FINAL REPORT

'STUDIES ON THE IMPACT OF WARANA RIVER FLOOD ON THE SOIL FERTILITY AND SOCIO-ECONOMY OF THE REGION IN KOLHAPUR DISTRICT'

MINOR RESEARCH PROJECT

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Submitted by

Principal Investigator: **Dr. Sudhakar Sambhaji Khot**
M.Sc., Ph.D.
Assistant Professor in Botany
e-mail: sudhakarskhot@ycwm.ac.in

Co-Investigator: **Mr. Jagannath Yashwant Buchade**
M.Sc., M. Phil.
Assistant Professor in Botany
e-mail: jybuchade@rediffmail.com

YASHWANTRAO CHAVAN WARANA MAHAVIDYALAYA,

WARANANAGAR – 416 113, DIST. KOLHAPUR (MS)
NAAC Re-Accreditation: B Grade (CGPA 2.85)
Website: ycwm.ac.in, e-mail: ycwcwarana@yahoo.co.in

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DECLARATION AND CERTIFICATE

I hereby declare and certify that, the Minor Research Project entitled 'STUDIES ON THE IMPACT OF WARANA RIVER FLOOD ON THE SOIL FERTILITY AND SOCIO-ECONOMY OF THE REGION IN KOLHAPUR DISTRICT' [F.No. 47-1170/09(WRO) dated 26/10/2009] is a bonafide record of research work carried out by me during the year 2009-2011.

It is also certified that the work presented in the report is original and carried out according to the plan in the proposal and guidelines of the University Grants Commission.

Co-Investigator **Principal Investigator**

(J.Y.Buchade) **(S.S.Khot)**

CONTENTS

1. INTRODUCTION

Water is one of the fundamental factors controlling growth, development and reproduction of plants. Although all plants require access to free water, its deficit or excess amount in the root environment can be harmful as it blocks the transfer of oxygen and other gases between the soil and the atmosphere. Flood is one of such natural calamity that induces water –logging stress to the crops.

Floods occur frequently throughout the world. The global assessment report on disaster risk reduction revealed that on an average of 53.2 million people worldwide are exposed each year to the flood events. (Peuzzi *et al*., 2009). It further reported that, the geographic distribution of flood mortality is heavily concentrated in Asia. India is at the topmost level of the mortality risk index. floods have been recurrent phenomenon in India and over 40 million hectares of land is prone to the floods. The range of consequences that a flood brings about includes economic, political, social, psychological, ecological and environmental damages and damages to cultural heritage (Pistrika, 2010). There is a substantial body of international literature that provided evidence of extensive expertise in the field of damage estimation. However, the datasets anf risk estimation at global level should not be used for local level planning. Peuzii and coworkers (2009) emphasized need of study at local level.

Flood is a situation when there is flow of water in a river more than its capacity and the water overflows the levees and spread in nearby areas. Water-logging is defined as the state whereby soil becomes saturated with water within the depth of the root zone for a period that affects yield and quality of crops (Biswas and Mukherjee, 1994). Central ground water board reported that during monsoon period an area of 36.36 million ha is temporarily water-logging (Gupta, 2001). The flood causes submergence of crop plants restricing respiration and gaseous exchange thereby ceasing all growth processes leading to death and decay. Aerobic crops cannot restist standing water and submergence (Mishra et al., 2011).

Soil chemical properties change when anaerobic conditions persist for several days, increasing the availability of some major or minor elements while decreasing the availability of others (Reynolds *et. al.*, 2001). Ethylene is produced both by the roots and by microorganisms in waterlogged soils which cannot escape due to water. Ethylene is known to be a trigger of leaf senescence. When crop plants are subjected to soil water-logging, or an anaerobic condition, their root and shoot systems respond differently. A

variety of morphological and anatomical alterations develop in the root system. Reduction of the root respiration rate has been reported in both flooding-tolerant and intolerant species (Chung and Chin, 2001). The effects of water-logging condition on physiology of various crops like maize (Andrews et. al., 1994), rice (Bertani et al., 1981), tomato (McNamara and Mitchell, 1989), wheat (Samad *et. al.*, 2001) etc. have been studies. However, much of the work has been carried out under artificial flood or over watered conditions. Reynolds *et al.* (2001) feel that screening for water-logging is best done in the field, rather than in less realistic laboratory conditions.

Soil water-logging has been identified as a major abiotic stress that imposes the marked effects on plant growth and development. During water-logging or submergence, plants are exposed to a reduction in oxygen supply because of the slow diffusion rate of oxygen in water and its limited solubility. If such event occurs in spring, it can greatly reduce seed germination and seedling establishment. Thus, it is an important abiotic factor which affects the growth, development and survival of most of the plant species not only in natural ecosystems but also in agricultural and horticultural systems.

Kolhapur district, situated between 15^0 and 17^0 N longitude and 73^0 and 74^0 E latitude in Maharashtra State is the agricultural district having about 506,400 hectares land (i.e. 65.33% of total land) under agriculture. The annual average rainfall is 1015 mm (Collector office Kolhapur,_irrigation: http://kolhapur.nic.in/). The main crop of the district is sugar cane and other crops include Jawar, Groundnut and Soybean taken in Kharif Season. Along the rivers of the district namely, Krishna, Warana, Panchganga, Dudhganga, Vedganga, Hiranyakeshi and Ghatprabha crops are cultivated in both the seasons. The major rivers have deposited alluvium along the bank thickness of which varies between 6 to 20 meters and forms the valley fill. The alluvium consists of clay, silt and sand. Warana river forms almost the entire northern boundary separating Sangli and Kolhapur districts. Warana is the main tributary of Krishna river in the district and merges with it in Shirol tahsil. Warana dam is situated in Shahuwadi tehsil. It has the capacity of 974.19 MCFT water. It had benefited 105 villages in the basin region with the command area of 50131 hectares. (Colletor Office, Kolhapur, irrigation: http://kolhapur.nic.in/)

According to the 1991 population census, the population of the Kolhapur district is 29.74 lakhs out of which 73.60% inhabit in rural area. The secondary source of income is milk production. The district is rich in livestock with cattle population of 1,136,722 and poultry population of 1,383,027.

About 188 villages of riverside are prone to floods in Kolhapur district. High floods generally occur due to heavy rainfall in catchment area of major dams and release of excess water. Although, earlier records show that high floods in Kolhapur occurred in 1989 and 1994, floods are continuous in last few years viz., 2005, 2006, 2007 and in 2008. However, the impact of flood on environment particularly on soil fertility, cropping pattern and socio-economy of the society is not studied. In any locality, the cropping systems are the cumulative results of past and present decisions by individuals, communities or governments and their agencies (Jaiswal *et al.* 1980).

To meet the ever increasing demand of food, to maintain the rate of socio-economic development in good pace, it is necessary to screen the short term effects and long term effects of flood on soil fertility, crop production, alternative cropping patterns, develop flood tolerant varieties, and availability of flood tolerant crop varieties.

The problem of this research project deals with various disciplines like, livelihood of the society, their economy, collection of the data of the agricultural cropping pattern, response of various crops of the region to the flooding stress, identification of better and flood tolerant varieties and study of status of soil fertility with relation to flood.

1.1 OBJECTIVES

- To study economy of the society with relation to flood
- To study the steps taken by the farmer to overcome the loss caused due to flood.
- To study physicochemical properties and fertility status of the soils before and after flooding.
- To study history and present status of cropping pattern in the region.
- To study response of crop plants to various degree of water logging and or submergence.
- To find out appropriate conclusion and suggestions.

2. METHODOLOGY

2.1 Study Area and Sample collection

The Warana river flows along Shahuwaddi, Panhala, Hatkanangale and Shirol tehsils of Kolhapur and meets to river Krishna at Kothali in Shirol. The Warana river starts from Warana Dam and flows in west to east direction. It is a natural border which separates the districts Kolhapur and Sangli. The proposed study was carried out in the region along bank of Warana River flowing through Kolhapur district.

Extensive field visits were arranged during October 2009 to 2011, along the Warana river basin in Kolhapur district. We have divided the Warana river basin in 3 zones for convenience of the study, viz, upper region (Shahuwadi Tehsil), middle region (Panhala tehsil and part of Hatkanangale) and lower basin region (Hatkanangale and part of Shirol tehsil).

We have selected Bhedasgaon (Shahuwadi Tehsil), Kakhe (Panhala Tehsil), Bhadole (Hatkanagale Tehsil) and Kavathesar (Shirol Tehsil) for study. The socio-economic information and soil samples were collected from these villages. The soil samples were collected before and after the flood (Photo Plate 9 and 10) from these selected sites and analyzed for their physico-chemical properties.

2.2 Soil analysis

The soil samples were analyzed for it fertility by studying following physico-chemical properties:

Soil pH:	pH meter (Elico)
EC:	Systronic 306 model
Organic Carbon:	UV-visible spectrophotometer (Systronic 119)
Nitrogen:	Kjeldhas assembly
Phosphorus:	UV-visible spectrophotometer (Systronic 119)
Potassium:	Flame phorometer
Calcium:	EDTA titration
Magnesium:	EDTA titration
Sulphate:	UV-visible spectrophotometer (Systronic 119)
Copper, Iron, Manganese and Zinc:	AAS (Systronic 113)
Boron:	UV-visible spectrophotometer (Systronic 119)

2.3 Study of Socio-economy

A questionnaire (Annexure – A) was developed to collect the information of farmers regarding various social, economical and agronomical aspects. The information was collected from the local farmers. The data collected was analyzed statistically to get the inference. Response of crops to various degrees of water logging (and submergence) was recorded from field observations.

2.4 Laboratory experiments

Two plant species namely *Vigna aconitifolia* and *Portulaca oleracea* were grown in the plastic pots filled $3/4^{th}$ by red garden soil. The plants were initially grown by using Hoagland solution for 30 days as an establishment of plants. Then, they were artificially exposed to flood conditions. The plants were collected at 0, 7, 14 and 21 days interval after establishment and analyzed for the root length, shoot length, leaf area, fresh weight and dry weight.

3. RESULTS

3.1 Study Area and Sample collection

The field visit study along Warana River revealed that the river basin is narrow in upper region of flow, became broader towards Hatkanagale and Shirol tehsil. Furthermore, the soil in is red alluvial soil in most of the basin. The depth of the the river is more in upper basin and became shallower towards middle and later part. Due to this nature of basin, the agricultural area in middle and lower basin is more prone to flood. Especially the part of Shirol and Hatkanagale tehsil frequently experienced the flood. Torrential rains, flooding and the offshore vortex caused over 1000 death in the western Indian coast in July 2005. The floods disrupted lives of about 20 million people and caused financial losses of over 150,000 million rupees (Ref. 'Floods in Mumbai and Maharashtra', July 2005, A report by Action Aid International).

Retarded flow due to back water effect is one of the factors causing flood situations in lower basin. Union of Warana river into Krishna interrupted the rate of water flow in the river stream. According to some leaders, height of the Alamatti Dam pushes the water back in Krishna River. It was noted that, heavy rainfall in the catchment area of Warana and release of excess water from the Dam results in flood situation during rainy season. Population in 16 villages of Kolhapur district situated along Warana river were affected by flood during 2005 (*Krishna river flood report, 2005*).

3.2 Soil analysis

The soil samples were collected for two years (2010 and 2011) of the study period from Bhedasgaon, Kakhe, Bhadole and Kavathesar. Soil samples collected during May were considered as samples before flood and those collected in August as samples after flood. The analysis of the samples showed following characteristics.

As shown in the Table. 1. The pH of the soil was little acidic and EC was less than 0.42 mS/cm. According to the standards, N- content of fertile soil ranges between 281 to 420 Kg/Hectare. Average quantity of N reported was too low than the standard amount required and was further decreased after flood. The

soils were also deficient in calcium and boron whereas, quantities of sulphur reported were too high than normal range.

Table 1. Characteristics of soil at Bhedasgaon

	May-I	**Aug-I**	**May-II**	**Aug-II**	**Average**
pH	6.3	6.6	6.7	6.4	6.50
EC (mS/cm)	0.26	0.23	0.33	0.42	0.31
Nitrogen (Kg/H)	34.35	23.41	23.34	18.06	24.79
Phosphorus (Kg/H)	14.46	43.68	21.5	20.57	25.05
Potassium (Kg/H)	262.46	142.05	102.98	62.31	142.45
Organic C (%)	2.34	1.59	1.59	1.23	1.69
Calcium (meq/L)	19.75	22.5	19	18	19.81
Magnesium (meq/L)	19.78	6.9	11.27	21.39	14.84
Sulphur (ppm)	67	5.5	63.5	164.5	75.13
Copper (ppm)	6.6	5	5.2	4.4	5.30
Iron (ppm)	26.4	14.68	12.88	21.2	18.79
Zinc (ppm)	1.26	0.82	0.8	0.66	0.89
Manganese (ppm)	86	7.8	7.6	7.92	27.33
Boron (ppm)	0.16	0.23	0.1	0.044	0.13

The pH of soil at Kakhe site (Table 2.) was ranged between 6.4 to 6.9 and EC was less than 0.65 mS/cm. the soils were deficient in nitrogen, calcium and boron. They showed excess amounts of magnesium and sulphur. Furthermore, the nitrogen contents were decreased after flood.

Table 2. Characteristics of soil at Kakhe

	May-I	Aug-I	May-II	Aug-II	**Average**
pH	6.5	6.77	6.4	6.9	6.64
EC (mS/cm)	0.38	0.65	0.45	0.13	0.40
Nitrogen (Kg/H)	32.94	27.3	47.56	35.67	35.87
Phosphorus (Kg/H)	57.83	27.89	11.79	46.03	35.89
Potassium (Kg/H)	625.04	130.96	184.41	168.88	277.32
Organic C (%)	2.19	1.86	3.24	2.43	2.43
Calcium (meq/L)	13.75	8.75	12.5	3.75	9.69
Magnesium (meq/L)	23.69	23	21.16	42.09	27.49
Sulphur (ppm)	120	793	261.5	7.5	295.50
Copper (ppm)	7	3	5.4	7	5.60
Iron (ppm)	28.08	13.8	16.15	20.2	19.56
Zinc (ppm)	1.88	1.1	1.31	1.86	1.54
Manganese (ppm)	5.94	28.2	32	5.8	17.99
Boron (ppm)	0.108	0.06	0.072	0.29	0.13

Table 3. Characteristics of soil at Bhadole.

	May-I	Aug-I	May-II	Aug-II	Average
pH	8	7.2	7.6	7.01	7.45
EC (mS/cm)	0.1	0.45	0.42	0.26	0.31
Nitrogen (Kg/H)	17.61	31.26	36.11	3.038	22.00
Phosphorus (Kg/H)	19.82	25.54	27.89	40.66	28.48
Potassium (Kg/H)	47.95	196.76	205.53	262.24	178.12
Organic C (%)	1.2	2.13	2.46	2.07	1.97
Calcium (meq/L)	13	10	12	10.5	11.38
Magnesium (meq/L)	23	17.25	32.66	32.43	26.34
Sulphur (ppm)	385	133	46	43	151.75
Copper (ppm)	2.2	4	5.2	4.6	4.00
Iron (ppm)	6.35	9.95	5.53	9.61	7.86
Zinc (ppm)	0.19	1.09	1.06	1.18	0.88
Manganese (ppm)	9.2	16.15	12.4	19.2	14.24
Boron (ppm)	0.096	0.057	0.096	0.032	0.07

Table 4. Characteristics of soil at Kavathesar.

	May-I	Aug-I	May-II	Aug-II	Average
pH	7.2	6.7	6.5	6.4	6.70
EC (mS/cm)	0.36	0.23	0.37	0.1	0.27
Nitrogen (Kg/H)	53.28	32.58	63.85	31.26	45.24
Phosphorus (Kg/H)	49.39	56.11	31.14	14.9	37.89
Potassium (Kg/H)	172.79	457.53	153.67	323.61	276.90
Organic C (%)	3.63	2.22	4.35	2.13	3.08
Calcium (meq/L)	27.5	11	18.75	13.75	17.75
Magnesium (meq/L)	4.2	22.54	21.85	34.5	20.77
Sulphur (ppm)	75.5	110	4.95	5.5	48.99
Copper (ppm)	5.4	5.2	6.8	8.6	6.50
Iron (ppm)	9.22	23.2	30.2	47.4	27.51
Zinc (ppm)	1.06	1.04	1.52	1.76	1.35
Manganese (ppm)	1.62	6.96	5.62	90.8	26.25
Boron (ppm)	0.056	0.176	0.12	0.4	0.19

The soils at Bhadole (Table 3.) showed alkaline pH ranging between 7.01 to 8. Electrical conductivity was less and ranged from 0.1 to 0.45 mS/cm. Among the macro-nutrients, N- content was low and S- content was more than fertility norms. Magnesium quantity were higher with an average of 26.34 meq/L. Soils were deficient in Ca and B.

Fig. 1. Status of pH in the soils between 2005-2010 (% of the samples analyzed)

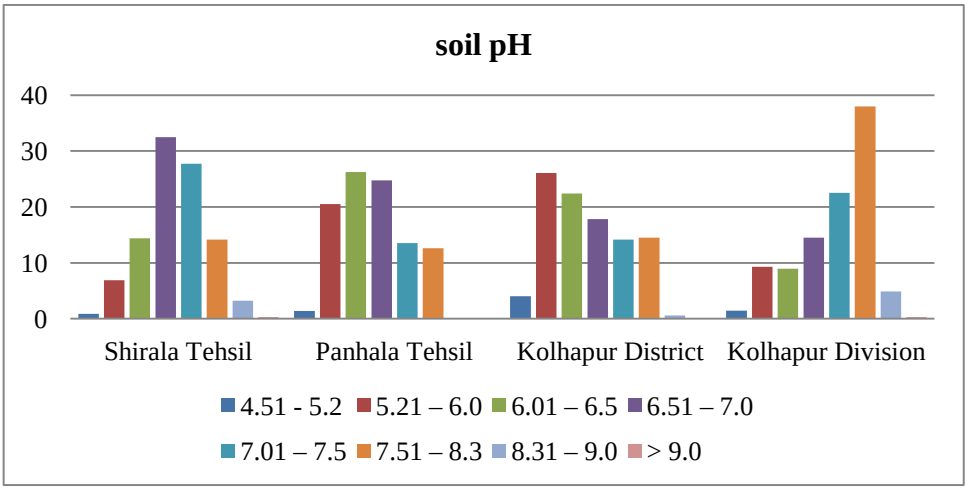


Fig. 2. Status of pH in the soils between 2005-2010 (% of the samples analyzed)

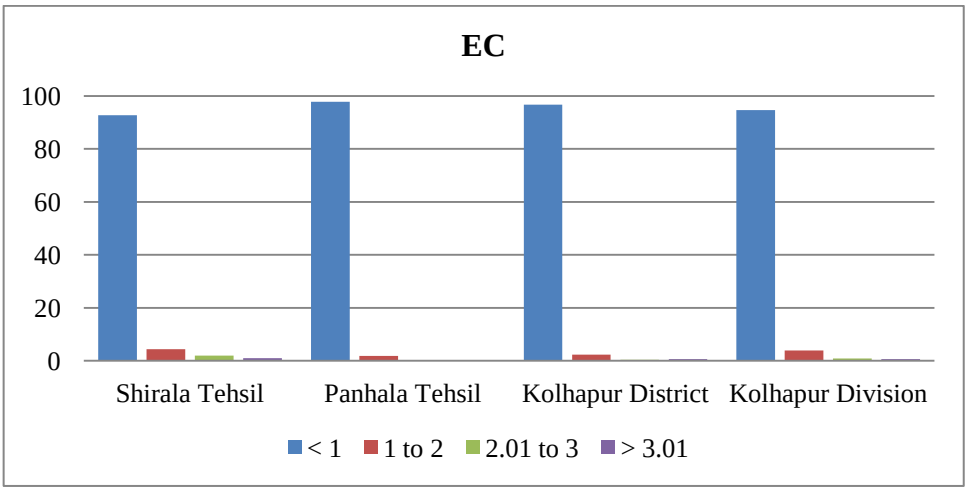
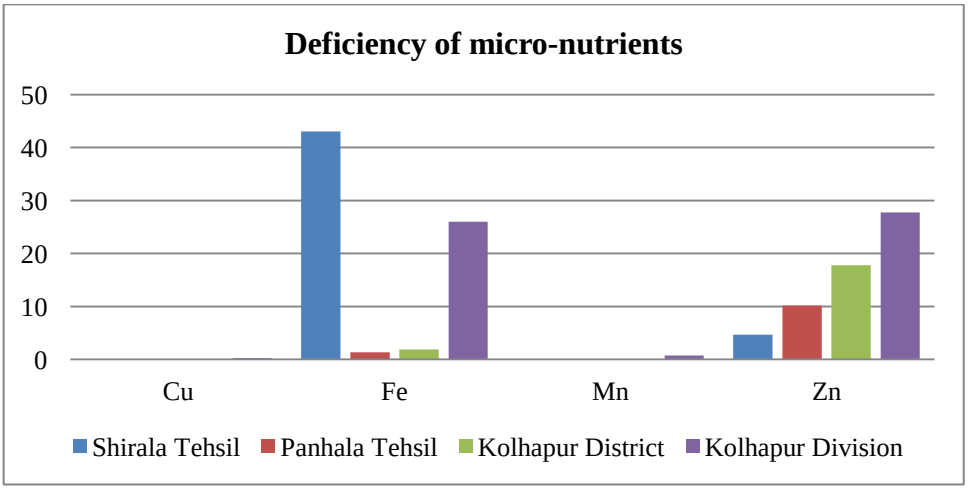


Fig. 3. Status of micro nutrient deficiency in the soils between 2005-2010 (% of the samples analyzed)



The Kavathesar site (Table 4.) soils were acidic in pH and normal in EC. Soils were rich in sulphur and deficient in nitrogen and calcium. The nitrogen content was further decreased after flood.

Figure 1. shows the trend of soil pH in Shirala Tehsil (Warana river basin in Sangli District), Panhala tehsil (Warana river basin in Kolhapur district), Kolhapur District and Kolhapur Division. It exhibited that most of the soils in Panhala tehsil have pH between 6.01 to 7 whereas those in Shirala tehsil and in Kolhapur division are alkaline in pH.

The Electrical conductivity of the soils (Fig. 2.) remained less than 1 dS/m. Few soils showed deficiency in Cu and Zn (Fig. 3.) whereas negligible were deficient in Cu and Mn. However data on quantity of B was not available. Present study showed that the soils in Warana river basin were also deficient in Boron.

3.3 Study of Socio-economy

The information regarding socio-economy of the society in Warana river basin was collected through organizing field visits, personal interviews and the questionnaire.

3.3.1 Study of Socio-economy

It was noted that, agriculture is the main occupation of the population. They are dependent on agricultural produce for their livelihood. Most of the land is irrigated after the construction of Warana Dam in Shahuwadi tehsil. The main water source is rain water received during monsoon season in the catchment area. It has the capacity of 974.19 MCFT water. It had benefited 105 villages in the basin region with the command area of 50131 hectares. (Collector Office, Kolhapur, irrigation: http://kolhapur.nic.in/).

The important crops are sugarcane in middle and lower basin area, whereas paddy fields are dominant in upper basin area. In addition to these crops, other cash crops as soybean, groundnut and vegetables are also cultivated in the irrigated land. However, the flood prone area is mainly cultivated under sugarcane crop.

The survey revealed that during 2009 - 2011, the duration of flood varied between 3 to 7 days in middle basin. It caused loss of about 75 % crop

production, in case of the farmers having their agriculture in close vicinity of the river bank (Photo plates 1 to 6).

Although, development of various industries like sugarcane industry, milk processing units, textile spinning mills etc created job opportunities, milk production and small scale poultry are the secondary sources of the income of the society.

3.3.2 Study on cultivation practices

The agronomical information regarding awareness of farmers, flood tolerance mechanism, use of advance techniques, local practice for reducing adverse effect etc was collected through field visits and questionnaire. Analysis of these information showed that:

a. Only one third farmers had received compensation from government against the crop loss due to flood.
b. Sixty one percent farmers were not aware of the flood tolerant varieties, or such concept.
c. Farmers are trying to change the cropping pattern. Instead of early cultivation (in the month of June-July) of sugarcane, farmers planted the crop in late August and September. By doing this, it is assumed that the one can escape from the effect of flood on young crop.
d. However, the about 10 month old crop of sugarcane when exposed to flood, the crop production was decreased partially or completed. It was depended on severity and duration of flood. It was reflected through the answer that 79 % farmers did not found it helpful to avoid complete loss.
e. Most of the farmers changed the crop preference. Sugarcane requires 16 to 18 month duration for harvesting. Due to this, the chance of loss due to flood remains even after cultivation at any season in the year. Recognizing this fact, farmers preferred seasonal crops and vegetable instead of sugarcane. 88% farmers attempted change in crop preference.

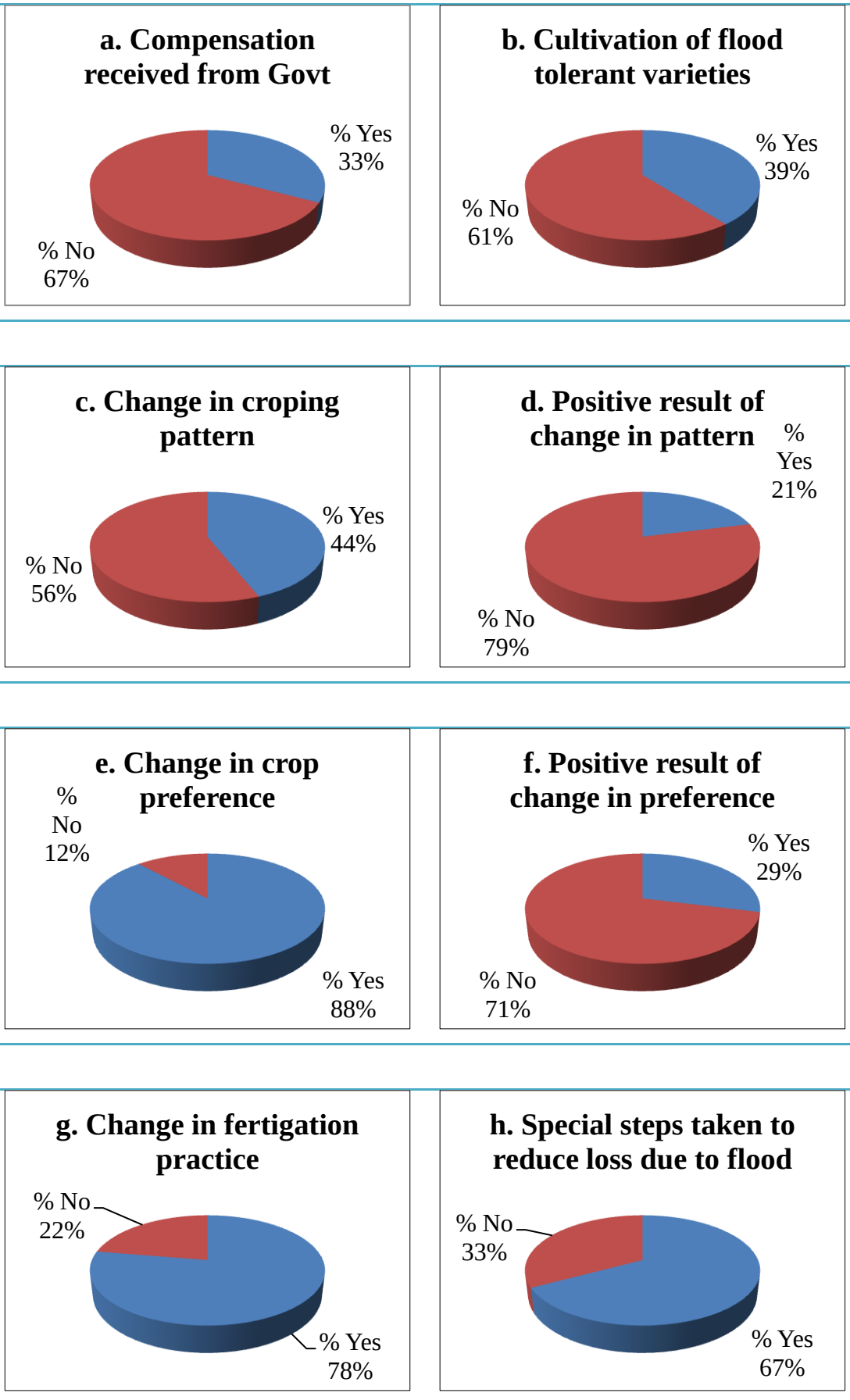


Fig. 4 to 11. Response of the farmers to the flood

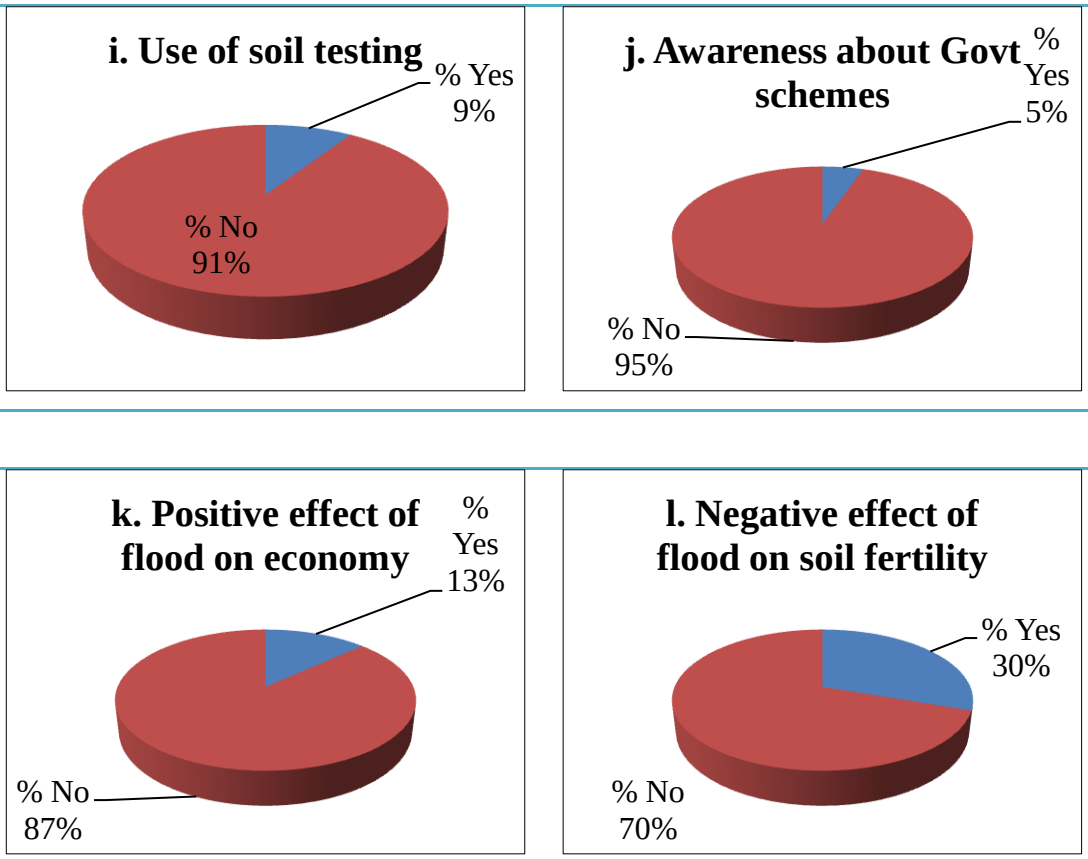


Fig. 12 to 15. Opinion of farmers on impact of strategies against flood

f. Although, most of the farmers were not satisfied with this practice.

g. The farmers were aware of the adverse effects of chemical fertilizers. Furthermore, they also recognized that chemical fertilizers were get washed out after submergence of the land under flood water. 78 % farmers changed their chemical fertigation practices to organic, use of biofertilisers and integrated fertigation.

h. Sixty seven percent farmers were aware of crop loss due to flood and they attempted various mechanisms to reduce loss due to flood

i. The number of farmers using soil analysis for available nutrient was negligible. 91 % farmers did never analyzed their soil samples from any laboratory.

j. The region was under urgent need of social awareness regarding various governmental schemes for agriculture.

k. 87 % farmers agreed that flood cause economical loss either in the form of loss of standing crops, loss of livestock, loss of yield etc.

l. Significantly, 70 % farmers did not agree that flood affect the soil fertility adversely. It was noted by personal interactions with farmers and field visits that flood deposit a clay layer on agricultural land.

Flood was responsible for loss of standing crops but did not affected soil fertility. It was also clear from the analysis of soil samples, that flood washed out nitrogen however improved organic decomposition of the crop and other soil humus. This was resulted in excess amount of organic carbon in all the studied soils.

3.3.3 Suggestions given by farmers

The important suggestions given by farmers were as below:

a. Along with government, educational institutes and research institutes should take initiatives for soil testing. They should also provide guidance to the farmers regarding flood tolerant varieties, techniques and tools.
b. Sugar factories should make the crop harvesting mechanism more effective. Furthermore, the sugarcane should be harvested within due period of harvesting.
c. Few of them have also suggested that all farmers should be alert regarding advance Agriculture techniques.
d. The farmers also underline the need of organization of awareness campaign and soil testing workshops by the education institutes.
e. Farmers require development of flood tolerant varieties.

3.4 Laboratory Experiments

Two plant species were selected to understand the effects of flooding on the growth. *Vigna aconitifolia* is a leguminous crop plant rich in protein content and *Portulaca oleracea* is a common, succulent weed plant growing in almost all countries.

3.4.1 Details of plants selected

A. ***Vigna aconitifolia* (Jacq.) Marechal**:

Moth bean (*Vigna aconitifolia* (Jacq.) Marechal) is one of the minor legume crops. The National Academy of Sciences has identified moth bean as

possibly more significant food source for the future (NAS, 1978). It is known by different common names such as kidney bean, dew bean, dew gram, Turkish gram, moth, mat, mat bean and matki. The name "moth" comes from the Hindi word pronounced "mat" or "mote," according to the National Academy of Sciences.

In India, green pods are eaten as a vegetable. The tiny seeds are also eaten whole or split. The seeds are also used for preparation of curry after they sprout. As far as India is concerned moth bean dal is used for preparation of traditional products like papad and sandge. Seeds contain 22-24% protein. The seeds of the moth bean have medicinal value and are used in the diets of patients suffering from fevers.

It is also grown for fodder and as a soil conditioner. Dried moth bean plants form an excellent hay. Green plants are a good fodder for sheep. The straw is highly palatable and nutritious. Moth bean (*Vigna aconitifolia* (Jacq.) Marechal, synonym *Phaseolus aconitifolius* (Jacq.) belongs to family Fabaceae, (Leguminosae, subfamily Papilionoideae).

B. *Portulaca oleracea* L.

Portulaca oleracea, commonly known as purslane / pigweed (in the U.S.), is herbaceous weed. It is a member of Portulacaceae, which consists of more than 120 species of succulent herbs and shrubs (Hyam and Pankhurst, 1995). Some of the common names include garden purslane, little hogweed and wild *Portulaca*. The origin of purslane is uncertain (likely native to North Africa, the Middle East, and the Indian subcontinent).

It is fast growing having succulent leaves with prolific seed production and has an ability to survive in all types of soils from high organic matter to heavy clay. It is found to be growing in almost any un-shaded area, including flower beds, corn fields, and waste places. *Portulaca oleracea*, is a highly variable, weedy plant with a wide distribution. It can be found growing wild and/or cultivated in most part of the world.

3.4.2 Effect of flood on growth under laboratory conditions

The effect of flood on the growth parameters of the two selected plant species was studied by recording root length, shoot length, root: shoot ratio, leaf area, fresh weight, dry weight and dry weight: fresh weight ratio.

The growth of both pants was adversely affected by flood. Fig. 16 to 22 shows effect of flood on the growth of *Vigna aconitifolia*. The root length was increased initially after 7 days of flooding, and decreased during further extension of flood. The reduction was about 50 % after 21 days (Fig. 16). The species showed continuous decrease in the shoot length under flooding. After 21 days the shoot length was limited to 50 % of those under control conditions (Fig. 17). Similar trend was reported for leaf area, fresh weight and dry weight also. However, flooded plants developed more biomass than non-flooded. The dry weight in flooded plants was more than that of control (Fig. 22.)

It was noted that the plants tends to develop adventitious roots due to decomposition of the initial tap root. The root in flooded plants also showed more number and larger size of root nodules. Similar observations were also reported under natural conditions of flood. The leguminous crops exposed to river flood showed more nodulation. It might be the result of anaerobic conditions developed by flood.

The effect of flood on *Portulaca oleracea* is represented by the fig. 23 to 29. The weed was found to be more tolerant to the flood in comparison with *Vigna aconitifolia*. The root length in *P. oleracea* was increased up to 14 days exposure to flood and decreased after 21 days. The shoot length was decreased with increase in duration of flooding (Fig. 24). The root: shoot ratio was always more in flooded plants than that in control. Fig. 26. showed that the leaf area in flooded plants of the succulent plan was remarkably decreased. Fresh weight and dry weight was decreaed in flooded Portulaca and the increasing dry wt: fresh wt ratio in flooded plants showed more accumulation of biomass in flooded plants.

4. SUMMARY AND CONCLUSIONS

I. Warana river is very important river flowing in this region. The total economy of the people is based directly or indirectly on Warana river. It provided irrigation for agriculture, which is source of fodder for livestock.

II. The socio-economy of the people was mainly based on agriculture. Milk production is second most important source of income for the people.

III. The study showed that there is more threat of flood in lower portion of Warana river basin. Heavy rainfall in catchment area and release of excess water from Warana dam are important factors responsible for flood. It was also affected by back water effect of Krishna river.

IV. Negligible number of farmers had received compensation from government against the crop loss due to flood.

V. To reduce the adverse effect of flood on crop, farmers made an attempts to change the cropping pattern, (i.e. plantation of sugarcane in late monsoon rather than in early monsoon). By doing this, it is assumed that the one can escape from the effect of flood on young crop. However, it could not save 100 % production of agriculture produce.

VI. Most of the farmers changed the crop preference. Farmer preferred seasonal crops over annual crop like sugarcane.

VII. They also used integrated use of organic and biofertilizers along with chemical fertilizers.

VIII. There is urgent need of creating awareness among the farmers regarding use of soil testing, flood tolerant varieties, governments agriculture schemes and compensation facilities.

IX. The flood cause economical loss either in the form of loss of standing crops, loss of livestock, loss of yield etc.

X. The economical loss due to flood was severe however it did not affected the soil fertility level. The runoff water in upper river basin resulted in soil erosion. Lower basin lands got deposition of the soil resulting into improvement in soil fertility.

XI. Farmers expect much more from the departments of educational institutes and research centers with respect to the facility of soil testing and recommendations of application of fertilizers.

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Photo Plate. 1. Flood situation at Bhadole Site.

Photo Plate. 2. Crop damage due to flood at Bhadole site

Photo Plate. 3. Flood situation at Kakhe Site.

Photo Plate. 4. Crop damage due to flood at Kakhe site

Photo Plate 5. Induction of adventitious root in sugarcane due to flood.

Photo Plate 6. Induction of adventitious root in sugarcane due to flood.

Photo Plate 7. Erosion of soil due to flood.

Photo Plate 8. Exposure of root system due to soil erosion by flood

Photo Plate 9. Collection of soil samples after flood.

Photo Plate 10. Collection of the soil samples after flood.

Photo Plate 11. Growth of *Vigna aconitifolia* after 30 days of establishment

Photo Plate. 12. Uprooted *Vigna aconitifolia* showing growth after 30 days of establishment

Photo Plate 13. Effect of flooding on *Vigna aconitifolia* after 7 days of treatment

Photo Plate 14. Uprooted *Vigna aconitifolia* showing growth after 7 days of treatment (single individual placed on right side is treated)

Photo Plate 15. Effect of flooding on *Vigna aconitifolia* after 14 days of treatment

Photo Plate 16. Uprooted *Vigna aconitifolia* showing growth after 14 days of treatment (two individual placed on right side is treated)

Photo Plate 17. Effect of flooding on *Portulaca oleracea* after 14 days of treatment

Photo Plate 18. Effect of flooding on *Portulaca oleracea* after 14 days of treatment (Top view)

Fig. 16. Effect of flooding on root length of *Vigna aconitifolia*

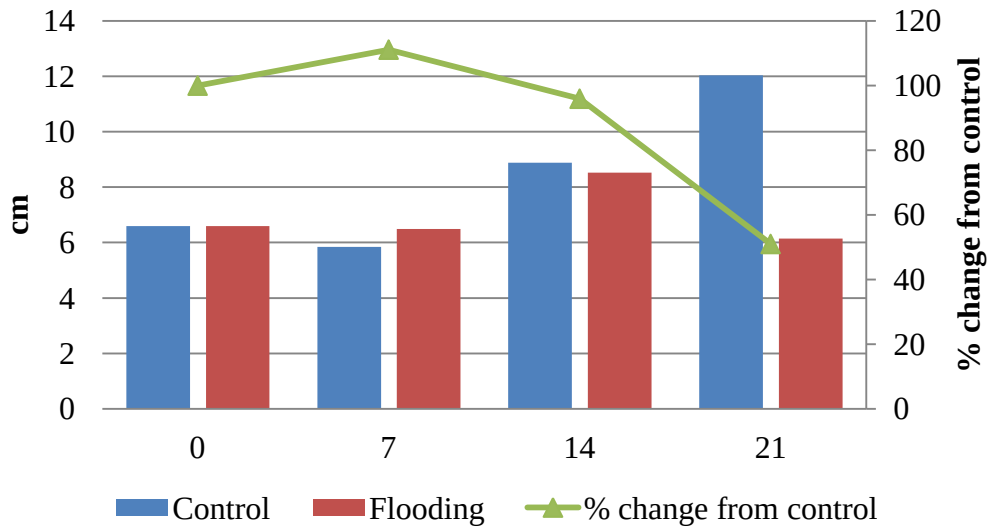


Fig. 17. Effect of flooding on shoot length of *Vigna aconitifolia*

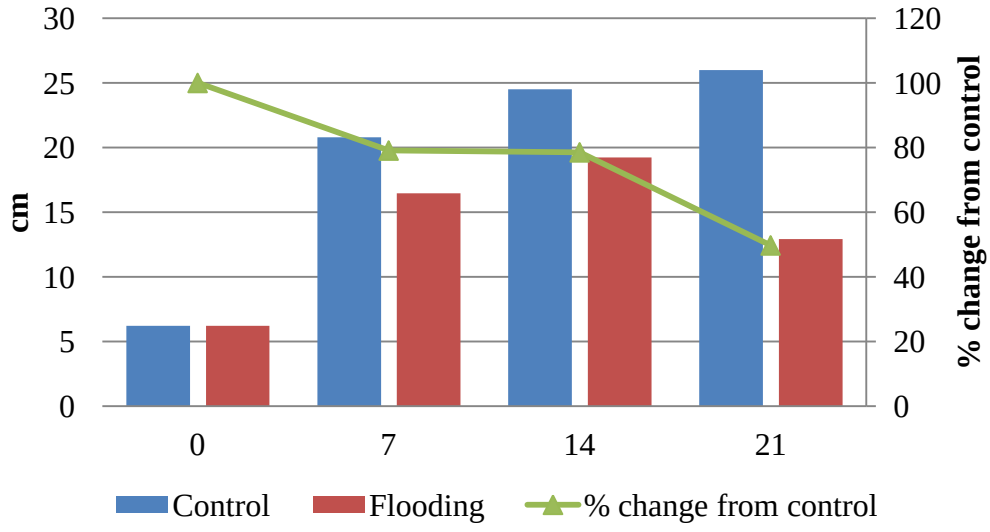


Fig. 18. Effect of flooding on the root/ shoot ratio of *Vigna aconitifolia*

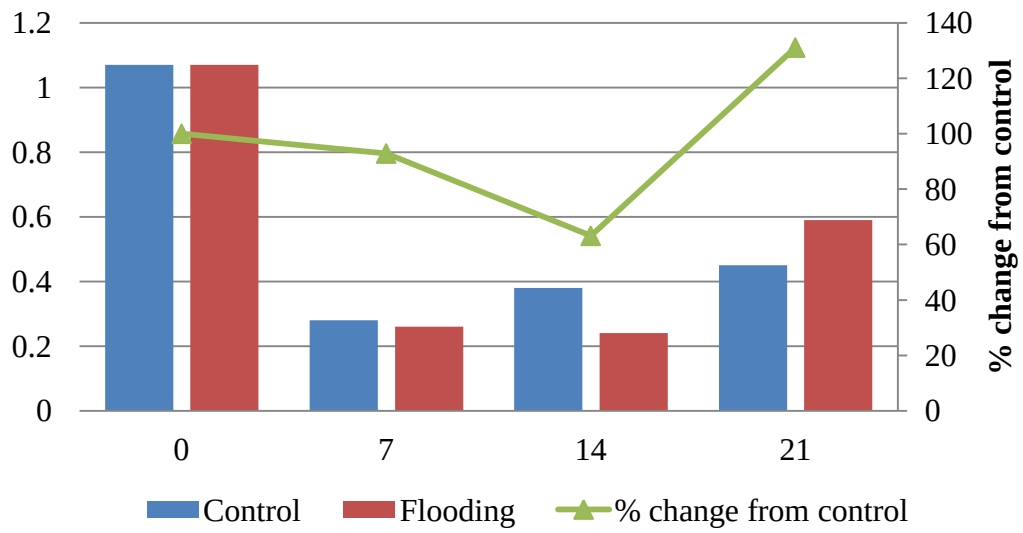


Fig. 19. Effect of flooding leaf area of *Vigna aconitifolia*

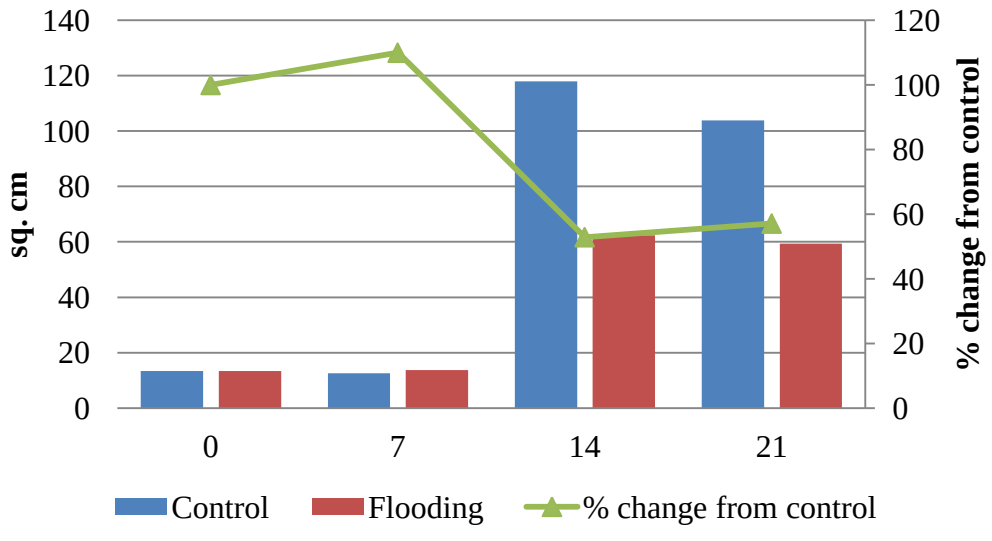


Fig. 20. Effect of flooding on fresh weight of *Vigna aconitifolia*

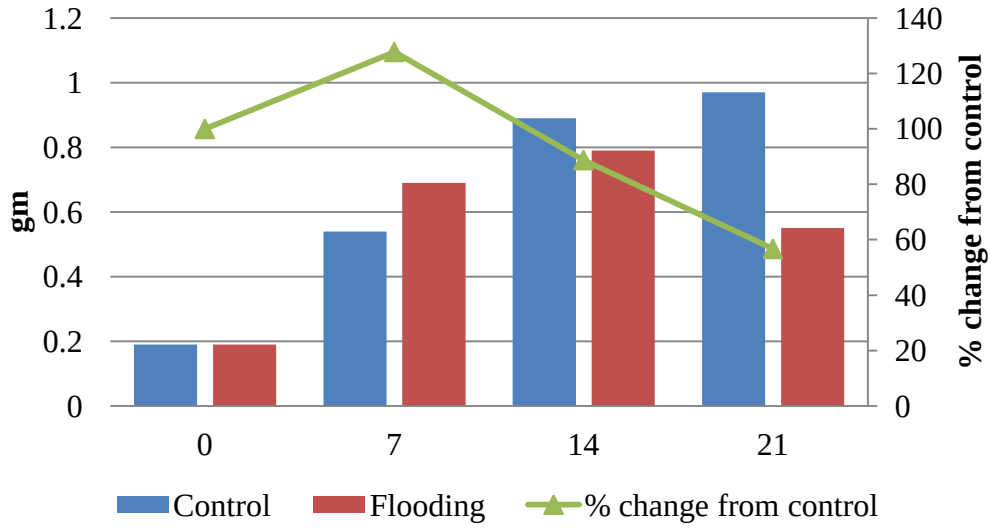


Fig. 21. Effect of flooding on dry weight of *Vigna aconitifolia*

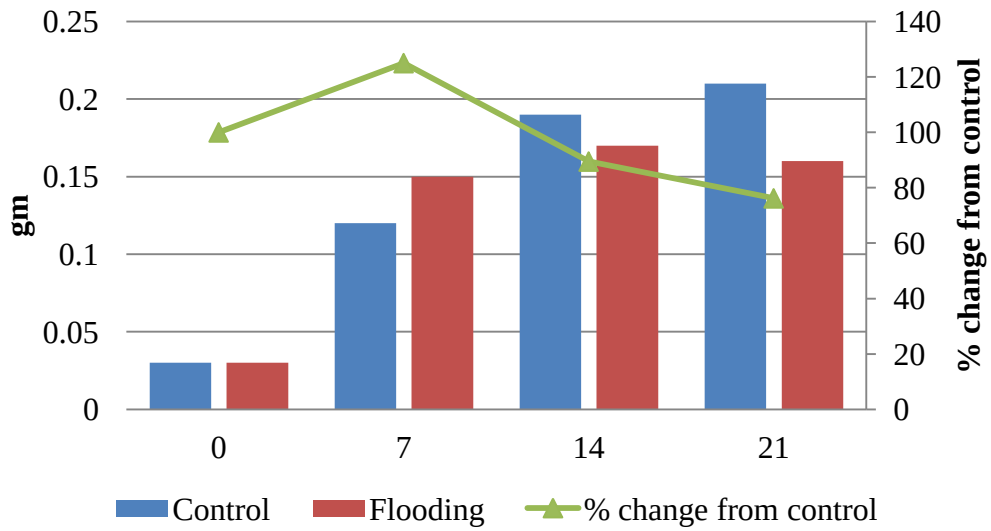


Fig. 22. Effect of flooding on dry wt/ fresh wt ratio in *Vigna aconitifolia*

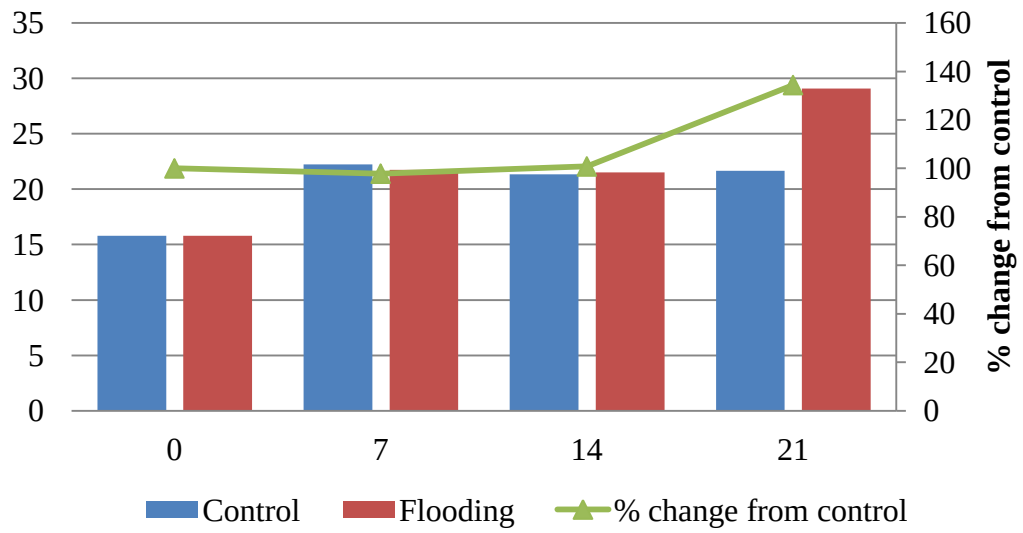


Fig. 23. Effect of flooding root length of *Portulaca oleracea*

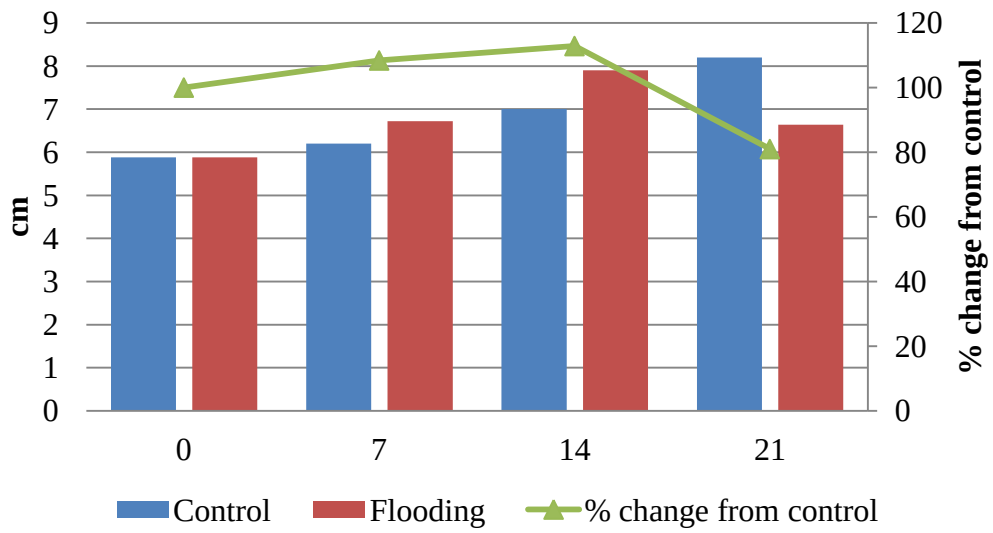


Fig. 24. Effect of flooding on the shoot length of *Portulaca oleracea*

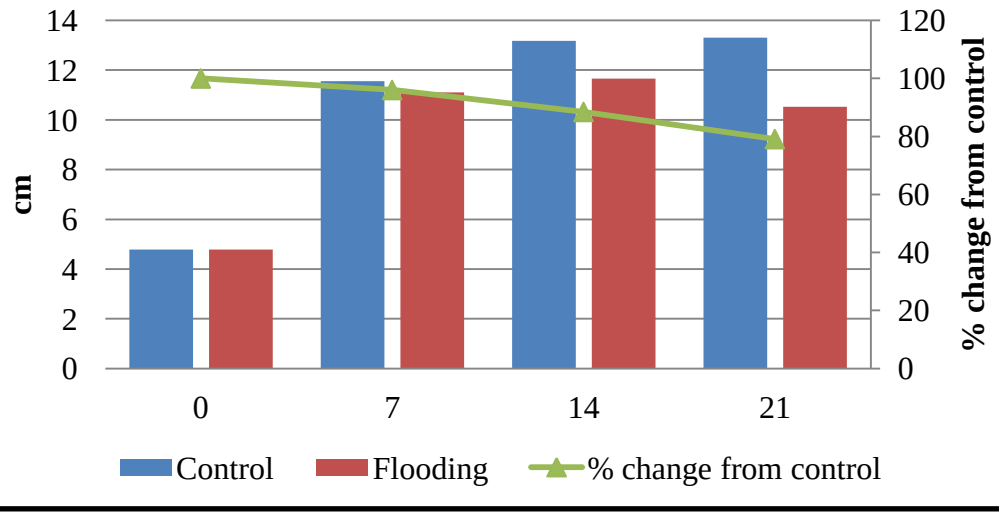


Fig. 25. Effect of flooding on the root shoot ratio of *Portulaca oleracea*

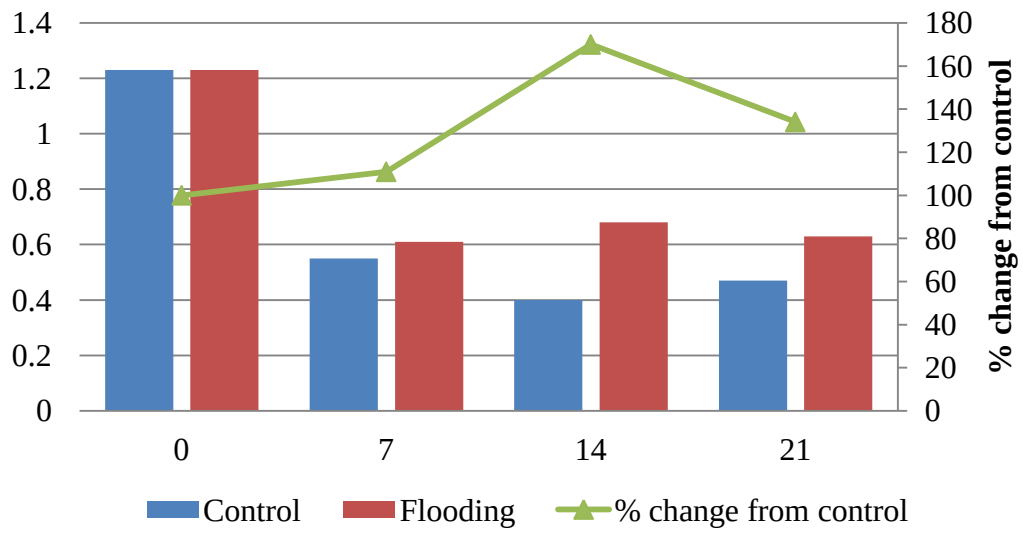


Fig. 26. Effect of flooding on the leaf area of *Portulaca oleracea*

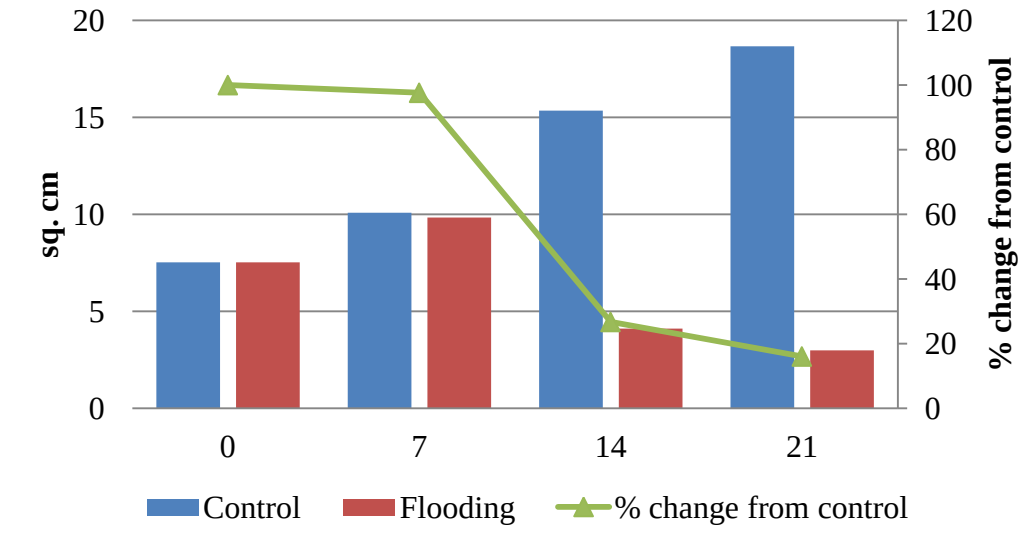


Fig . 27. Effect of flooding on the fresh weight of *Portulaca oleracea*

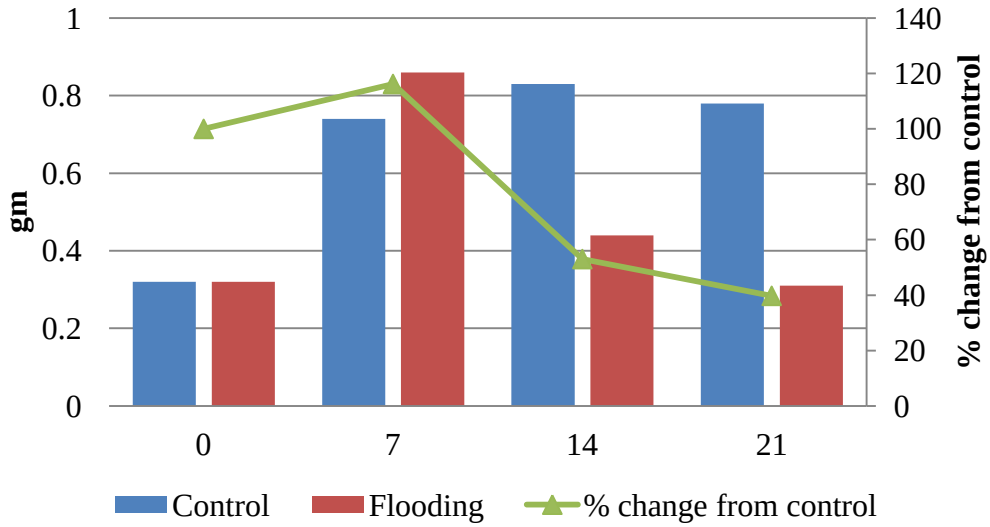


Fig. 28. Effect of flooding on the dry weight of *Portulaca oleracea*

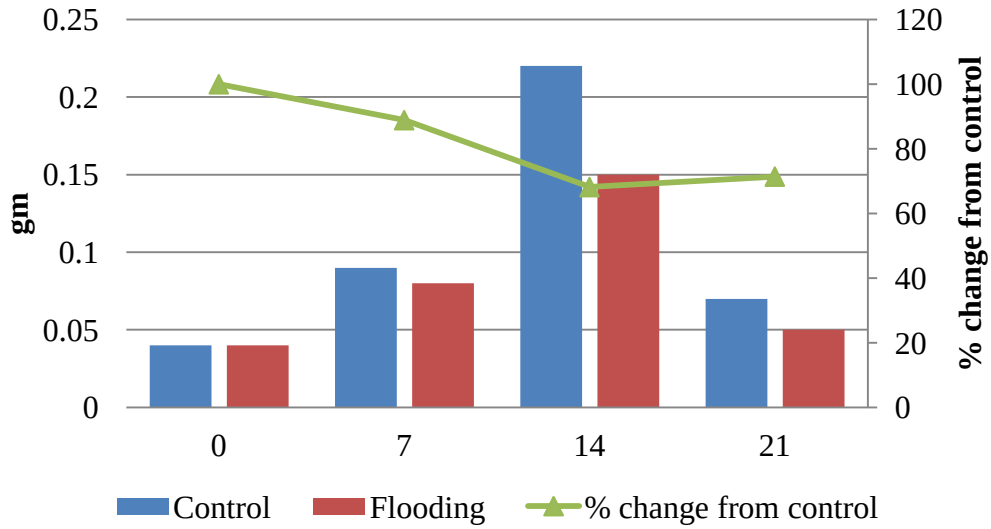
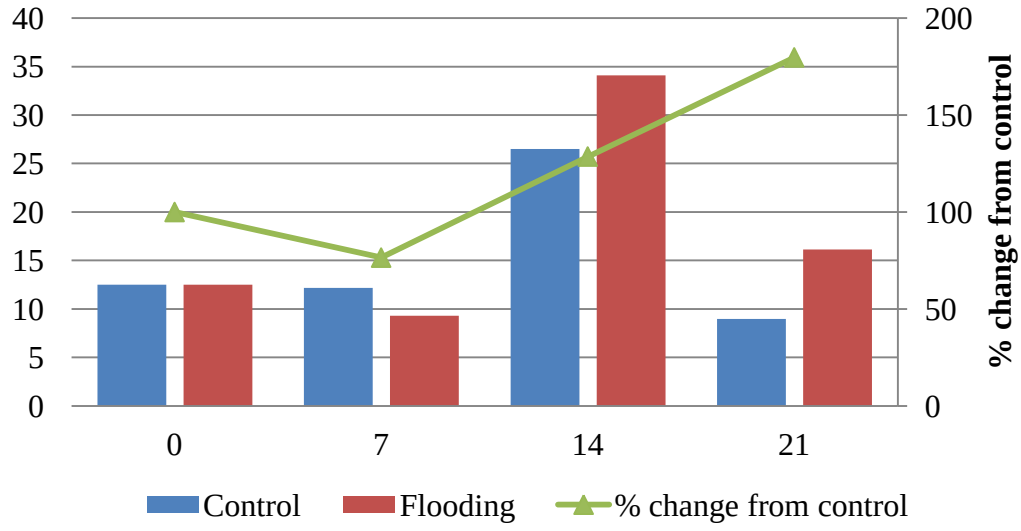


Fig. 29. Effect of flooding on the dry wt/ fresh wt ratio in *Portulaca oleracea*



Questionnaire (प्रश्नावली)

(for the purpose of Minor Research Project only)

(संशोधन प्रकल्पासाठी)

1. Name of the farmer(शेतकऱ्याचे नाव): .....
2. Village (गावाचे नाव): ..... Tal (तालुका) : .....
3. Main Occupation (प्रमुख व्यवसाय):– Agriculture (शेती) / service (नोकरी)
4. Side business (इतर व्यवसाय): रोजगार / दुध उत्पादन / कुक्कुट पालन, इतर.
5. Flood Prone agricultural area (पुराचा धोका असणारी जमीन): .....
6. Main crop (मुख्य पिक): .....
7. Area affected by flood (पुराने नुकसान झालेल्या पिकाची माहिती):

Year (वर्ष)	% of total (एकूण जमिनीच्या किती टक्के)	Intensity of flood soil (पुराची तीव्रता)		% of total loss (उत्पादनामध्ये झालेली घट %)	शेरा
		Soil submerged for days (शेत जमीन किती दिवस पाण्याखाली होते)	Crop submerged for days (पिक किती दिवस पाण्याखाली होते)		

8. Compensation received from government (शासनाकडून मिळालेली भरपाई):

   Full (१०० %)/ Half (५० %) / Little (किरकोळ) / Nil (काहीच नाही)

9. Change in cropping pattern (if any) and result (पिक पद्धती मध्ये काही बदल केला काय?)

   a. Cultivation of flood tolerant varieties (पूर प्रतिकारक वाणांचा वापर) आणि result (मिळालेला परिणाम):.....

   b. Change in crop preference (पिक क्रमवारीत केलेला बदल आणि मिळालेला परिणाम) उदा. Instead of sugar cane / soya/ ground nut / vegetable (ऊसपिका ऐवजी सोयाबीन / भूईमुग / भाजीपाला इ.): planted (घेतलेले पिक)..... result (उत्पादनात झालेला बदल): वाढ / घट

   c. Time of plantation (पिकाच्या पेरणी वेळात बदल केला काय? असल्यास मिळालेला परिणाम): Crop (पिकाचे नाव) .....month (पेरणीचा महिना).....result (परिणाम) .....

d. Variation in fertilization pattern (खत पद्धतीतील बदल): Chemical / organic fertilizers (रासायनिक / सेंद्रिय खत) Changes in dose (खत मात्रे मधील बदल) result (मिळालेला परिणाम): .....

10. Any side business adapted (इतर व्यवसाय अवलंबला असल्यास, कोणता?): .....
11. Steps taken to avoid loss due to flood (पुरामुळे होणारे नुकसान टाळण्यासाठी केलेले उपाय): .....
12. Have you tested your soil (तुम्ही माती परीक्षण करून घेता काय? कोणत्या संस्थेकडून): .....
13. माती परीक्षणा नंतर दिलेले सल्ल्याप्रमाणे उपाय योजना केली काय? असल्यास मिळालेले परिणाम): .....
14. Do you know about government schemes, crop insurance, and flood tolerant varieties (पूर परिस्थितीमध्ये शेतकऱ्यांसाठी असणाऱ्या शासनाच्या योजना, पिक विमा, पूर प्रतिकारक पिकाच्या जाती याबद्दल आपणास माहिती आहे काय?): .....
15. Guidance received from agencies (कृषी विकास अधिकारी/ शेतकरी कार्यालय/ इतर संस्था यांचेकडून काही मार्गदर्शन मिळाले काय?): .....
16. Your opinion regarding Effect of flood on soil fertility (पुराच्या पाण्याचा जमिनीच्या सुपिकातेवर काय परिणाम होता?): सुपीकता वाढते / घटते.
17. Effect of flood on economy (पुराचा अर्थ व्यवस्थेवर होणारा परिणाम?): चांगला / वाईट
18. Your suggestions (तुमचे मत)
    A. For government (शासनाने काय करणे आवश्यक आहे): .....
    B. For sugar factory authorities (साखर कारखान्याने काय करावे?): ....
    C. For Academic Institutions (शैक्षणिक संस्था व संशोधन संस्थांना काय सुचवाल?): .....
    D. For farmers (शेतकऱ्यांनी कोणते पर्याय अवलंबावेत?) .....

Date (दिनांक): / /२० signature (सही)

स्थळ: ..... (नाव: .....)

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