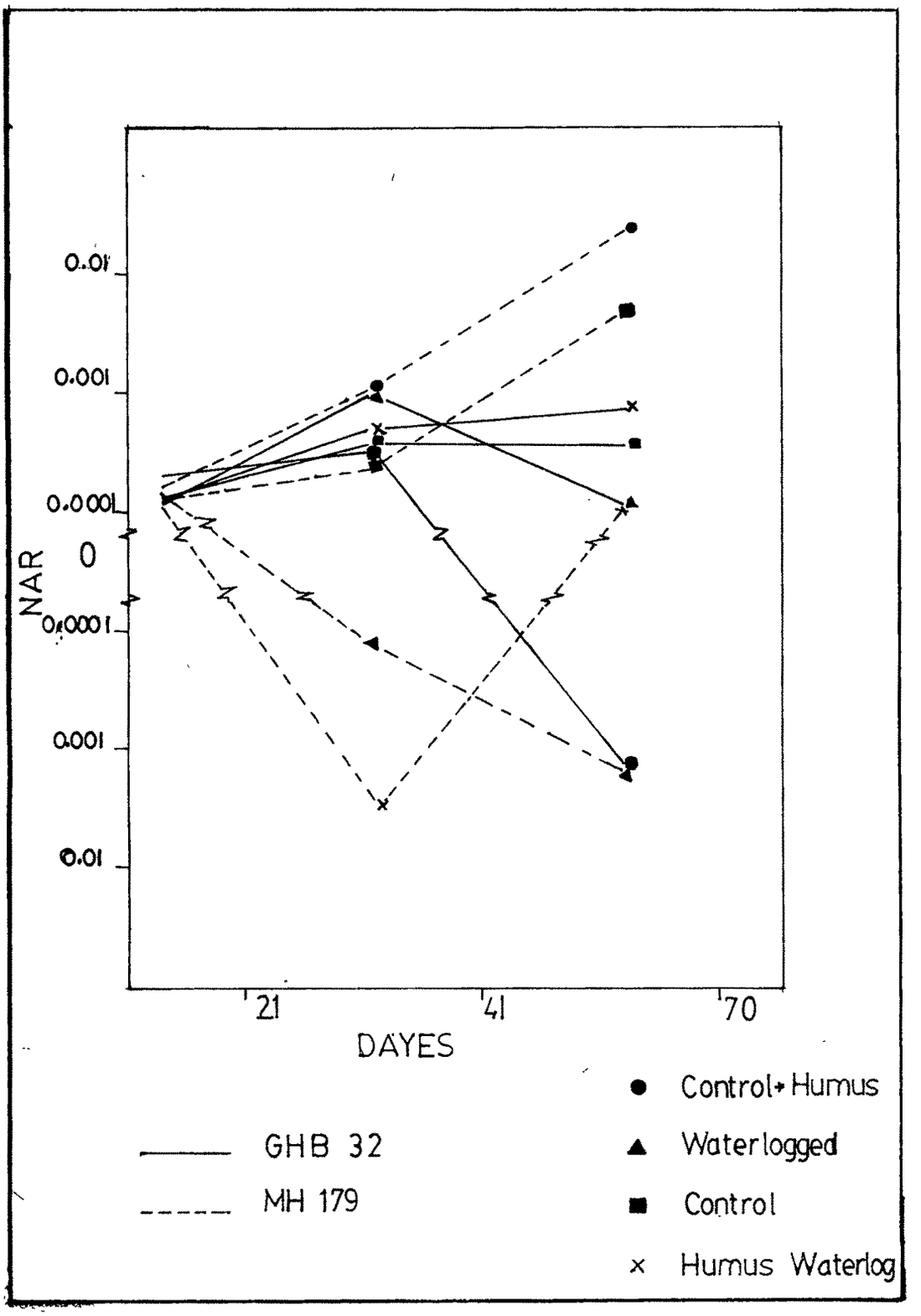


FIG. 29. Net Assimilation Rate of Pearl millet.

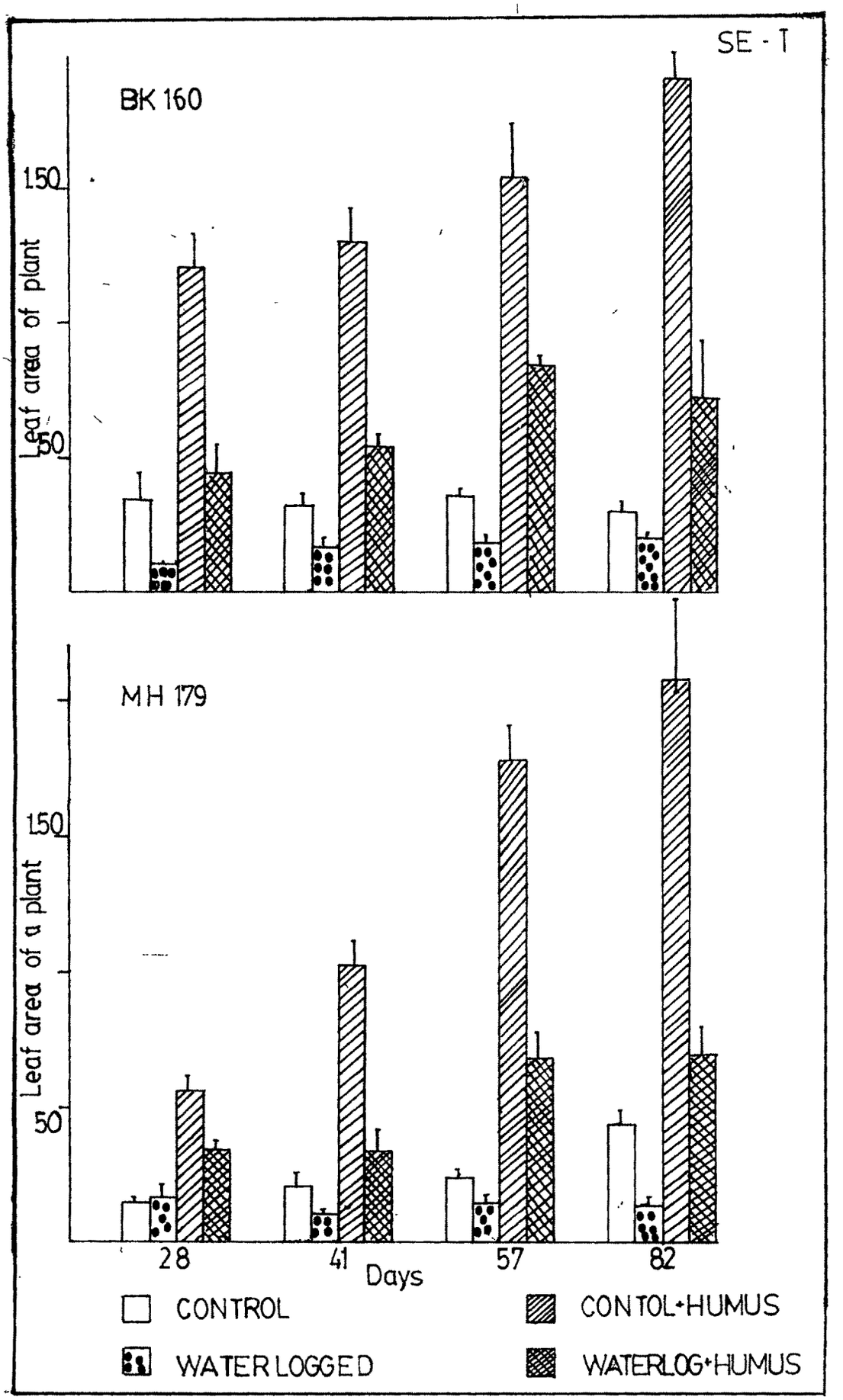


FIG. 30. LEAF AREA OF PEARL MILLET.

TABLE 20- Effect on the content of Chlo. 'a' and 'b' (mg/gm fresh wt.) at different stages of pearlmillet at waterlogging stress.

Cultivar	Treatments I	Chlorophyll-'a' I	Chlorophyll-'a' III	Chlorophyll-'b' I	Chlorophyll-'b' III
GHB-32	FD + NH	0.25	0.36	0.36	0.36
	WL + NH	0.16	0.27	0.25	0.24
	FD + HH	0.22	0.57	0.33	0.75
	WL + HH	0.21	0.35	0.33	0.46
MH-179	FD + NH	0.26	0.43	0.37	0.54
	WL + NH	0.13	0.25	0.17	0.32
	FD + HH	0.4	0.66	0.51	0.87
	WL + HH	0.27	0.37	0.36	0.46
LSD	5%	0.082	0.144	0.123	0.185
	1%	0.1104	0.193	0.166	0.248

TABLE 21- Effects on carotenoids (mg/gfresh weight) at different stages of growth in pearlmillet under waterlogging stress.

Growth	GLB-32				MH-179				LSD	
Stage	FD + NH	WL + NH	FD + HH	WL + HH	FD + NH	WL + NH	FD + HH	WL + HH	5%	1%
I	0.13	0.11	0.12	0.13	0.13	0.09	0.2	0.17	0.035	0.047
II	0.11	0.12	0.20	0.19	0.16	0.19	0.22	0.22	0.062	0.083
III	0.21	0.17	0.29	0.21	0.23	0.17	0.34	0.2	0.041	0.055

LSD ?

Last Course Derivation

ABLE 22- Effect of waterlogging for nine days & humus application on 27 days'old plants of Brassica juncea.

		Control FD	Waterlogging WL	Control HH +Humus	Waterlogging +Humus
hoot Length n cm.		6.3 (1.2)	6.1 (0.7)	10.8 (0.7)	10.6 (0.9)
resh eight n gm.	Leaf	0.18 (0.01)	0.15 (0.01)	0.92 (0.15)	0.34 (0.02
	Stem	0.09 (0.02)	0.07 (0.01)	0.34 (0.08)	0.19 (0.03)
	Shoot	0.27 (0.03)	0.22 (0.02)	1.3 (0.02)	0.53 (0.04)
ry eight n gm	Leaf	0.17 (0.002)	0.019 (0.002)	0.07 (0.01)	0.05 (0.02)
	Stem	0.008 (0.002)	0.008 (0.003)	0.02 (0.004)	0.02 (0.003)
	Shoot	0.025 (0.002)	0.03 (0.004)	0.09 (0.02)	0.05 (0.005)
ig- ent	Chlo.a	0.08 (0.02)	0.13 (0.03)	0.18 (0.05)	0.15 (0.01)
	Chlo.b	0.11 (0.03)	0.16 (0.03)	0.18 (0.07)	0.15 (0.02)
	Caro-tereed	0.06 (0.01)	0.25 (0.013)	0.096 (0.02)	0.08 (0.006)

tandard error values are in paranthesis.

the stem at the air water interphase under waterlogging condition.

Contrary to Brassica juncea, the response of Vetiveria lawsoni to waterlogged stress revealed a favorable tolerance nature of the grass to waterlogging as witnessed from the dry weight accumulation and Height of the plant.(Table.23). However, waterlogging has brought about a decrease in the pigment level during the early stage while the prolonged waterlogging indicated, a recovery with the level equal to that of non-waterlogged plants.(Table.24)

Yield:

Waterlogging adversly affected all the yield and the reproductive components in all the three cultivars of P. typhoides.(Table.25,26) (Plates 25,26,27) The length of the ear was reduced by 47 to 56 % and the girth by 30 to 38 % in response to the waterlogging treatment in cultivars. Though the length of the spike was reduced only by 47% to 56%, the root-zone waterlogging tremendously decreased the number of florets, Number of grains per ear, with an increase in the percentage of sterility, bringing overall effect on the economic yield, which was reduced greatly, 91 to 97 % in the cultivars of P.typhoides.Even though BK-560, indicated a very large decrease due to waterlogging in number of grains and the number of florets,due to the combination of 2 cultivars in the ANOVA analysis and the resultent high LSD, the difference between the means of normal watering and waterlogging had not registered

TABLE 23- Effect of waterlogging and salinity (EC-10) and its combination on the growth of Vetiveria plant

Treatment	LEAVES			STEM			SHOOT		
	I	II	III	II	I	III	I	II	III
Control.	0.56 (0.07)	0.69 (0.09)	0.47 (0.09)	0.24 (0.05)	0.23 (0.06)	0.16 (0.06)	0.78 (0.08)	0.93 (0.09)	0.63 (0.1)
Con. + waterlog.	0.56 (0.09)	0.55 (0.09)	0.59 (0.07)	0.27 (0.07)	0.17 (0.06)	0.29 (0.04)	0.73 (0.11)	0.83 (0.11)	0.89 (0.08)
Con. + salinity 10 EC.	0.63 (0.07)	0.52 (0.08)	0.45 (0.09)	0.13 (0.03)	0.2 (0.09)	0.11 (0.07)	0.83 (0.08)	0.64 (0.08)	0.56 (0.11)
Salinity + Water-log.	0.44 (0.07)	0.34 (0.06)	0.38 (0.09)	0.14 (0.04)	0.18 (0.05)	0.16 (0.07)	0.62 (0.08)	0.48 (0.06)	0.54 (0.12)

*SE: values are in paranthesis.

TABLE 23 - Changes in Height of the plant.

Stage	Control	Con. + Waterlogged	Con. + Salinity	Salinity + Waterlogged
I	57.6 (5.5)	55.6 (7.9)	64.2 (6.0)	57.7 (6.2)
II	63.2 (4.0)	53.7 (6.4)	55.3 (6.9)	42.1 (5.7)
III	53.5 (9.1)	65.4 (4.2)	48.9 (6.6)	47.9 (7.0)

*SE:Values are in paran thesis.

TABLE 24- Changes in the level of pigment in the plant growing under waterlogging and saline stress

	Chlo.a.			Chlo.b.			carotenoids.		
	I	II	III	I	II	III	I	II	III
Control.	1.9 (0.18)	0.53 (0.2)	0.59 (0.12)	1.03 (0.13)	0.35 (0.16)	0.36 (0.05)	0.69 (0.09)	0.31 (0.12)	0.32 (0.06)
Con. + water-logged	1.2 (1.15)	0.28 (0.09)	0.49 (0.06)	0.71 (0.01)	0.29 (0.04)	0.37 (0.08)	0.49 (0.09)	0.20 (0.07)	0.27 (0.00)
Con. + salinity (10EC)	2.06 (0.14)	0.7 (0.17)	0.64 (0.16)	1.1 (0.09)	0.55 (0.13)	0.41 (0.14)	0.75 (0.07)	0.32 (0.08)	0.29 (0.12)
Salinity+ water-logged	1.2 (0.12)	0.39 (0.18)	0.55 (0.11)	0.66 (0.08)	0.4 (0.08)	0.39 (0.11)	0.41 (0.44)	0.22 (0.09)	0.32 (0.09)

*SE: Values are given in paranthesis.

TABLE 25- Ameliorative value of Humus on the yield of pearlmillet growing under waterlogging stress.

	GHB-32				MH-179				LSD	
	W0H0	W1H0	W0H1	W1H1	H0W0	H0W1	H1W0	H1W1	5%	1%
Length	8.9	4.5	11.6	7.2	9.4	4.2	10.9	5.9	1.2	1.8
Girth	3.0	1.86	3.7	3.1	3.0	2.1	3.1	2.6	0.35	0.53
No.of florets	398	174.6	824.6	257	346	97.2	600	193.2	92.9	139.8
No. of grains	196.8	40.6	644.8	177.4	225.2	30	492	103.2	83.7	125.9
% of sterility	49	74.7	22.4	31.6	34.5	69.4	17.4	46.7	0.66	0.99
Biological yield	1.97	0.49	5.3	1.97	1.69	0.33	4.26	1.08	0.73	1.1
Wt.of grains	0.752	0.07	2.34	0.74	0.73	0.03	1.48	0.23	0.27	0.40
Harvest index	0.36	0.14	0.45	0.46	0.43	0.1	0.4	0.21	0.11	0.16

TABLE 26 - Effect of waterlogging and Additional Humus content on the different components of reproductive part and yield of Pennisetum typhoides cultivar MH-179 and BK -560.

	BK-560				MH-179				LSD	
	H0W0	H0W1	H1W0	H1W1	H0W0	H0W1	H1W0	H1W1	5%	1%
Length of spikelet	6.2	3.3	10.6	5.3	8.6	3.9	11.7	5.9	1.9	2.7
No. of florets	174	51	699	151	291	159	739	250	158	219
No. of grains	153	9.7	601.3	95.7	288	21	641	118	144	200
% sterility	12.6	80.9	14.8	35.9	12.4	87.1	13	52.2	18.1	25
Wt. of grain(gms)	0.35	0.01	2.5	0.41	0.68	0.03	1.5	0.3	0.8	1.11
Biological yield	0.84	0.14	5.7	1.4	1.1	0.11	4.9	1.03	0.7	0.9
Harvest index	0.42	0.13	0.4	0.29	0.61	0.25	0.31	0.32	0.17	0.2

Plate 25,26,27. Effect of waterlogging on the reproductive components of **Pennisetum typhoides** Cv. GHB 32 MH 179 BK 560

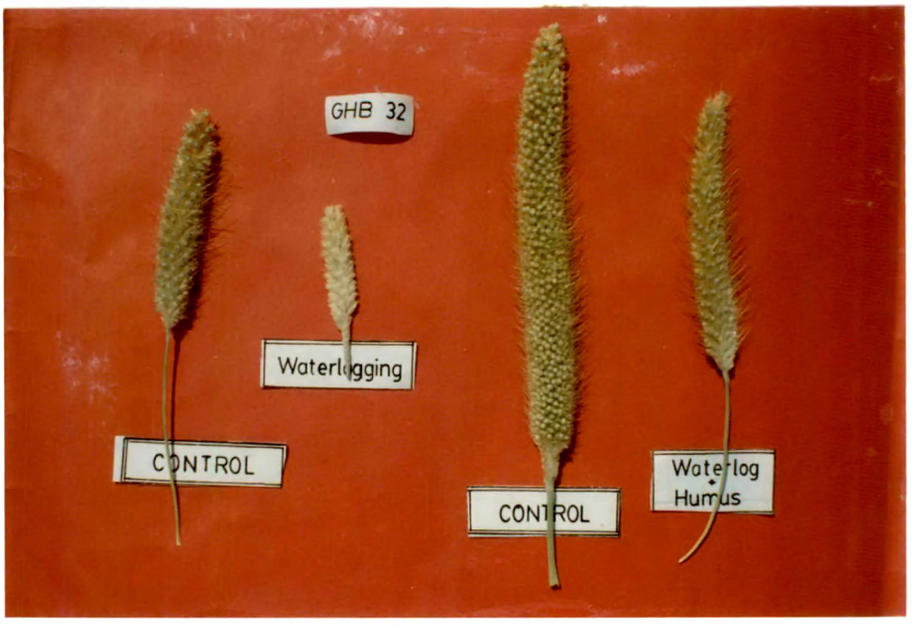


Plate 25

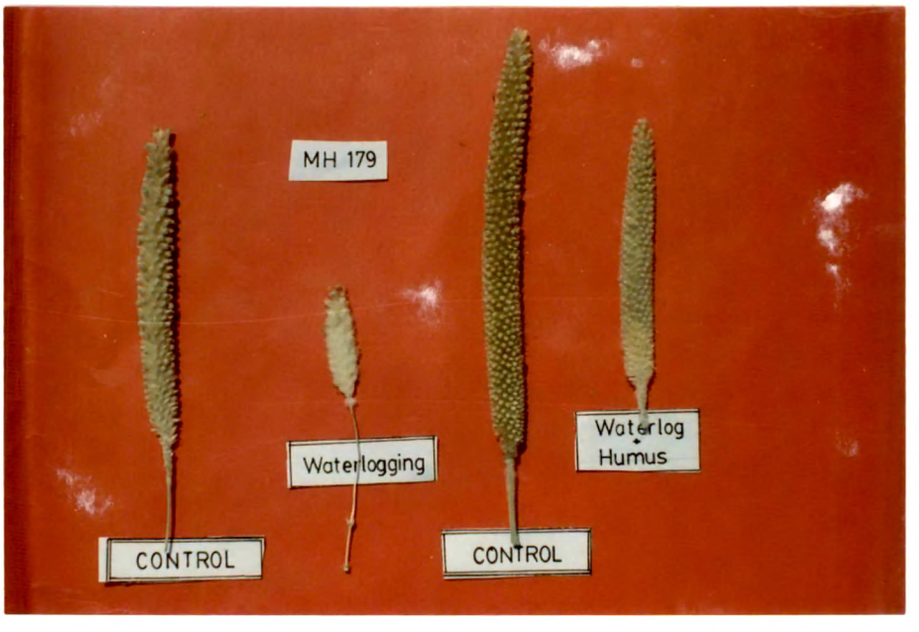


Plate 26

Plate 28 Ameliorative value of Putrasine spray on the growth of Pearlmillet, under waterlogging and saline stress.

Plate 29 **Vetiveria lowsoni** under waterlogging and saline stress condition

statistical significant.(Table.26). The reduction in the biological yield from 75% to 90% in the waterlogged condition was computed.The changes in a economic and Biological yield manifested in a tremendous reduction (59 to 77%) in the economic yield of cultivars, GHB-32, MH-179 & BK-560.

Combined effect of waterlogging and Salinity:

Both waterlogging and salinity stress,affects growth of Pennisetum typhoides cv. GBH-32 (Table.27) (Plate 28) the dry matter accumulation of the above cultivar was affected more by waterlogging condition comparatively. Combination of these two treatments brought about an additive inhibitory effect,which was more evident in the dry matter accumulation of the shoot system,leaf and stem. Contrarily,.The pigments were affected by waterlogging alone, where as, imposition of salinity, did not bring about any significant change in the contents of the pigments.The combination of both exhibited the reduction in the pigment to the same extent or slightly more of that of the waterlogging treatment alone (Table.28). Similarly , the Vetiver grass in response to the waterlogging or salinity or incombination, though indicated a tendency of slight inhibition, it did not show any significant change in growth (Table. 20,21) (Plate 29). Waterlogging though reduced the pigment levels, imposition of salinity of EC value 10 mmhos/cm resulted in a definite increase of chlorophyll 'a' and slightly chlorophyll 'b'.The combination of salinity and waterlogging exhibited pigment levels equal to that of the waterlogging treatment alone.

TABLE 27- Effects of putrasine spray on the dry matter accumulation of pearl millet CV GHB-32 growing under salinity, waterlogging and salinity + waterlogging stress.

		Control	Waterlog.	Control + Saline	Wat.log. + Saline	Sal.+ P.	P + S + Wl	LSD 5%	LSD 1%
LEAF	I	0.21	0.12	0.15	0.09	0.12	0.1	0.03	0.04
	II	0.29	0.14	0.19	0.07	0.21	0.15	0.12	0.1
STEM	I	0.14	0.01	0.08	0.05	0.07	0.06	0.04	0.06
	II	0.24	0.1	0.14	0.06	0.24	0.13	0.04	0.06
SHOOT	I	0.34	0.22	0.26	0.15	0.17	0.16	0.04	0.06
	II	0.58	0.27	0.34	0.12	0.49	0.28	0.08	0.11

What about mulch the effect on root zone?

TABLE 28- Effects of Putrasine spray on the pigment level of the plants growing under waterlogging,salinity and waterlogging + salinity stress.

	Stage	Con.	Waterlog	C + S	W + S	CS + P	P + S + W	5%	1%
Chlø.a.	I	1.4	0.8	1.2	0.69	1.2	1.4	0.33	0.45
	II	1.6	0.85	1.1	0.8	1.3	1.1	0.29	0.39
	III	1.3	0.56	1.2	0.58	0.91	0.77	0.14	0.2
Chlø.b.	I	0.69	0.47	0.65	0.38	0.62	0.8	0.23	0.31
	II	0.99	0.6	0.85	0.65	0.92	0.76	0.19	0.26
	III	0.77	0.41	0.82	0.4	0.6	0.5	0.08	0.26
Carotenoids	I	0.43	0.28	0.41	0.31	0.37	0.47	0.13	0.17
	II	0.52	0.3	0.47	0.28	0.49	0.38	0.06	0.08
	III	0.58	0.36	0.63	0.32	0.41	0.41	0.01	0.05

explain by additive effect in case Carotenoids

Chl.a > Chl.b > Car.

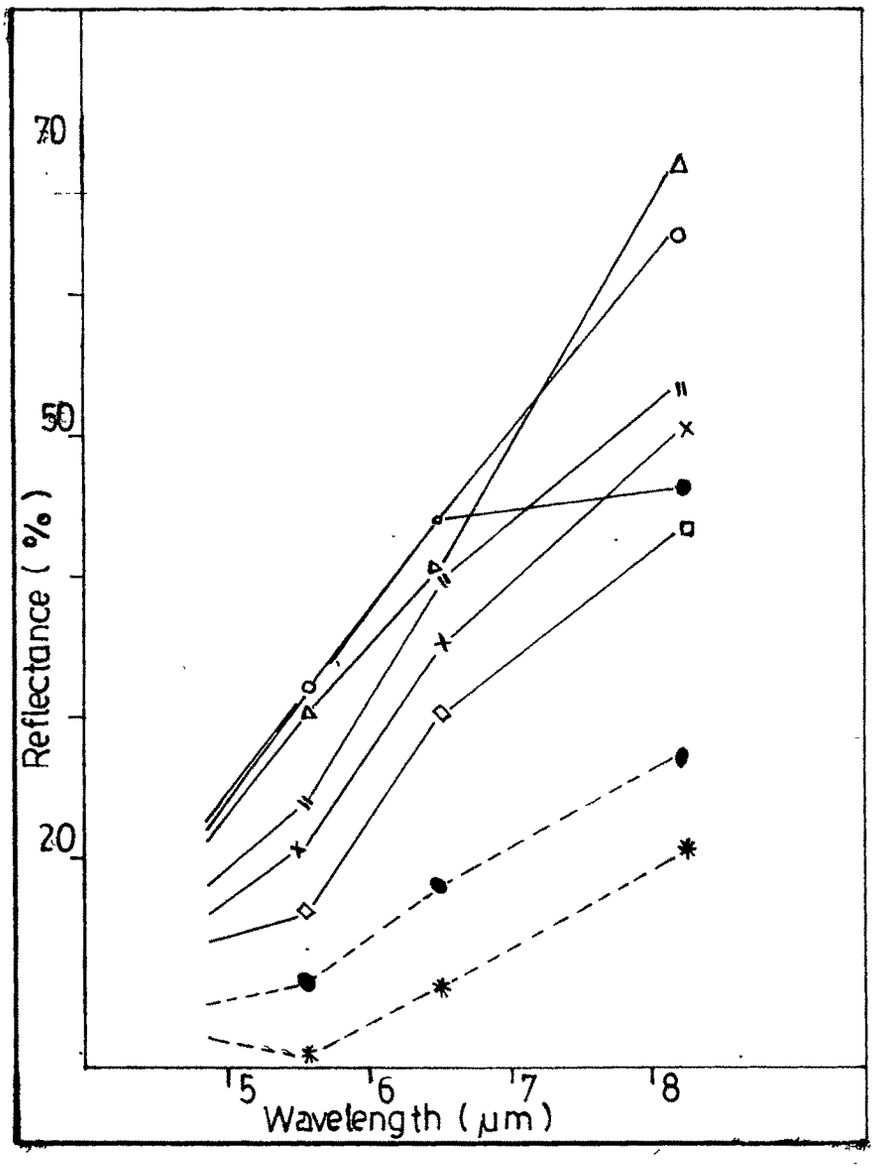
Reflectance study:

The spectral reflectance, study was carried out

i) to study the effect of waterlogging, salinity stress and combination of both the stress condition on pearl millet and

ii) to assesss the utility of this reflectance study for stress moinitoring. Four spectral bands, corresponding to the bands of 1RS-1A, were used in this present study. It has been observed that the wet soil was indicated by the lower percentage of reflecatance than that of the dry soil in all regions of electro magnetic spectrum (Fig.3E). The peak reflectance of the radiation was at the near infrared region followed by red, band 2 and 1. However, the sharp decrease in the reflectance percentage at red and infrared regions (620 to 860nm) and increase of reflectance percentage in the wave length 550 nm of the electro magnetic spectrum was observed for the plants growing under waterlogging condition, and combined stress conditons (Fig.26). Thus the reflectance curve of these plants were altered, by the stress conditions. The shape of the curve was slightly resumed to its normal pattern in the polyamine treated plants the normal pattern of curve in saline stress indicated the negligible effect of saline stress at 10 mmhm/cm on pearlmillet. However, the plants grown under control plot, was exhibited a normal sigmoid reflectance curve, indicated a normal patterns of growth of the plant.

The two indices namely infrared/red ratio (1R/R) and normalized difference (ND) ND=(1R-R/1R+R) derived from the



Control
Waterlogged
Con + Salt
Saline + Putrasine
Salt + Waterlog
Salt + Waterlog + Put
Dry soil
Wet soil

FIG 31 Spectral Reflectance curve

reflectance value of red and infrared region,of EMR, for the plants growing under different conditions, revelaed that the maximum value (1.72) of 1R/R ratio was shown by the control plants,and the minimum values were exhibited in the plants growing under waterlogging stress and combined stress condition.The ND value also decreased in the plants growing under stress conditons,than that of the control plants from. 0.27 to 0.03 (Table.29)

An attempt to correlate the spectral reflectance with leaf area index (LAI) and Biomass of the indicated that the biomass of the plant showed a significant linear correlation with the 1R/R ratio and LAI of the plants (Table.30) . However the other correlations stuidied like LAI with 1R/R and ND, Biomass with ND, though insignificant, showed definite positive correlation (Fig. 32). Similarly the 1R/R ratio and ND Value was directly proposonal to the value of the pigment contents of the chlorophyll 'a', 'b' and carotenoids (Table.29).

Ameliorative Value Measures:

An attempt to study ameliorative value of humus content to increase the availability of organic matter for the plant growth under waterlogged conditions, proved the distinct partial ameliorating effect on growth of the plant Pennisetum typhoides and Brassica juncea under waterlogged stress. It was observed that by the addition of high humus content to the soil under waterlogged conditions, the height of the plant Pennisetum

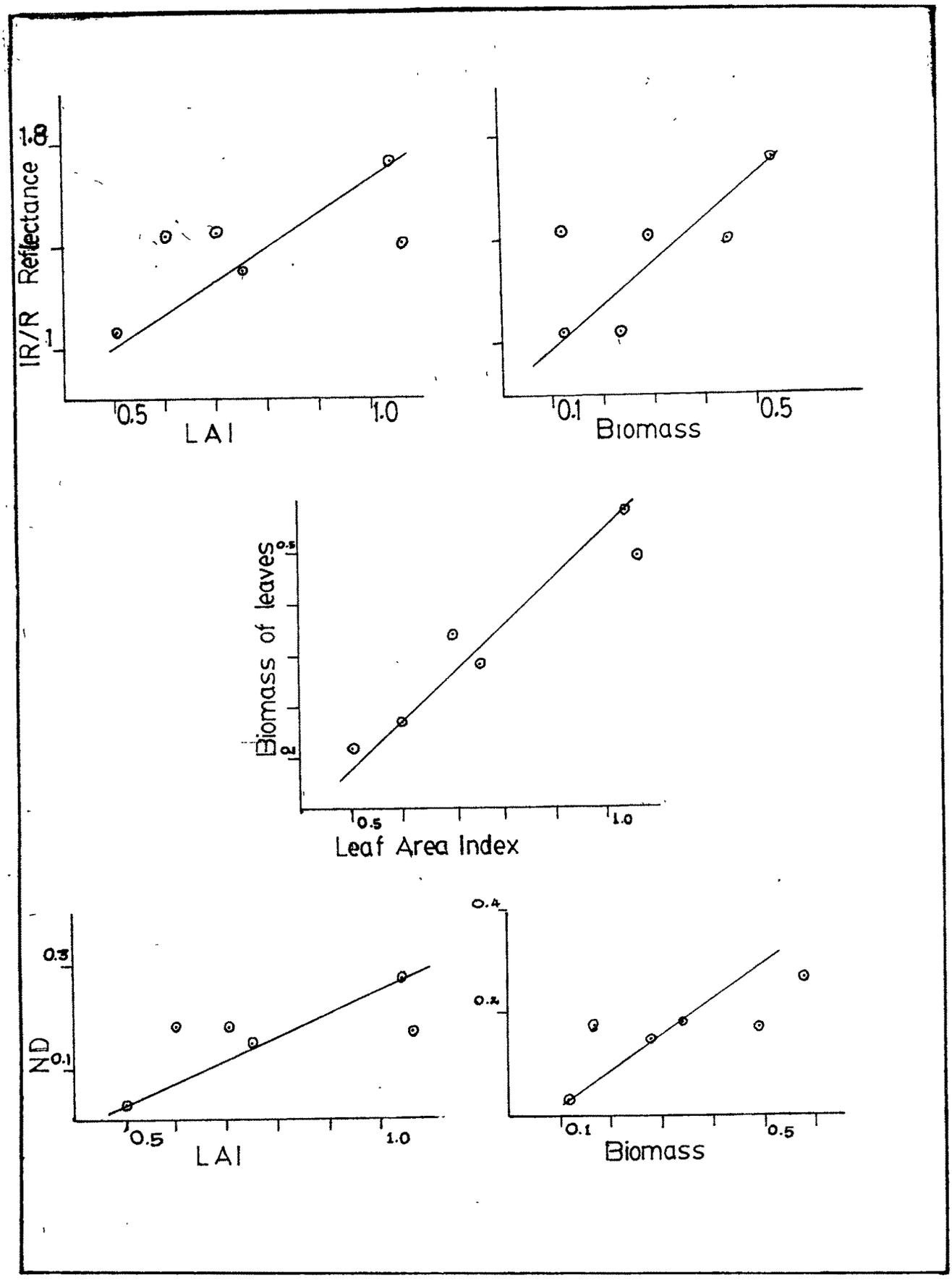


FIG .32. Correlation of Spectral reflectance with LAI , BIOMASS

TABLE 29- Relation of different indices with the pigment.

Item	IR/R	ND	Chlo.a	Chlo.b	Carotenoid
Control	1.72	0.27	1.6 (0.17)	0.99 (0.08)	0.52 (0.04)
Water-logging	1.44	0.18	0.85 (0.04)	0.6 (0.05)	0.3 (0.03)
Con + Salt	1.52	0.18	1.1 (0.1)	0.85 (0.07)	0.47 (0.02)
Salt + wat.log	1.1	0.03	0.8 (0.03)	0.65 (0.02)	0.28 (0.02)
Salt + Putrasine	1.4	1.17	1.3 (0.07)	0.92 (0.03)	0.49 (0.02)
Salt + Wat + Put	1.3	0.15	1.1 (0.09)	0.76 (0.04)	0.38 (0.02)

TABLE 30- Regression and co-efficient values by reflectance study.

	Corr.Coeffi.(r)	Regression coeffi.(y)	(t)
LAI/1R/R	0.69	0.26 + 0.60 X	1.6
LAI/ND	0.69	0.28 + 0.66 X	2.0
LAI/Biomass	0.95	0.25 + 0.32 X	2.8*
Biomass/1R/R	0.83	0.25 + 0.9 X	2.7*
Biomass/ND	0.83	0.25 + 0.34 X	0.12

* P= 5% level

typhoides cultivars GHB-32, MH 179, BK-560, exhibited a significant improvement over that of the waterlogged plants without humus treatments.(Fig 26,27) Similarly , the humus application brought about a partial recovery in the fresh and dry matter accumulation of the shoot system, stem and leaves the shoot growth in all the three cultivars, with the exception of the cultivar MH-179 in IInd year experiments, carried out in the year 1989 (Table 15,16,17,18). The partial improvement was also observed in the Leaf area Index (LAI) and the photosynthetic leaf area, of the cultivars under waterlogged condition, with high humus content (Table 19, Fig.30). Addition of humus to the soil increased the pigment levels of the plants under well drained conditions. However under waterlogging it reduced the pigment levels, though it was well above the waterlogging treetment alone (Table. 20,21). The definite influence of the humus on the cultivars of P.typhoides under the well drained and waterlogging conditions,was brought out clearly by the RGR (Relative growth rate) and NAR (Net assimilation rate) curves (Fig. 28 and 29) though similar trend,with humus application was noticed with the short term waterlogging of Brassica juncea.(Table 22) the continuous waterlogging for more than 10 days resulted in a severe mortality rate of the seedlings, even under high soil humus treatment. (Table.22)

Humus application has decreased though partially the percentage sterility of the florets significantly. Additional humus in a well drained soil has increased the number of florets from 73 to 153 percent in MH-179, 107 in GHB-32 and 302 percent

in BK-560. This increase in the number of florets has reflected in the number of grains matured, which range from 118 to 293 percent.It also increased the dry matter accumulation of the grain. Similarly 1.5 to 5.8 fold increase was noticed in the biological yield,when humus was added,to the soil under waterlogged conditions (Table 25,26). When the yield characterestics were compared with the waterlogging plants,in the absence of additional humus, the humus treated plants under waterlogged conditions performed significantly better,almost equal to the normal plants without excessive humus.This effect has been clearly indicated when the analysis was carried out merging both cultivars (GHB-32, MH-179) of the first year study (Table 31). Similarly in table 32 the significant individual effect of humus on both the cultivars was brough out irrespective of the soil water soil.

The application of di and polyamines as sprays to ameliorate the ill-effect of waterlogging,proved to be of limited significant (Table 33) (Plate 30,31,32). Polyamines did not improve the dry matter accumulation in the system and inhibited the grain yield completely under waterlogging conditions, as a result of which the data on the grain yield of spermine & spremidine treatment under waterlogging, is not presented here . Contrarily to polyamines, the diamine putrasine,though did not result in an improved effect, on the biomass of the plants at different stages of growth,it improved the grain yield significantly (Table 34). Significant increase,observed in the pigment levels of chlorophyll 'a' and 'b' in response to

TABLE 31- Effect of waterlogging treatment and soil Humus status on different components of reproductive Part of pearlmillet irrespective of cultivar

	W 0		W 1		LSD	
	H 0	H 1	H 0	H 1	5%	1%
Length	9.2	11.3	4.4	6.5	1.1	1.5
Girth	3.0	3.4	2.0	2.9	0.22	0.31
No. of florate	372.0	712.3	135.9	225.0	72.0	100.0
No.of grains	211.0	568.0	35.0	140.0	53.4	74.0
% of sterility	41.8	19.9	72.1	39.1	14.2	19.9
Biological yield	1.8	4.8	0.42	1.5	0.52	0.73
Wt.of grains/ear	0.74	1.9	0.05	0.49	0.24	0.34
Harvest	0.4	0.43	0.12	0.34	0.1	0.15

TABLE 32- Effect of Humus application on yield of P.typhoides under waterlogging stress.

	GHB-32		MH-179		LSD	
	H O	H 1	H o	H 1	5%	1%
Girth	2.2	3.4	2.6	2.9	0.35	0.5
No. of grains	119	411	128	298	56	79
Wt.of grains/ear	0.41	1.54	0.38	0.86	0.16	0.22
Biological yeild	1.23	3.61	1.02	2.68	0.70	0.98
Harvest index	0.25	0.46	0.27	0.31	0.13	0.18

TABLE 33- Changes in the attributes of growth by external application of di,polyamines at the different stages of Pennisetum typhoides cul. GHB-32 growing under waterlogging conditions (P= Putrasine Sp= Spermine Sd = Spermidine)

		Control (C)	Waterlog (W)	C + P	W + P	C + Sp	W + Sd	C +Sd	W + Sd	LSD 5%	LSD 1%
	I	0.05	0.04	0.04	0.025	0.037	0.02	0.02	0.02	0.208	0.01
	II	0.20	0.16	0.14	0.10	0.12	0.09	0.09	0.08	0.35	0.07
Leaf	III	0.18	0.22	0.28	0.19	0.22	0.16	0.16	0.17	0.06	0.09
	IV	0.25	0.09	0.21	0.18	0.22	0.11	0.16	0.10	0.05	0.07
	I	0.02	0.015	0.013	0.009	0.016	0.009	0.009	0.009	0.005	0.007
	II	0.12	0.14	0.09	0.06	0.1	0.06	0.06	0.06	0.05	0.05
Stem	III	0.38	0.23	0.34	0.28	0.26	0.20	0.22	0.12	0.06	0.09
	IV	0.65	0.41	0.59	0.37	0.41	0.16	0.41	0.18	0.17	0.24
	I	0.06	0.054	0.051	0.03	0.052	0.03	0.03	0.03	0.008	0.01
	II	0.32	0.29	0.22	0.14	0.22	0.14	0.15	0.14	0.06	0.09
Shoot	III	0.59	0.43	0.53	0.45	0.47	0.38	0.38	0.29	0.1	0.15
	IV	0.95	0.6	0.86	0.45	0.65	0.32	0.49	0.28	0.17	0.24

TABLE 34- Yield data from di and polyamine treated plants.

Treatments	Length cm	No. of florets	No. of grains	Wt. of grains g	Biological yield of	Harvest index
Control	10.2 (0.6)	447 (19)	278 (17)	0.43 (0.08)	1.3 (0.08)	0.33
Waterlogging	4.9 (0.3)	499 (28)	122 (34)	0.16 (0.03)	0.84 (0.01)	0.19
Control + Putra	7.6 (0.6)	373 (70)	228 (54)	0.49 (0.14)	1.4 (0.09)	0.35
Wat + Putra	8.0 (1.0)	333 (34)	187 (13)	0.54 (0.06)	0.86 (0.05)	0.62

Plate 30

Plate 31

Plate 32

Plate 30,31,32 - Effects of aerial spray of putrasine spermine and spermidine on Pearl millet growing under waterlogging condition.

putrasine treatment at the third growth stage perhaps could explain the efficiency of putrasine under waterlogging in improving the yield (Table 35). The increase in the grain yield was mainly due to the increasing number of grains. However, the biological yield was not affected by the putrasine application under waterlogged stress. Thus the increase in the harvest index was observed by putrasine spray,under waterlogged conditions.

Similar improvement in the levels of pigment has been brought-about by putrasine on the cultivar, GHB-32 of P. typhoides exposed to the combined effect of waterlogging and saline stress (Table.28). However, its effect on the improvement of the biomass of the shoot system was not significant from the results (Table 27).

Interactions Using the ANOVA Test

The variance calculated from ANOVA also confirmed that,the prolonged waterlogging reduced both fresh and dry matter accumulation of the shoot system throughout the growth as indicated by highly significant variance. However the waterlogging seemed to be ineffective during the first six days. Significant interactive responses were observed at the first order interaction between waterlogging and soil humus, ultimately at the second order interaction with cultivar, soil humus and weterlogging (Table 36,37,38[39]). However the interaction of cultivar and weterlogging was not consistant throughout the growth stages in the dry and fresh matter accumulation, in stem , leaf,shoot system of the plant. Similarly the interactive

TABLE 35- Effects of polyamine spray, on the pigment contents of pearlmillet growing under waterlogging conditions.

Pigments	Stage	C	W	C + P	W + P	C + Sp	W + Sp	C + Sd	W +Sd	LSD 5%	LSD 1%
Chlorophyll'a'	I	0.79	0.94	0.79	0.96	0.79	0.89	0.76	0.63	0.24	0.34
	II	1.3	0.96	1.0	1.1	1.3	0.73	1.3	0.53	0.25	0.37
	III	1.3	0.77	1.6	1.25	1.4	1	1.4	1.1	0.22	0.32
Chlorophyll'b'	I	0.4	0.58	0.49	0.52	0.49	0.49	0.49	0.38	0.10	0.15
	II	0.7	0.58	0.64	0.61	0.7	0.49	0.72	0.35	0.15	0.22
	III	0.75	0.54	0.93	0.76	0.84	0.67	0.79	0.67	0.15	0.22
Carotenoids	I	0.15	0.28	0.25	0.21	0.24	0.19	0.24	0.22	0.07	0.1
	II	0.36	0.34	0.39	0.34	0.41	0.33	0.27	0.29	0.07	0.1
	III	0.59	0.57	0.64	0.54	0.59	0.42	0.53	0.42	0.1	0.15

TABLE 36- Mean squares from ANOVA of Pearl millet response to vasitables like cultivar(C), waterlogging(W) and Humus(H) and their interactions in fresh wt. at different growth stages under waterlogging stress.

		LEAF			STEM			SHOOT		
		I	II	III	I	II	III	I	II	III
Replicate	4	0.03	0.4	0.3	0.03	0.47	0.73	0.18	1.7	1.7
Treatment	7	0.76**	3.0**	7.8**	0.19**	2.0**	19.9**	1.3**	9.5**	52.0**
Cultivar(C)	1	0.38**	0.44	2.9**	0.06*	0.18	0.23	0.17	0.05	4.9
Waterlogged(W)	1	0.38**	8.4**	21.9**	0.24**	3.2**	54.2**	1.1**	26.8**	14.5**
Humus(H)	1	4.0**	7.9**	21.5**	0.95**	5.7**	55.8**	6.9**	2.7**	147**
C * W	1	4^{-4}	0.06	0.32	0.00	0.01	0.23	0.03	0.00	0.32
C * H	1	0.17*	0.45	1.3*	0.05	0.04	0.71	0.03	0.35	3.8
W * H	1	0.25*	3.9**	6.9**	0.07*	2.6**	28.6**	0.75**	12.7**	63.1**
C * W * H	1	0.12	0.09	0.00	0.03	0.05	0.08	0.12	0.00	0.99
Err.	28	0.04	0.28	0.27	0.01	0.16	0.88	0.12	0.65	1.7

Level of significance : P =0.05(*) P =0.01(**)

TABLE 37 Mean squares of ANOVA examining effects of cultivar, waterlogging Humus, on fresh weight of Pearaillet (MH-179, BK-160) at different stages of growth under waterlogging conditions.

Variance	DF	LEAF				STEM				SHOOT			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
Replication	4	0.05$	0.15	0.17	0.18	0.03	0.08	0.03	1.0	0.15	0.4	0.8	1.7
Treatment	7	1.7$$	2.2$$	5.9$$	5.3$$	0.61$$	1.4$$	8.6$$	44.5$$	4.5$$	7.0$$	26.4$$	88.8$$
Cultivar	1	1.0$$	0.75$$	0.1	0.03	0.44$$	0.7$$	3.9$$	0.04	2.9$$	2.9$$	2.2	0.6
Waterlogged	1	1.8$$	3.4$$	8.9$$	10.6$$	0.6$$	1.7$$	1.6$$	92.1$$	4.6$$	9.9$$	38.4$$	169.2$$
Humus	1	6.1$$	8.8$$	24.8$$	19.6$$	2.1$$	4.1$$	31.1$$	150$$	15.5$$	24.7$$	115.5$$	2.78$$
C x W	1	0.81$$	0.15	0.9$	0.07	0.3$$	0.54$$	0.8	0.2	1.9$$	1.2$$	0.32	1.1
C x H	1	0.98$$	0.19	0.3	9.2$$	0.34$$	0.7$$	2.9$$	0.339	2.3$$	1.9$$	0.96	0.7
W x H	1	1.3$$	2.3$$	5.8$$	6.2$$	0.4$$	1.8$$	9.3$$	68.7$$	3.0$$	8.3$$	27.5$$	116$$
C x W x H	1	0.22$$	0.01	1.1$	0.00	0.12$	0.16	0.5	0.2	1.1$	0.4	0.02	0.3
Err.	28	0.003	0.09	0.19	0.23	0.026	0.05	0.33	1.2	0.16	0.22	1.04	2.2

P =0.05($) P =0.01($$)

TABLE 38- Mean squares from analysis of variance examining effects of cultivars(C) Waterlogging(W) and Humus(H) and their interactions on dry matter accumulation at different growth stages under waterlogging stress.

Variance	DF	LEAF			STEM			SHOOT		
		I	II	III	I	II	III	I	II	III
Replicate	4	0.001	0.0	0.025	5^{-5}	0.003	0.04	0.0005	0.013	0.08
Treatment	7	3.6**	0.1**	0.31**	0.0009*	0.93**	0.37*	0.006**	0.284**	1.28**
Cultivar(C)	1	8^{-4}	0.02	0.2**	4^{-6}	0.06**	0.02	5^{-4}	0.002	0.11
Waterlogged(W)	1	0.002	0.27**	0.81**	1^{-4}	0.06**	0.91**	0.023	0.481**	3.36
Humus(H)	1	0.02	0.28**	0.85**	5^{-7}**	0.25**	1.2**	0.052**	1.74**	4.01**
C x W	1	0.00	0.03*	0.00	8^{-5}	0.006	0.007	0.00	0.04	0.01
C x H	1	0.09**	0.002	0.05	5^{-4}	0.06**	0.33	0.00	0.002	0.03
W x H	1	0.005	0.39**	0.17**	0.00	0.05**	0.56**	0.003	0.18**	1.31**
C x W x H	1	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.00	0.21*
Err	28	0.005	0.005	0.007	10^{-4}	0.002	0.07	8^{-4}	0.011	0.004

TABLE 39- Mean Variance of independent effects of cultivar, waterlogging, humus and their interactions on the dry matter accumulation of the two cultivars (MH-179, BK-560) of pearlmillet under waterlogging stress.

Variance	D.F.	LEAF				STEM				SHOOT			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
Replication	4	0.008	0.002	0.002	0.05	0.0308	0.0305	0.008	0.08	0.0005	0.0	0.02	0.13
Treatment	7	0.03	0.37	0.16	0.47	0.006	0.03	0.17	1.8	0.06	0.17	0.6	4.0
Cultivar	1	0.01**	0.05**	0	0.03	0.005**	0.02**	0.15**	0.10	0.02**	0.09**	0.17**	0.5
Waterlogged	1	0.03**	0.08**	0.19**	1.1**	0.006**	0.017**	0.16**	3.3**	0.05**	0.13**	0.7**	7.9**
Humus	1	0.1**	0.29**	0.7**	1.6**	0.03**	0.1**	0.64**	6.4**	0.23**	0.58**	2.8**	14.18**
C X W	1	0.01**	0	0	0	0.0002	0.01**	0.03*	0.6**	0.03**	0.05**	0.03	0
C X H	1	0.01**	0.02	0	0	0.0004	0.015**	0.1**	0.005	0.02**	0.12**	0.01	5.9*
W X H	1	0.02**	0.05**	0.17**	0.5**	0	0.015**	0.11**	1.6**	0.04**	0.16**	0.4**	6.1*
C X W X H	1	0.007**	0	0.04*	0	0	0.003*	0.01	0.015	0.004	0	0.03	0
Err.	28	0.0007	0.005	0.007	0.07	0.0001	0.0006	0.005	0.07	0.0015	0.006	0.02	0.9

Level of significance P = 05 (*) P = 01(**)

response on Leaf Area Index was observed only on the last stages of the growth between Humus and Waterlogging . No sinificant interaction was exhibited between cultivar and weterlogging and cultivar and humus (Table 40). Omitting the humus effect, permanant weterlogged condition had a deleterious effect on shoot growth of pearlmillet.cv. GHB-32, MH-179. It depressed the accumulation of dry matter of shoot in different stages of ghowth and the depression seemed to be highly significant (P 0.01) in later developmental stages. (Table 41).Similarly when the cultivar response was ignored, soil humus brought about distinct partial ameliorating effect on the waterlogging stres throughout the different stages of growth (Table 42). The result of Anova also clearly indicated the adverse effect of waterlogging treatment and the partial recovery by the additional humus on the different yield parameters conducted during the kharief seasons in the year 1988 and 1989, of the cultivars GHB-32, MH-179 and BK-560 of*P.typhoides* though there were no considerable difference in the economic biological yield between the three cultivars of peart millet, highly significant differences (P = 0.01) were observed between the control, waterlogging stress and humus application to the soil. The first order of interaction was observed to be significant between waterlogging and humus treatment. There was again significant interaction between cultivar and humus (Table 43,44,45). The interaction of waterlogging and humus also revealed that length, girth, number of florets, number of grains per spike were highly reduced in waterlogging treatment than control. However in the humus treatment, significant improvement in all characters was evident

TABLE 40- Mean squares from Analysis of variance Examining effects of Cultivar(C) Waterlogging (W) and Humus (H) on Leaf Area Index of pearl millet at different growth stages

Variance	D.F.	I	II	III	IV
Replication	4	0.43	0.08	1.5	0.45
Treatment	7	2.9	6.2	6.4	4.9
C	1	3.6**	1.1	3.7	5.6**
W	1	4.6**	13.6**	15.9**	13.3**
H	1	8.8**	19.6**	16.8**	7.7**
CW	1	0.3	0.1	0.2	0.9
CH	1	0.31	1.2	1.6	2.2
WH	1	3.1	7.6	6.3*	3.5*
CWH	1	0	0.1	0.3	1.0
Err	28	0.8	1.9	1.3	0.73

* P=0.05 ** P=0.01

TABLE 41- Effect of waterlogging treatment and cultivar variability of Pearlmillet on the dry weight (gm) of plant at different stages of growth irrespective of soil humus status.

Growth stage	GHB-32		MH-179		LSD	
	FD	WL	FD	WL	5%	1%
I	0.104	0.092	0.1	0.083	0.031	0.043
II	0.439	0.161	0.358	0.199	0.098	0.138
III	0.93	0.339	0.81	0.248	0.196	0.276
IV	1.735	0.673	1.44	0.462	0.523	0.734

TABLE 42- Effect of waterlogging and soil Humus status on the dry weight (gm) of the Pennisetum typhoides irrespective of cultivars at different growth stage.

Growth stage	(FD) Flooded		(WL) Waterlogged		LSD	
	NH	HH	NH	HH	5%	1%
I	0.057	0.147	0.06	0.114	0.013	0.018
II	0.196	0.6	0.11	0.25	0.065	0.092
III	0.363	1.38	0.167	0.421	0.153	0.214
IV	0.926	2.25	0.29	0.85	0.458	0.643

TABLE 43 - Mean squares from the Analysis of Variance Examining effects of cultivar(C) Waterlogging(W) Humus(H) and their interactions on different components of the reproductive parts of *Pennisetum typhoides*.

Variance	DF	Length of ear(cm)	Girth of ear	No. of florets	Sterility(%)	No. of grains/ ear
Replicate	4	0.7	0.1	6161	340	6449
Treat	7	40.4**	1.8**	297819**	2172**	239952**
Cultivar(C)	1	2.0	0.4*	109098**	59	273353*
Waterlogged(W)	1	229.9**	5.9**	1307908**	6147**	911436**
Humus(H)	1	46.9**	4.2**	461176**	7517**	534534**
C x W	1	1.5	0.15	11458	536	980
C x H	1	2.8	1.1**	1580	558	37454*
W x H	1	0.01	0.6*	157628**	311	15926**
C xW x H	1	0.01	0.00	21669	72	8644
Err.	28	1.2	0.1	6799	2.09	5518

Levels of significance: P =0.05(*) P=0.01(**).

TABLE 44- Mean variance of independent effects of cultivar, waterlogging and humus and their interactions on Biological yield,wt. of grains and Harvest index of pearlmillet under waterlogging stress.

Variance	D.F.	Biological yield straw + grains	Wt. of grains /ear	Harvest index
Replicate	4	0.23	0.13	0.01
Treatment	7	15.4**	3.08**	0.11**
Cultivar(C)	1	3.24**	1.26**	0.05*
Waterlogged(W)	1	53.9**	11.24**	0.34**
Humus(H)	1	40.74**	6.49**	0.15**
C x W	1	0.17	0.08	0.06
C x H	1	1.43	1.06**	0.07*
W x H	1	8.42**	1.34**	0.09**
C x W x H	1	0.01	0.09	0.00
Err.	28	0.43	0.06	0.01

Levels of significance: at 5%(*) and 1%(**); each value is the mean of 10 replicates.

TABLE 45 - Mean squares from Analysis of Variance Examining effects of cultivar(C) waterlogging(W) Humus(H) on the different components of reproductive part of pearl millet under waterlogging stress.

Variance	DF	Length of spike(cm)	No. of florets	No. of grains	% sterility	Biological yield Straw+Grain	Wt.of grain	Harvest Index
Replicate	2	7.6	3732	4760	32.1	0.25	0.05	0
Treatment	7	28.2	203743	187669	2964	14.3	2.3	0.06
Cultivar	1	8.3*	49777*	16120	157	0.11	0.26	0
Water-logged	1	131**	626943**	777599**	15509**	37**	7.1**	0.19**
Humus	1	50**	508959**	362604**	2222**	44.8**	5.2**	0
CW	1	6.7*	925	7490	224	0.19	0.1	0.02
CH	1	0.43	2752	2688	26	1.0**	0.8*	0.04
WH	1	4.7	229126**	142912**	2560**	16.1**	2.0**	0.1**
CWH	1	0.0	7717	4267	52	0.8*	0.64	0.05*
Err	14	1.3	8147	6824	106	0.21	0.16	0.01

Level of significance P= 0.05* 0.01**

as compared to the normal humus treated control.This was mainly due to the improved vigour of the crop as a result of additional soil humus (Table 43,45). The biological yield, weight of grains per ear and Harvest index were also significantly (0.01) reduced the waterlogging treatments and there were significant improvement in the above characters by the application of humus to the soil (Table 44, 45). Definite influence of the organic matter on the yield and other components of ear was found as indicated by the interaction of cultivar and humus irrespective of the waterlogging stress (Table 32). However, the rate of increase in the above reproductive components due to humus applications was less under the waterlogging stress as compared to the rate observed in the absence of waterlogging condition.(Table 31). Similarly the ANOVA tested, presented in the table 46, indicated the independent as well as combind effects of other treatment such as di & plyamine sprays on dry matter accumulation of GHB 32. The interaction between the waterlogging and polyamines was also apparent in the pigment studies.(Table 47). Among the other treatments tried , combined effects of salinity and diamine putrasine also indicated distinct independent effect on the dry matter accumulation of leaf ,stem and shoot. The interaction between waterlogging and orther treatment put together was clearly evident on the dry matter accumulation of shoot . (Table 48). The interaction of waterlogging and salinity and putrasine treatment put together , significantly affected the pigment contents of chlorophyll 'a' and 'b' during all the growth stages studied and the

TABLE 46- Mean squares from Analysis of variance examining effect of waterlogging(W) and other treatments (Treated with growth regulators) and their interactions on dry matter accumulation at different stages of growth, under waterlogging stress.

Variance	DF	LEAF				STEM				SHOOT			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
Replication	4	5^{-5}	7^{-4}	0.002	0.01	1^{-4}	0.003	0.007	0.05	0.00	0.035	0.007	0.005
Treatment	7	7^{-4}	0.007**	0.036*	0.02**	1^{-4}**	0.006**	0.03**	0.14**	1^{-3}**	0.025**	0.05**	0.25**
Waterlogged (W)	1	0.002**	0.01**	0.01*	0.08**	5^{-4}**	0.004**	0.09**	0.52**	3^{-3}**	0.02**	0.15**	1.0**
Other treatment(O.T.)	1	0.003**	0.05**	0.03**	0.03**	8^{-4}	0.03**	0.14**	0.46**	5^{-3}**	0.15**	0.2**	0.92**
W x O.T.	1	0.0	0.0	0.02**	0.07**	0.0	0.006**	0.15**	0.01	0.00	0.01**	0.02	0.08**
Err.	28	6^{-5}	2^{-3}	2.6^{-3}	3^{-3}	2^{-5}	0.001	0.0035	0.03	7^{-5}	4^{-3}	0.01	0.03

Significance of level F*= 0.05 ** P= 0.01

(4) What are the growth regulator used and relative effect

TABLE 47- Mean squares of ANOVA, responses to the variables like waterlogging(W) and other treatments(spraying of polyamines) and their interactions on the pigment content at different growth stages of Pearl millet growing under waterlogging stress.

Variance	FD	Chlo.a			Chlo.b			Carotenoids		
		I	II	III	I	II	III	I	II	III
Replicate	4	0.06	0.05	0.015	0.002	0.005	0.01	0.005	0.003	0.0025
Treatment	7	0.06**	0.38**	0.34**	0.014	0.07**	0.07**	0.008	0.02**	0.03**
Waterlogged(W)	1	1.05	1.4**	1.5**	0.002	0.3**	0.02**	0.004	0.04**	0.12**
Other treatments(O.T.)	1	0.03	0.15**	0.45**	0.00	0.00	0.3**	0.004	0.038**	0.04**
W x O.T	1	0.32**	1.15**	0.41**	0.098**	0.21**	0.15*	0.052**	0.062**	0.07**
Err.	28	0.05	0.06	0.045	0.008	0.02	0.05	0.004	0.005	0.01

P = 0.05(*) P = 0.01(**)

TABLE 48 - Mean variance of independent effects of waterlogging(W) and other treatments(Putrasine and salinity) and their interactions on the dry matter accumulation of pearlmillet cv GHB-32 at two different stages of growth.

Variance	D.F	LEAF		STEM		SHOOT	
		I	II	I	II	I	II
Treatment	4	0.008**	0.03*	0.0048*	0.03**	0.026*	0.17**
Replication	5	0	0.0075	0.0025	0	0.0025	0.003
Waterlogged	1	0.02**	0.096**	0.005*	0.1*	0.04**	0.6**
Other treatment	2	0.005**	0.026**	0.009**	0.015**	0.035**	0.085**
WXO.T	2	0.005**	0.0012	0.0005	0.01**	0.01**	0.04**
Err	20	0.0005	0.0095	0.0015	0.0015	0.0015	0.004

* Significance P = 0.05(*) P = 0.01(**)

carotenoides in the last stage of growth of the cultivar GHB-32, of Pennisetum typhoides. (Table 49).

TABLE 49- Mean variance of independent effects of waterlogged and putrasine spray and their interactions on the pigment content of the Pennisetum typhoides cul.GHB-32 growing under waterlogging and salinity stress.

Variance	D.F	Chlo.a			Chlo.b			Carotenoids		
		I	II	III	I	II	III	I	II	III
Replicate	5	0.02	0.03	0.04	0.03*	0.0	0.004	0.015	0.007	0
Treatment	4	0.04**	0.42**	0.29**	0.11*	0.12**	0.09**	0.03*	0.05**	0.04**
Water-logged	1	0.57**	1.27**	1.2**	0.08*	0.48**	0.32**	0.04**	0.2**	0.1**
Other treatment	2	0.16	0.2*	0.05*	0.09*	0.01	0.01	0.03*	0.015**	0.00
W x O.T	2	0.55**	0.22**	0.08**	0.15**	0.05	0.045**	0.02	0.00	0.045**
Err.	20	0.07	0.05	0.014	0.03	0.02	0.004	0.008	0.002	0.001