INDIAN NATIONAL COMMITTEE ON SURFACE WATER (INCSW- CWC)

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Name of R&D Scheme	DIVERSIFIED UTILIZATION OF HARVESTED FARM POND WATER TO AUGMENT THE WATER PRODUCTIVITY IN RAINFED *ALFISOLS* OF EASTERN DRY ZONE OF KARNATAKA
Name of PI & Co-PI	PI - Dr. G.N. DHANAPAL Co-PI Dr. M.A. SHANKAR & Dr. D. SEENAPPA
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Central Water Commission

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This report contains the results of research conducted during 2006-2013. We are highly grateful to Mr. Anuj Kanwal, Member Secretary, INCSW New Delhi, Mr. Yogesh Paithankar, Former Secretary, INCSW Secretariat Secretariat & RR Directorate, Central Water Commission, Govt. of India, Mr. S. K. Gangwar, Director (R & D Division), Ministry of Water Resources, Govt. of India, New Delhi for their valuable guidance and timely financial support in implementing programme efficiently. I express my profound gratitude to Dr. H. Shivanna, Vice Chancellor and former Vice Chancellors, Dr. Shadakshari, Y. G., Director of Research and Dr. M.A. Shankar, Former Director of Research, and Co-Investigator of the project, University of Agricultural Sciences, Bangalore for their valuable guidance, professional and administrative support in implementing the research programme during the year 2006-2012. I acknowledge with gratitude the support and technical input given by Dr. D. Seenappa, Professor & Scheme Head, Inland Fisheries Division, MRS, Hebbal and Co-Investigator of the project. The help and cooperation in executing experiments and preparation of the report by the Research Associates is thankfully acknowledged.

It is with deep sense of appreciation and gratitude I acknowledge the cooperation and support rendered from the scientists and staff of AICRP for Dry land Agriculture and Operational Research Project, GKVK, Bangalore in conducting the experiments and bringing out this report.

December 10, 2017
Bengaluru-560 065

(G.N. DHANAPAL)
Principal Investigator & Professor &University Head and Project Head, AICRP on Weed Management

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EXECUTIVE SUMMARY

The R&D Scheme entitled **"Diversified utilization of harvested farm pond water to augment the water productivity in rainfed *alfisols of* eastern dry zone in Karnataka"** was sanctioned to the Dry land Agriculture Centre, UAS, GKVK, Bengaluru Vide sanction order No.21/88/2006 R&D/550-62 dated: 06.02.2006 with a total budget of Rs. 18,15,433=00. An amount of Rs. 11,39,399=00 was spent against a total release of Rs.14,93,000=00 upto end of March, 2012. Further, for the years 2013-14 and 2014-15, revalidation and extension of time was not granted, hence the expenditure was not booked

BACKGROUND:

The project area is located in the Eastern Dry Zone of Karnataka (Zone-5). The average rainfall of this area is 925.8 mm per annum. The soils of this region are red loamy in texture. Agriculture in this part is left to the vagaries of uncertain rains because of no permanent river basins. Nearly 75 per cent of cultivated area in this zone is under rainfed condition. The major field crops of this zone nourished through bore wells and surface water. However, the proper management of surface harvested water can play a significant role in rejuvenating the underground water resources and in supporting the increased water use efficiency of rainfed crops.

It is evident from the recent studies of dry land research that the productivity of rainfed crops especially in cereals and pulses has been increased to an extent of 2-3 times especially in cereals and pulses as compared to traditional methods because of the effective harvesting and recycling of stored water. But the problem is envisaged with the effective and economical use of harvested water. In this context, to augment the total productivity of the system in dry land, the subsidiary enterprise like fish rearing can be introduced. For effective and economical use of resources which is the need of the hour in dry land agriculture to sustain the productivity.

The project was implemented at the dry land agriculture centre to achieve the following objectives by conducting various experiments to come out with suitable recommendations and practical utility of the investigation including economic implications of the results for the benefit of the farming community.

PROJECT OBJECTIVES:

(a) To estimate the run-off pattern and to strengthen the farm ponds through lining material being used indigenously at farmers' level.

(b) To determine the utilization efficiency of stored water through drip system and to know the potentiality of fish culture through farm ponds besides, working out the economic feasibility and

(c) To know the effect of accumulated Sesqui-Oxides on growth and yield of fishes in farm ponds and to develop methods to neutralize their effects.

PROJECT OBJECTIVE-I:

To estimate the run-off pattern and to strengthen the farm ponds through lining material being used indigenously at farmer's level

The number of runoff causing rainfall events was 16 and 24 during 2007 and 2008 respectively. The extent of runoff water was 57 (523.4 mm) and 38 per cent (242.2 mm) during 2007 and 2008 respectively. The runoff losses under different live barriers, data indicated that Khus (*Vetiver zizinoides*) and Nase grass (*Pennisetum hoenikaeri*) was found to be effective in conserving soil and water.

Khus and *Nase* grass as live bunds between contour bunds. Bio-engineering structures *viz.*, Khus and Nase grass were planted at 15 m interval between contour bunds to reduce soil loss by erosion and conserve moisture for longer period and facilitate better yield of crops.

Performance

The average yield increase in finger millet : 51%

Reduced soil loss by : 36%

Reduced runoff by : 12%

Runoff and soil loss in *Alfisols* at GKVK during 2010

The runoff events and intensity of runoff depends on amount of rainfall in consecutive days, number of rainy days, soil type, extent of slope, vegetation cover, cultivable/ uncultivable land etc during 2010, the number of runoff causing rainfall events was 11 and the extent of runoff water was 16.7 per cent.

Runoff and soil loss studies

Water running down the sloping land constitutes destructive forces that cannot be completely controlled. The most constructive step is to plan vegetative crop cover and suitable farming practices for different slopes to check the destructive forces of running water. Under normal conditions when the soil is in good tilth, rain water will infiltrate better than when it is compacted. Obviously when rainfall intensities are high, it results in excess runoff that will cause the soil erosion.

Considering the crop and slope factor, runoff and soil loss studies were carried out to obtain some of the hydrological information from different systems of land and surface treatments of smaller as well as bigger catchments and under different crop canopies.

Three runoff plots (4x50 m) with a slope of 1.5 per cent was constructed. Groundnut, finger millet and maize were grown across the slope with one control plot.

The fallow plots prior to tillage operations and sowing of crops the runoff was to the extent of 74-76 per cent with 23-36 mm of rainfall. In the ploughed land runoff was not more than 50 per cent till 2-3 good rains were received. Amongst the crops after sowing groundnut had the least runoff in early stages of crop as compared to maize and finger millet.

The runoff data indicated that the average runoff from maize crop was 9.5 per cent as against 13.7 in finger millet. The runoff increase in maize was less especially fter earthing up (ridging). The average runoff from groundnut plot was 19.2 per cent.

Runoff and soil loss data indicated that the fallow plots generally recorded a higher percentage of runoff as compared to the crops plots. The average percentage of runoff for different crop canopies has been worked out. The average runoff from the maize plot was 8.5 per cent as against 12, 13 and 25 per cent of average runoff from finger millet, groundnut and fallow plots, respectively. Further, the loss of water as well as soil loss was less in maize plots as they raised up and ridges were formed.

The average percentage of runoff during the years under different crop canopies were 36.8, 32.9, 22.3, 21.3 and 25.9, respectively in fallow, groundnut, finger millet, maize, intercrop and vegetative barrier plots. The mean soil loss in tonnes per ha per year were 10.2, 10.5, 9.5, 4.7, 5.3 and 5.7. The efficiency of different treatments to reduce soil loss was in the following order maize, intercrop, vegetative barriers, finger millet, groundnut and fallow.

It was observed that the runoff as well as soil loss under fallow conditions before preparatory tillages are higher when compared during preparatory tillages and after sowing of crops till harvest.

However, the trend of runoff in the cultivated fallow field remained the same around 30 per cent throughout the year. But, in the cropped area though a similar trend was observed. There was a decreasing trend from fallow to cultivated and to cropped fields, namely groundnut, finger millet and maize etc.

Alternatively, it was also observed from the different types of crops like groundnut, finger millet and maize, maize provided better check against erosion when compared to groundnut and finger millet crop. Whereas, groundnut and finger millet crop showed similar trend in controlling erosion.

Construction of farm pond and lining materials: A big farm pond was handed over to the INCID project during August, 2007 after putting *Kadapa* stone slabs as a lining material. The total cost is Rs.8.5 lakhs (out of which Rs.6.00 lakhs was borne by the UAS, Bangalore and Rs.2.5 lakhs was provided by INCID project. The farm pond has capacity to store 3200 Cubic mt. of water. Besides, other ponds with different lining materials are also being taken in to account for implementation of the project.

Farm pond technology: Climate change is another aberration in dryland agriculture especially in terms of rainfall. Although, the total quantity of rainfall was not altered much from the normal, the distribution is changed in terms of onset, withdrawal and number of rainy days. Under these circumstances, *ex-situ* harvesting of runoff, its efficient storage and its multiple use helps for bringing resilience towards livelihood security. Any effort of conserving rainwater *in-situ* in *Alfisols* will yield hardly 70-75% which enters the soil moisture pools and 5% as groundwater recharge and remaining 25-30% goes as runoff.

Farm pond with appropriate lining and its multiple use of harvested water were demonstrated for the benefit of the farmers, policy makers, extension worlers and students. Considering the rainfall and soil factors, 250 m^3 volume of farm pond is recommended for one hectare of catchment area. To attain this, excavation of earth by 12 m x 12 m top, 6 m x 6 m bottom and vertical height of 3 m, in 1:1 slope is recommended.

Measurement details of Farm pond.

Particulars/Pond dimensions	Big Farm pond	Small Farm pond (Micro-watershed)
Top dimensions (m)	Length – 35 m Width – 33 m	Length – 10.5 m Width – 10.5 m
Bottom dimensions	Length – 27 m Width – 26 m	Length – 6 m Width – 6 m
Pond depth	3.5 m	3 m
Farm pond capacity	3200 Cubic mt	180 Cubic mt
Lining	Kadapa slab	Soil + Cement (8:1)
Height of lining material	1.2 m	3.0 m
Area of lining	Bottom - 901 Sq. m 4 Sides - 155 Sq. m (34.2 x 2 sides = 68.4 sq. m & 43.2 x 2 sides = 86.4 sq. m)	Bottom - 36 Sq. m 4 Sides - 138 Sq. m (34.26 x 4 sides)
Total area of lining	1056 Sq. m	175 Sq. m

B. LINING MATERIALS

Lining of farm pond for seepage regulation with different materials were demonstrated. The lining materials consists of;

- Stone dust + cement (8:1)
- Soil + cement (8:1)
- Brick lining
- Brick compartment (1 m^2) & soil + cement (8:1) lining
- Granite stone slab

A clear difference between different lining materials can be visualized with respect to longevity in water storage and seepage control. Among different lining materials *viz*., stone dust + cement, soil + cement, brick, granite slabs which were executed as part of study, lining of farm pond with 400-500 micron gauge LDPE (Low Density Poly Ethylene) sheet with 8:1 ratio of soil-cement plastering to 5 cm thickness mortar in 1 m^2 rectangular brick compartments on all the four sides of farm pond and brick lining over LDPE sheet performed better its stability and minimzing water loss.

Performance:

- Reduced seepage losses
- Longer storage of water

PROJECT OBJECTIVE: II

To determine the utilization efficiency of stored water through drip system and to know the potentiality of fish culture through farm ponds besides, working out the economic feasibility.

Crop production activities by protective irrigation to improve water use efficiency with integrated nutrient management practices

Experiment 1: ***Maize production under protective irrigation at Dry land agriculture project, GKVK, Bangalore during 2008-09***

Grain yield of maize: Grain yield was significantly influenced by different sources of manures in combination with fertilizers despite equivalent nutrients application.

Application of 100% recommended fertilizers resulted in significantly (4374 kg/ha) superior grain yield than all other integrated treatments. Among other treatments, integrating 50% N through fertilizer with 50% N through poultry manure or sewage sludge to supply balance N produced distinctly superior grain yield (3996 kg/ha and 3810 kg/ha), respectively. Use of poultry manure could result 8.5 per cent lesser grain yield than using fertilizer alone, while use of sewage sludge could result into 24 per cent lesser grain yield. Other treatments involving FYM, Glyricidia and composted parthenium had equivalent grain yield in the range of 3539-3645 kg/ha. However, use of city compost did not produce grain yield more than 3201 kg/ha, which accounted for 27 per cent lesser grain yield than use of recommended fertilizer alone.

Stover yield: Stover yield differed significantly due to the application of different combination of organic and inorganic nutrient sources. Maximum stover yield (6.683t ha^{-1}) registered with the application of recommended NPK through fertilizers followed by 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (6.463 t ha^{-1}). Despite application of 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers gave lower stover yield (5.833 t ha^{-1}) than all treatments but was on par with the rest of treatments.

Harvest Index: Among the treatments application of recommended NPK through fertilizers recorded higher harvest index (0.40) than other treatments and treatment applied 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers had lower harvest index (0.35).

Effect of integrated nutrient management on economics of different sources of nutrient: Application 50% N through fertilizer + 50%N through FYM + balance P and K as fertilizers recorded maximum cost of cultivation (Rs. 12,784 ha^{-1}) as compared to the other treatments. However, minimum cost of cultivation was noticed 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (Rs. 9,910 ha^{-1}) followed by 50% N through fertilizer + 50% N through glyricidia + balance P and K as fertilizers (Rs. 9,953 ha^{-1}).

Higher gross returns was obtained with the application of recommended NPK through fertilizers (Rs. 40,521 ha^{-1}) followed by 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (Rs. 37, 198 ha^{-1}) as compared to other treatments. Lower gross return was obtained in treatment received with 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers (Rs. 30,125 ha^{-1}).

The highest net returns (Rs. 29,562 ha^{-1}) was obtained with the application of recommended NPK through fertilizers followed by 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (Rs. 27,288 ha^{-1}) and the lowest net returns was observed in 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers(Rs. 19,370 ha^{-1}).

Benefit cost ratio of maize was differed with the combined application of organic and inorganic sources of nutrients. Among all the treatments application of 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers recorded the highest (2.75) B:C ratio, followed by application of recommended NPK through fertilizers (2.70). However, application of 50% N through fertilizer + 50%N through FYM + balance P and K as fertilizers recorded the lowest B: C ratio (1.67) among all the treatments.

Experiment-2 during 2009-10: Studies on utilization efficiency of harvested water through different methods of irrigation with integrated nutrient management practices for finger millet (*Eleusine coracana*) production in *alfisols*.

The results of the field experiment *"Studies on utilization efficiency of harvested water through different methods of irrigation with integrated nutrient management practices for finger millet (Eleusine coracana) production in alfisols"* during *Kharif* 2009-10 conducted at Dry Land Agriculture Project, GKVK, University of Agricultural Sciences, Bengaluru are presented below.

In the present investigation, different soil moisture conservation methods were tried in combination with different sources of nitrogen with a main objective to utilize the organic source of nutrients available on the farm and to attain sustainability in yield levels.

Among different *in-situ* soil moisture conservation, opening conservation furrow between rows and mulching in those rows proved to be better in attaining better growth parameters in finger millet.

Application of nitrogen to finger millet by different sources had recorded differences in growth parameters in plant at various growth stages. Application of 100% of recommended dose of nitrogen through fertilizer recorded progressive plant height and chlorophyll content at all the growth stages of crop growth as compared to integrated approach of nitrogen application viz., 50% recommended dose of nitrogen (RDN) through fertilizer and 50% RDN through poultry manure and 50% RDN through fertilizers and 50% through glyricidia (62.4 cm, 94.9 cm and 100.5 cm respectively) during 45 DAS, 90 DAS and at harvest. Significantly higher chlorophyll content was observed in treatment receiving 100% RDN through fertilizer at all the growth stages of finger millet (37.8, 39.5 and 18.6 during 45 DAS, 90 DAS and at harvest respectively).

Apart from the influence of growth and yield components uptake of nutrients also influenced the grain yield of finger millet, soil moisture conservation methods coupled with one protective irrigation helped the plant to take up higher amounts of macro nutrients which in turn helped for production of higher photosythates and its translocation from source to sink effectively.

Higher grain yield and net income in finger millet can be realized by adoption of *in-situ* soil moisture conservation practices along with application of recommended dose of fertilizers. Better utilization and conservation of farm resources and yield sustainability of finger millet could be attained by adopting proper land configuration with recommended dose of fertilizers proved to be better in realizing higher yield in finger millet. Apart from this, both crop productivity and water productivity could be improved by storing the runoff water in farm ponds and using the same during long dry spells / at critical crop growth stages as protective irrigation during *Kharif* in order to obtain higher grain yields.

Experiment-3 (2009-10): Studies on utilization efficiency of harvested water through different methods and levels of irrigation for french bean (*Phaseolus vulgaris*) production in *Alfisols.*

Results of the field experiment “Effect of different methods of irrigation and sources of nitrogen on growth and yield of French bean” conducted at the Dry Land Agriculture Centre, UAS, GKVK, Bengaluru during late *kharif* 2009-10 by utilizing stored/harvested rain water are presented below;

Stage of irrigation had significant impact on growth components of french bean throughout the crop growth. Providing irrigation at 0.9 IW: CPE recorded significantly better growth components viz., plant height, number of branches, dry matter production and distribution in to different plant parts and chlorophyll content at 45 DAS and at harvest.

Methods of irrigation had recorded significant difference with respect to bean yield. Higher green bean yield (9290 kg ha^{-1}) was obtained in treatment receiving irrigation by micro-sprinkler. The higher yield is a cumulative effect of yield components viz., number of beans per plant and yield per plant. Relatively higher number of beans per plant (17.48) and yield per plant (76.56 g $plant^{-1}$) was observed in M_3 (micro-sprinkler). So better yield and yield components are the result of better growth components viz., plant height, number of branches, dry matter production and its distribution in to different plant parts at various stages of plant growth were observed in treatment receiving irrigation through micro-sprinkler.

Significant variation was observed with respect to stage of irrigation. French bean plants responded positively for providing irrigation at 0.9 IW: CPE ratio and recorded higher bean yield (9754 kg/ha) as compared to providing irrigation at critical stages for irrigation. Similar trend was noticed with respect to number of beans per plant (18.33/plant) and yield per plant (79.24 g $plant^{-1}$).

Application of Nitrogen (100% RDN) through fertilizer recorded higher green bean yield (9374 kg ha^{-1}) as compared to N_2 and N3. The trend was similar in number of beans per plant (17.02) and yield per plant (73.33g/plant). Better performance of french bean plant and attaining high yield in N_2 is a cumulative effect of better growth and yield components observed during different growth phases.

Differential response of french bean plants to different methods of irrigation, stages of irrigation and sources of nitrogen was found to be non significant.

Application of 100% RDN through fertilizer had significant effect with respect to uptake of plant nutrients. Significantly higher nitrogen, phosphorus and potassium content in leaf (38.65, 5.06, and 26.00 1g ha^{-1} respectively) stem (18.82, 2.42 and 15.50 kg ha^{-1} respectively) and in pod (55.53, 9.17 and 45.33 kg ha^{-1} respectively) were observed in treatment receiving 100% RDN through fertilizer. Similarly, total dry matter production per plant was higher in 100% RDN through fertilizer.

Experiment – 4 (2010-11): Studies on utilization efficiency of harvested water with moisture conservation practices and integrated nutrient management practices for radish (*Raphanus sativus* L.) production in *Alfisols*.

The results of the field experiment "Studies on utilization efficiency of harvested water with moisture conservation practices and integrated nutrient management practices for radish (*Raphanus sativus* L.) production in *Alfisols*" during *Rabi* 2010-11 conducted at Dry Land Agriculture Project, GKVK, University of Agricultural Sciences, Bengaluru are presented below;

In the present investigation, protective irrigation with and without soil moisture conservation practices were tried in combination with different sources of nitrogen with a main objective to utilize the organic source of nutrients available on the farm and to attain sustainability in yield levels.

Radish yield differed significantly among main plot treatments, moisture conservation furrow + protective irrigation + mulching (M1) recorded significantly higher root and biomass yield (14287 and 28228 kg ha^{-1} respectively) as compared to M_2 (M1-Mulching) and control (without protective irrigation). The higher yield level in M_1 could be attributed to alteration in land configuration by providing moisture conserving furrow + mulching and protective irrigation during long dry spell as compared to control. Apart from this, yield attributing parameters such as root length per plant (15.5 cm), root diameter (3.43cm) significantly higher in M_1, as compared to M_2 & $M_{3.}$ Thus, owing to integrated effect of these yield parameters favorably influenced the root yield of radish. Differences observed in root yield of radish due to moisture conservation practices with protective irrigation, production could be traced back to differences in dry matter production and its accumulation in different plant parts and relatively higher leaf area was observed in moisture conservation furrow + protective irrigation with mulching at all the growth stages of plant.

Root and shoot N, P and K contents varied significantly by the soil moisture conservation furrow + protective irrigation + with and without mulching were tried in combination with different sources of nitrogen. Root and leaf content were maximum with moisture conservation furrow + protective irrigation + mulching among main plots and application of 100% recommended dose of nitrogen through fertilizer. Soil moisture conservation practices coupled with the protective irrigation helped the plant to take up higher amounts of macro-nutrients which in turn helped for production of higher photosythates and its translocation from source to sink effectively.

Yield maximization of any crop depends on the processes associated with content/concentration of nutrients, translocation, partitioning, assimilation and mobilization of nutrients at different growth stages of crop. These multitudes of processes are influenced by genetic potential of the crop variety, cultural practices, soil manipulations, climatic factors and efficient management of inputs.

The growth and yield of crop plants are determined by the presence of sufficient quantities of nutrients in the soil in available form for plant uptake. Crops often respond quickly to fertilizer application due to higher concentration of nutrients present in them.

Among soil moisture conservation practices with protective irrigation, treatment moisture conservation furrow + protective irrigation + mulching resulted in higher net returns and benefit: cost (B: C) ratio than compared other treatments. Application of 100% of recommended dose of nitrogen through fertilizer recorded the highest net returns and benefit: cost (B: C) ratio.

Higher root yield and net income in radish can be realized by adoption of soil moisture conservation practices with protective irrigation along with application of recommended dose of fertilizers. Better utilization and conservation of farm resources and yield sustainability of radish could be attained by adopting proper land configuration with recommended dose of fertilizers proved to be better in realizing higher yield in radish. Apart from this, both crop productivity and water productivity could be improved by storing the runoff water in farm ponds and using the same during long dry spells / at critical crop growth stages as protective irrigation during *rabi* in order to obtain higher root yields.

Experiment-1: Potentiality and Economic feasibility of fish culture in stored water

For the first time different fish fingerlings were released in to the pond by the Vice Chancellor, UAS, Bangalore on 14-08-2007.

As part of the research programme fish species viz., Common Carp, Catla, Rohu and Grass Carp were released in 4:3:2:1 proportion to the farm ponds. The same ratio of fish fingerlings was released in to the pond in the subsequent years. Before release of fishes 15 days in advance, farm ponds were neutralized with lime and cow dung. The feeding was done at the rate of 5 per cent of the average body weight of fish fingerlings. The body weight was measured once in 15 days. The mortality rate and disease incidence of different species was recorded during each observation. Mortality rate is worked out by considering the number of dead fishes to the total number fishes released into farm pond and expressed in percentage. The feeding material was supplied by fishing rearing unit, Hebbal during early stages, later groundnut cake and rice bran were mixed in equal proportion to make required quantity. In addition to solid feed materials the grasses, crop residues etc were given at regular basis. A person was engaged to watch and ward, feeding, catching fishes etc. throughout the season.

In the year 2007-08 due to very low water level, we were compelled to harvest fishes before attaining maturity and their mean weights are presented. During 2008-09 the fishes were harvested at 165 days after release and during 2009-10 the fishes were harvested before attaining physiological maturity due to the fact that less amount of stored water in the pond. The periodic observation on average length, breadth and weight of fishes were recorded. The mean weight of different breeds was ranged from 30-44 g in grass carp to 102-124 g in common carp.

Among different breeds rohu (17%) has more mortality rate followed by common carp (15%) however, it was lower in grass carp (8%).

The mortality rate and suitability of each fish species in run-off water was worked out at harvest. The fishes were sold at present market price of Rs. 70 per kg. The economic feasibility of fish culture was worked out by considering the total returns and cost of production and it was found that the net returns to the tune of Rs. 3957=00 in 2008-09, Rs. 3117=00 during 2009-10 and Rs. 3107=00 during 2010-11

PROJECT OBJECTIVE: III

To know the effect of accumulated Sesqui-Oxides on growth and yield of fishes in farm ponds and to develop methods to neutralize their effects.

Experiment 1: Studies on minimizing effects of accumulated sesqui-oxides on fishes in farm pond.

Water sample analysis for Sesqui-oxides:

The water samples were drawn from the farm ponds where runoff water collected from arable and non-arable lands.

The different chemical parameters of runoff water values were categorized into different groups as follows. Based on the experimental data the water quality has been assessed for suitability to fish and crop production activity.

Before fish release: The water samples collected from farm ponds were analyzed for physical and chemical properties before fish release. The results indicated that pH (7.24) and EC (0.115) were in safe range and chlorides (0.6 me/l), bi-carbonates (1.2 me/l) and sodium (0.08 me/l) are present at safe level. Relative Sodium Carbonate (RSC) (0.09) and Sodium Adsorption Ratio (SAR) (0.11) were also at normal level indicating that water is good for fishing activity.

60 days after release of fishes: Water samples were collected from the same farm pond after 60 days of fish release and analyzed for chemical properties of water to test the suitability of water for fish activity. The results indicated that pH (7.36) and EC (0.035 dSm-1) were in safe range but decreased over before fish release. While, bicarbonates (0.6 me/l), calcium (0.22 me/l) and magnesium (0.06 me/l) concentrations were decreased as the duration of water storage increases. Similarly chlorides, bicarbonates and sodium were present at safe level. RSC (0.32) and SAR (0.11) were also at normal level indicated that the runoff water is good for irrigation as well as pisciculture.

120 days after fish release: The data of chemical properties of runoff water samples indicated that pH (7.12) and EC were at safe level. The chlorides (0.4 me/l), carbonates (traces), bicarbonates (0.5 me/l), calcium (0.27me/l), magnesium (0.27 me/l) and sodium (0.06 me/l) concentration were present in safe level. While, RSC (-0.19) and SAR (0.1) are also at normal level indicating that runoff water is good for irrigation and Pisciculture.

Final (at fish harvest): The fishes were harvested at 165 days after release and water samples were analyzed for its chemical properties. The results revealed that the runoff water was in safe limit with respect to all the parameters. The water pH (7.23) and EC (0.453 dS/m) were in the safe limit indicated that the runoff water collected in the farm pond was not contaminated and no adverse effect on fish growth and development was observed. But, the bicarbonates (3.8me/l), sodium (0.42me/l) concentrations and relative sodium carbonate (2.57) were increased to greater extent as compared to all other observations. However, all these were in safe limit without affecting fish growth.

Water chemical analysis indicated that the runoff water collected from arable and non-arable lands could be used for fish as well as crop production activities without affecting growth and development of both the components.

PRACTICAL UTILITY/RECOMMENDATIONS:

I. Rain water harvesting is a technology of runoff farming which is most feasible and location specific in dry land areas. In low rainfall areas there is a need to induce runoff by treating the uncultivated catchments with the objectives of its collection in the cropped micro-watershed. *Nase* grass as live barrier is helpful in reducing runoff and soil loss.

A. Farm pond technology: Climate change is another aberration in dryland agriculture especially in terms of rainfall. Although, the total quantity of rainfall was not altered much from the normal, the distribution is changed in terms of onset, withdrawal and number of rainy days. Under these circumstances, *ex-situ* harvesting of runoff, its efficient storage and its multiple use helps for bringing resilience towards livelihood security. Any effort of conserving rainwater *in-situ* in *Alfisols* will yield hardly 70-75% which enters the soil moisture pools and 5 per cent as groundwater recharge and remaining 25-30% goes as runoff.

Farm pond with appropriate lining and its multiple use of harvested water are demonstrated for the benefit of the farmers, policy makers, extension workers and students. Considering the rainfall and soil factors, 250 m^3 volume of farm pond is recommended for one hectare of catchment area. To attain this, excavation of earth by 12 m x 12 m top, 6 m x 6 m bottom and vertical height of 3 m, in 1:1 slope is recommended.

Lining of farm pond for seepage regulation with different materials were also demonstrated. The lining materials consists of;

- Stone dust + cement (8:1)
- Soil + cement (8:1)
- Brick lining
- Brick compartment (1 m^2) & soil + cement (8:1) lining
- Granite stone slab

A clear difference between different lining materials can be visualized with respect to longevity in water storage and seepage control. Among different lining materials *viz*., stone dust + cement, soil + cement, brick, granite slabs which were executed as part of study, lining of farm pond with 400-500 micron gauge LDPE (Low Density Poly Ethylene) sheet with 8:1 ratio of soil-cement plastering to 5 cm thickness mortar in 1 m^2 rectangular brick compartments on all the four sides of farm pond and brick lining over LDPE sheet performed better its stability and minimzing water loss.

Performance:

- Reduced seepage losses
- Longer storage of water

B. Multiple use of farm pond water: Efficient use of farm pond water for different activities is as follows;

Utilization of protective irrigation of field crops

(i) **Protective irrigation:** Can be irrigated 1/3rd of the area with surface methods, entire catchment to a depth of 2.5 cm once with sprinkler.

(ii) **Double cropping:** Bi-modal rainfall distribution encourages double cropping of fodder crops/cowpea/sesame in early season (May-June) followed by chickpea/baby corn/chilli transplanting (Sept-Oct) with a protective irrigation during flowering/maturity in second crop resulted in improved rain water use efficiency and net income by Rs.10,244 to Rs.64,168 ha^{-1}.

(iii) In **maize,** application of 100% recommended fertilizers resulted in significantly (4374 kg/ ha) superior grain yield followed by integrating 50% N through fertilizer with 50% N through poultry manure (3996 kg/ha) or sewage sludge to supply balance N produced distinctly superior grain yield (3810 kg/ha).

(iv) Higher grain yield (4076 kg/ha)and net income in **finger millet** can be realized by adoption of *in-situ* soil moisture conservation practices (Moisture conservation furrow + protective irrigation + mulching) along with application of recommended dose of fertilizers.

(v) **French bean** plants responded positively for providing irrigation at 0.9 IW: CPE ratio and recorded higher bean yield (9754 kg/ha) as compared to providing irrigation at critical stages for irrigation and application of Nitrogen (100% RDN) through fertilizer recorded higher green bean yield (9374 kg/ ha).

(vi) In **Radish,** moisture conservation furrow + protective irrigation + mulching recorded significantly higher root and biomass yield (14287 and 28228 kg/ ha) as compared to without mulching and control (without protective irrigation).

(vii) **Nourishing fruit trees / plantations:** Water stored in one of the pond is used for nourishing the fruit trees / plantations planted in the catchment / outside specially during *rabi* /summer.

(viii) **Nutritional / kitchen garden:** vegetables, fruits, spices, flower crops were raised around the pond, which has resulted in an additional income of Rs.591 to 2000/-.

(ix) **Azolla cultivation:** Reducing evaporation losses and harnessing fodder for animals are possible through azolla cultivation in the farm pond.

II. The **fish culture** in dry land areas is technically feasible and economically viable and could be adopted by marginal and small farmers to obtain more monetary benefits. All the fish breeds *viz*., Rohu, catla, common carp, grass carp performed better in growth and development. Effectiveness of pisciculture depends on period of water availability in farm ponds. Normally areas receiving more than 650 mm rainfall per annum would be sufficient for fish production in addition to crop production. Fish fingerlings reared @ 1 m^2 with water storage for 6-8 months of water storage due to bi-modal rainfall distribution. An additional income of Rs. 3000-5000 was documented with fish culture.

The fishes were harvested at 165 days after release and water samples were analyzed for its chemical properties. The results revealed that the runoff water was in safe limlt with respect to all the parameters. The water pH (7.23) and EC (0.453 dS/m) were in the safe limit indicated that the runoff water collected in the farm pond were not contaminated and no adverse effect on fish growth and development was observed. But, the bicarbonates (3.8 me/L), sodium, (0.42 me/L) concentrations and relative sodium carbonate (2.57) were increased to greater extent as compared to all other observations. However, all these were in safe limit without affecting fish growth.

Water chemical analysis indicated that the runoff water collected from arable and non-arable lands could be used for fish as well as crop production activities without affecting growth and development of both the components.

STRATEGIES FOR UP SCALING:

- ❑ Realizing the importance of farm ponds, the Karnataka state government in its golden jubilee celebrations has announced a scheme popularly known as *"Suvarna Krishi Honda"* to motivate farmers by giving 50 per cent subsidy.
- ❑ Farm ponds are the effective water storage structures to collect the excess runoff water wherein, pisciculture could be successfully taken up so that farmers will be benefited by an additional income of at least Rs.1,500/- to 2,000/-
- ❑ Scarcity of fodder could be overcome by growing fodder crops in early *Kharif* and Cereals/vegetable crops could be raised by giving 2-3 protective irrigations stored in the farm pond.
- ❑ Different lining materials for farm pond construction could be used from the locally available resources in order to reduce the cost of construction

FUTURE RESEARCH NEEDS:

- Need to evaluate alternate lining materials to reduce cost of construction by utilizing of locally available material with least seepage losses.

- Need to re-orient the farm size and shape based on soil type, rainfall pattern and slope.

- The diversified use of farm pond water in dry land need to be popularized with the involvement of state department, extension workers, organizations, Self Help Groups, Non-Governmental Organizations, local bodies etc.

DIVERSIFIED UTILIZATION OF HARVESTED FARM POND WATER TO AUGMENT THE WATER PRODUCTIVITY IN RAINFED *ALFISOLS OF* EASTERN DRY ZONE IN KARNATAKA

I	**Name and address of the Institute**	:	AICRP for Dry Land Agriculture, University of Agricultural Sciences, GKVK, Bengaluru-560 065 Karnataka
II	**Name and address of the Principal Investigator**		
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	Telephone	**:**	9845244458

III. Title of the Scheme:

"**DIVERSIFIED UTILIZATION OF HARVESTED FARM POND WATER TO AUGMENT THE WATER PRODUCTIVITY IN RAINFED *ALFISOLS OF* EASTERN DRY ZONE IN KARNATAKA"**

IV. Financial details:

Particulars	Amount (Rs)
Sanctioned amount	**18, 15,433=00**
Amount released for the year 2006-07	3,28,000=00
Expenditure for year 2006-07	*2,66,154=00*
Amount released for the year 2007-08	NIL
Expenditure for year 2007-08	*9,135=00*
Amount released for the year 2008-09	8,00,000=00
Expenditure for year 2008-09	*1,89,650=00*
Amount released for the year 2009-10	NIL
Expenditure for year 2009-10	*3,89,768=00*
Amount released for the year 2010-11	3,65,000=00
Expenditure for year 2010-11	*1,68,534=00*
Amount released for the year 2011-12	NIL
Expenditure for year 2011-12	*33,487=00*
Amount released for the year 2012-13	NIL
Expenditure for year 2012-13	*82,671=00*
Amount released for the years :TOTAL	**14,93,000=00**
Expenditure for years: TOTAL	***11,39,399=00***

For the year 2013-14 and 2014-15, revalidation and extension of time was not granted hence the expenditure was not booked

BACKGROUND INFORMATION:

The project area is located in "Eastern Dry Zone of Karnataka". The average rainfall of this area is 925.8 mm per annum. The soils of this region are red loamy in texture. Agriculture in this part is left to the vagaries of uncertain rains because of no permanent river basins. Nearly 75 per cent of cultivated area in this zone is under rainfed condition. The major field crops of this zone nourished through bore wells and surface water. However, the proper management of surface harvested water can play a significant role in rejuvenating the under ground water resources and in supporting the increased water use efficiency of rainfed crops.

It is evident from the recent studies of Dry Land research that the productivity of rain fed crops especially in cereals and pulses has been increased to an extent of 2-3 times especially in cereals and pulses as compared to traditional methods because of the effective harvesting and recycling of stored water. But the problem is envisaged with the effective and economical use of harvested water. In this context, to augment the total productivity of the system in dry land, the subsidiary enterprise like fish rearing can be introduced. For effective and economical use of resources which is the need of the hour in dry land agriculture to sustain the productivity.

SOILS

The soils of the farm area belong to Vijayapura series and are classified as *oxic haplustalf*. According to FAO classification, the soils are classified under *Ferric Luvisols*. The soils are reddish brown lateritic derived from granite gneiss under sub-tropical semi-arid climate which are sandy clay loam in texture, which become finer with depth, sub surface soil contains higher clay. The soils are deep and possess good drainage and are easy to cultivate. They are fairly low moisture holding capacity, which becomes higher with depth and have high infiltration rate varying from 4 to 6 cm/hour. The details with respect to soil physical and chemical properties are furnished below. The soils are slightly acidic in pH, low in organic matter and now it shows low in available nitrogen. In the beginning, the soils were low in available phosphorus, zinc and now it has medium, to high. Available potassium becomes low to medium. The P fixation capacity of these soils is about 40 per cent crust formation on drying was one of the serious handicap for seed emergence on these soils.

Physico-chemical properties of soil

1. Particle size distribution (%)

Depth(cm)	Coarse sand	Fine sand	Silt	Clay
0-8	42.00	31.50	6.00	21.00
8-30	30.50	22.00	7.40	36.60
30-90	29.10	22.00	8.00	40.80

2. Water retention characterization.

Soil depth (cm)	1/3 bar (%) (0.033Mpa)	15 bar (%) (1.5M pa)	Available Water (cm)	Bulk Density (g/cc)
0-15	14.30	6.50	1.86	1.59
15-30	17.70	9.30	1.94	1.54
30-60	19.90	12.80	3.02	1.42
60-90	21.80	13.10	3.70	1.42

3. Keen Raczkowski box measurement

Soil depth (cm)	Apparent Desnity (g/cc)	Absolute Specific Gravity (g/cc)	Maximum water Holding capacity (%)	Pore Space (%)	Volume Expansion (%)
0-15	1.45	2.49	39.30	41.16	0.39
15-30	1.40	2.41	37.50	41.90	0.74
30-60	1.46	2.40	35.50	39.10	0.60
60-90	1.38	2.42	42.10	42.90	0.78

4. Chemical Properties (Initial)

Soil pH	:	5.0 to 5.5
Electrical conductivity (dS/m) at 25C^o	:	Less than 0.2
Organic carbon) %)	:	0.40
Total Nitrogen (%)	:	0.048
Total Phosphorus (%)	:	0.025
Total Potassium (%)	:	0.25
Total Iron (%)	:	0.74
Available Nitrogen (kg/ha)	:	250.00
Available Phosphorus (kg/ha)	:	6.0 -12.0
Available Potassium)kg/ha)	:	160.00
Available Iron (ppm)	:	3.44
Available Copper (ppm)	:	0.80
Available Zinc (ppm)	:	0.33
CEC (m.e3/100g)	:	7.10
Exchangeable calcium (m.e/100g)	:	2.30
Exchangeable magnesiuim (m.e/100g)	:	1.10
Exchangeable Potassium (m.e/100 g)	:	0.30
Exchangeable acidity (m.e./100g)	:	0.20
Total acidity (m.e/100g)	:	10.00

PROJECT OBJECTIVES:

(a) To estimate the run-off pattern and to strengthen the farm ponds through lining material being used indigenously at farmers' level.

(b) To determine the utilization efficiency of stored water through drip system and to know the potentiality of fish culture through farm ponds besides, working out the economic feasibility.

(c) To know the effect of accumulated Sesqui-Oxides on growth and yield of fishes in farm ponds and to develop methods to neutralize their effects.

CLIMATIC CONDITIONS

During 2007, the total amount of rainfall received was 969.4 mm, which was higher to normal rainfall of 924.9 mm (1972-2006). There was 65 rainy days (2.5mm or more) was recorded during 2007. April, May, June November and December received 109.6, 85.4, 60.3 12.4 and 27.6 mm rainfall respectively. While, July, August, September and October received 148.6, 189.8, 139.0 and 146.8 mm rainfall respectively. Good rainfall distribution through out the year facilitated better establishment of crops. The highest monthly rainfall of 189.8mm was recording during august against the mean of 127.2 mm. April, July August and December months have excess rainfall than the normal. Except January and March months all the months received rains. The amount rainfall received on a single day during was 47.2mm on 20 th July. The monthly rainfall received during 2007 and normal rainfall is presented in Appendix-I and Fig .1

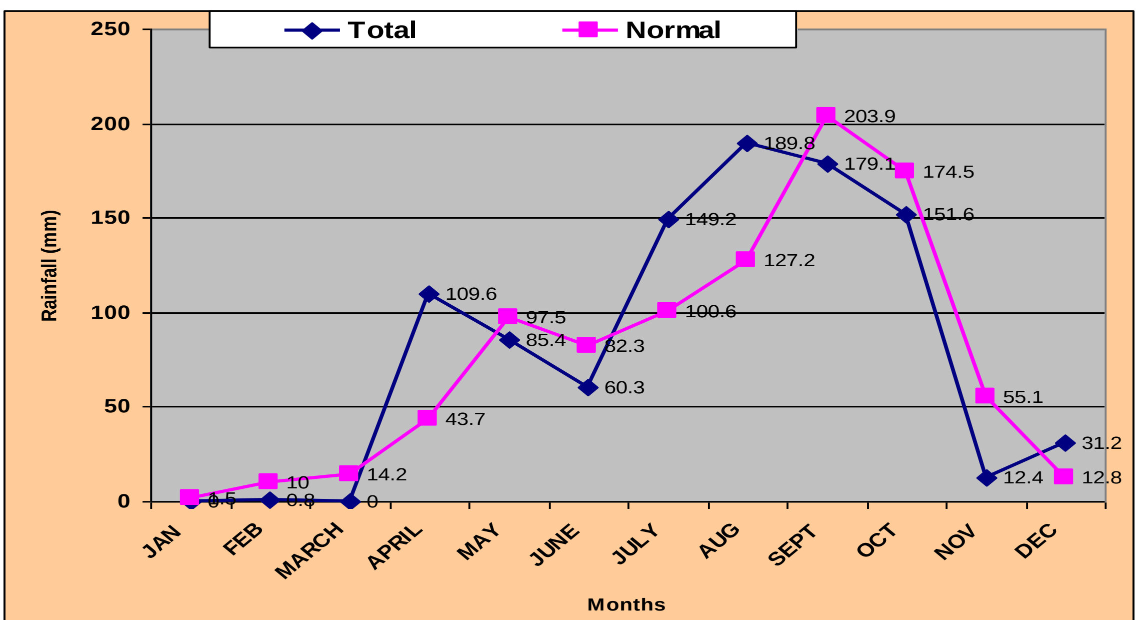

Fig. 1: Actual and normal rainfall (mm) at GKVK during 2007-08

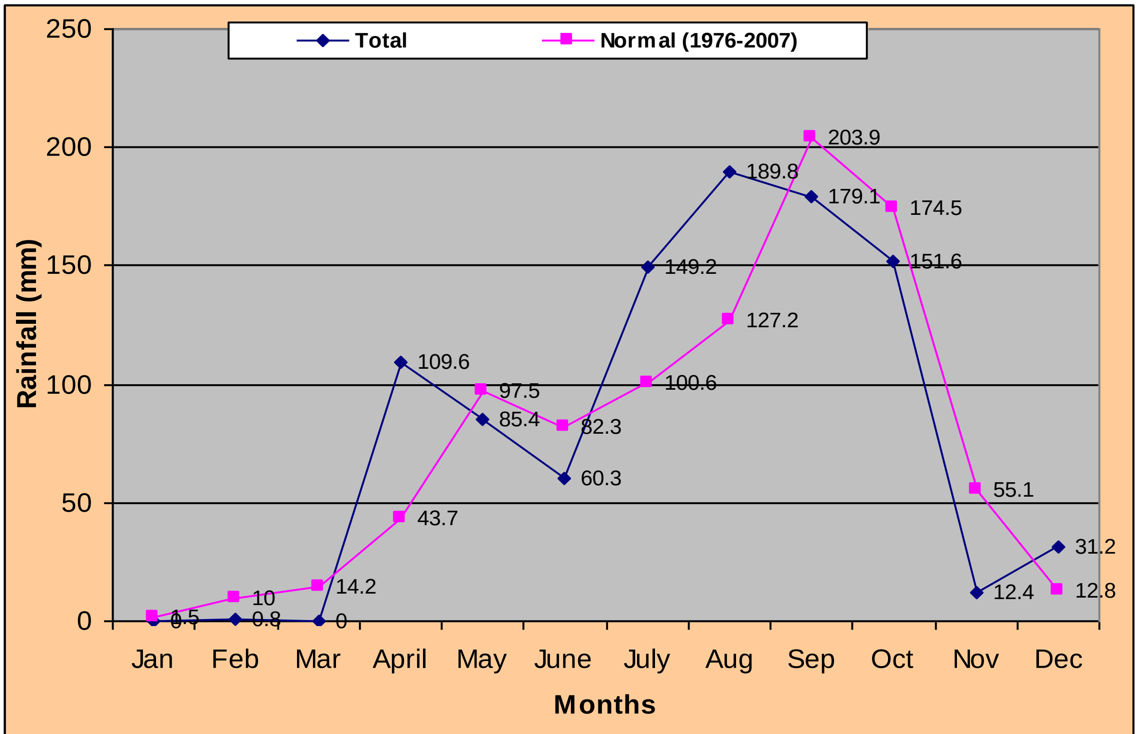

Fig. 2: Normal (1976-2007) and Actual (2008) rainfall during 2008 at GKVK, Bangalore

During 2008, the total amount of rainfall received was 1053.6 mm, which was higher to normal rainfall of 927 mm (1972-2007). There was 58 rainy days (2.5mm or more) was recorded during 2008. February, April, may, June and November received 13.2, 1.6, 98.8, 31.0 and 7.6 mm rainfall respectively. While, March July, August, September and October received 137.4, 182.8, 249.8, 126.9 and 205.4mm rainfall respectively. Good rainfall distribution through out the year facilitated better establishment of crops. The highest monthly rainfall of 249.8mm was recorded during August against the mean of 127.2 mm. March, July August and November months have excess rainfall than the normal. Except January, April and December months all the months received rains. The amount rainfall received on a single day during was 106.2mm on 27th March.

Rainfall and number of rainy days received during 2009 was 842 mm in 49 rainy days. 2009 experienced good rains during May followed by continued dry spells during June and July which resulted in delayed sowing of experiments. The year under consideration has received negative normal rainfall to an extent of -12.6 per cent, where as it is -12.5 per cent during crop growth period (S-W monsoon) which is negative normal. The highest monthly rainfall of 231.5 mm was recorded during September as against the mean of 201.1 mm. April and May months have recorded excess rainfall than the normal. March, June and July months received deficit rainfall. September month received positive normal rainfall +15.1 per cent. October month received only 29.6 mm which is scanty to an extent of -83.1 percent compared to normal rainfall of 174.8 mm. November and December months received negative normal rainfall. The highest amount of rainfall received on a single day during the year was 65.2 mm on 23rd April. The sowing months July and August have received the deficit rainfall (Fig.3).

The total amount of rainfall received during 2010 was 1022.4 mm in 64rainy days. The highest monthly rainfall of 158.2mm was recorded during August as against the mean of 130.7 mm. The rainfall received during the crop growth period was 137.5 mm in 7 rainy days (Appendix -1). November month received 136.87% more rainfall and December month received negative (-20%) rainfall compared normal rainfall. The highest amount of rainfall received on a single day during the crop growth period was 57.2mm on 7th November. The monthly rainfall received during 2010 and normal rainfall is graphically represented in Fig. 4.

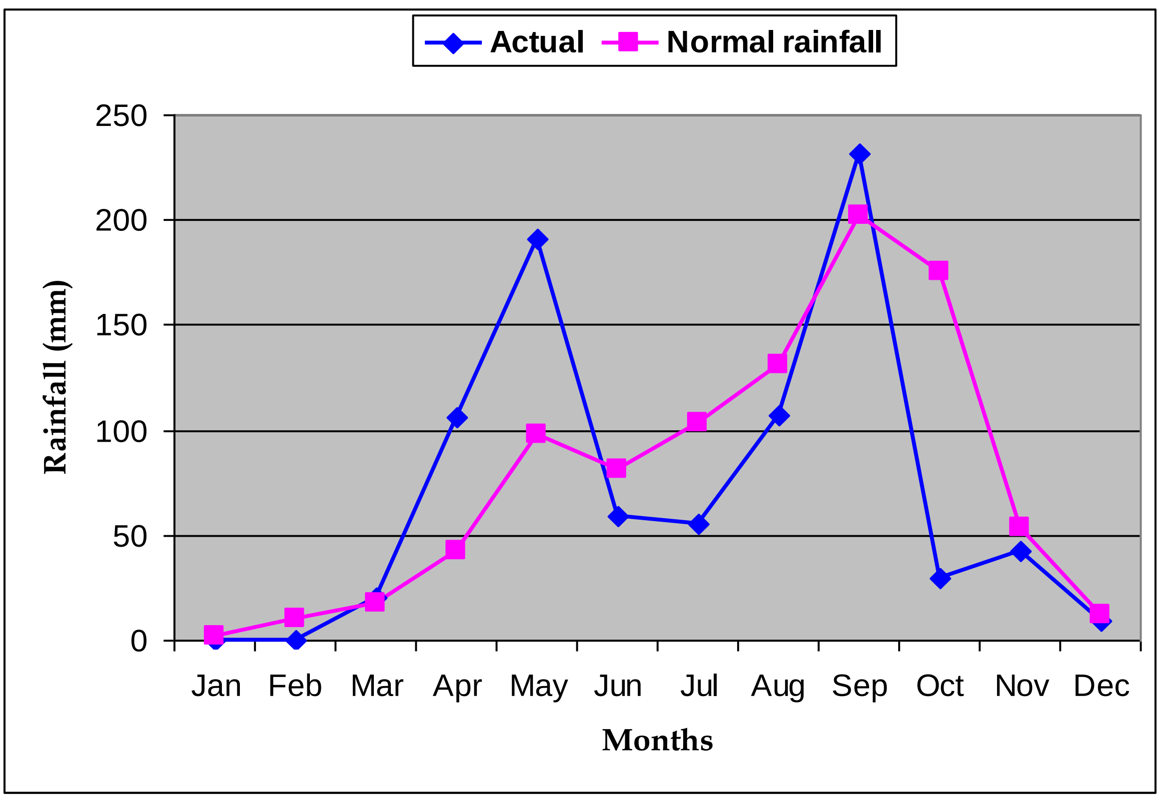

Fig.3: Normal (1976-2008) and observed (2009) rainfall at GKVK, Bengaluru

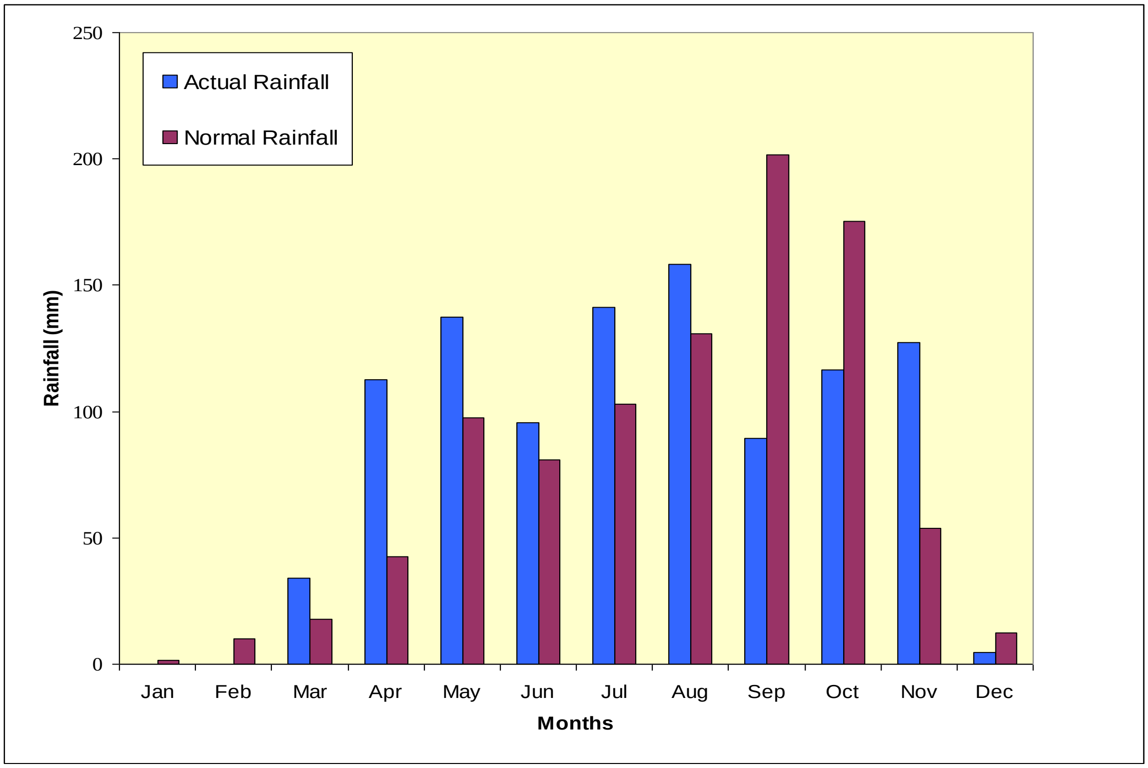

Fig. 4: Normal (1976 to 2009) and observed (2010) Rainfall at GKVK, Bengaluru

Studies on Runoff and soil loss in the dry land center at G.K.V.K, Bengaluru (2006-2012).

PROJECT OBJECTIVE: I

To estimate the run-off pattern and to strengthen the farm ponds through lining material being used indigenously at farmer's level

The number of runoff causing rainfall events was 16 and 24 during 2007 and 2008 respectively. The extent of runoff water was 57 (523.4 mm) and 38 per cent (242.2 mm) during 2007 and 2008 respectively. Even though, the rainfall received during 2007 was much lower than 2008 but runoff water is relatively higher than former (Table 5 &6). It depends on the intensity of rainfall, continuous rainy days and soil physico-chemical properties. The runoff losses under different live barriers, data indicated that Khus and Nase grass was found to be effective in conserving soil and water.

Table 5: Date of runoff events and its rainfall causing runoff during 2007 at Dry Land Agriculture Project, GKVK, Bengaluru

Sl. No.	Date of Runoff events	Rainfall causing runoff
1	20.04.2007	58.6
2	22.04.2007	20.4 (T)
3	27.05.2007	23.6
4	28.05.2007	18.2 (T)
5	06.06.2007	27.0
6	20.07.2007	47.2
7	22.07.2007	26.2 (T)
8	31.07.2007	27.0
9	01.08.2007	28.2
10	22.08.2007	28.8
11	24.08.2007	33.8
12	26.08.2007	41.8
13	09.09.2007	26.2
14	18.09.2007	26.8
15	18.10.2007	40.4
16	21.10.2007	34.6

T - Traces

Total Rainfall= 969.2 mm

Table 6: Rainfall distribution and runoff causing events during 2008 at Dry Land Centre, GKVK, Bengaluru

Sl. No.	DATE	Rainfall (mm)	Runoff (mm)in live barriers		Mean runoff (mm)
			Khus grass	Nase grass	
1	27.03.2008	106.4	38.33	38.33	38.33
2	26.05.2008	36.4	20.31	23.38	22.90
3	31.05.2008	25.8	11.5	13.8	12.46
4	01.06.2008	19.6	0.0	0	1.82
5	03.07.2008	13	0.0	0	0.00
6	15.07.2008	19.8	0.0	8.05	7.76
7	16.07.2008	17.2	6.13	0	5.37
8	14.07.2008	14.2	0.0	0	0.67
9	23.07.2008	35.4	20.31	23.38	22.42
10	24.07.2008	28.6	17.63	18.4	19.74
11	25.07.2008	19.2	0	0	2.44
12	13.08.2008	15.4	0	0	1.73
13	19.08.2008	31.2	13.8	18.01	15.81
14	20.08.2008	27	11.11	13.41	11.98
15	26.08.2008	42.2	18.78	25.68	23.52
16	27.08.2008	32	11.11	12.26	12.10
17	28.08.2008	68.4	17.63	27.98	23.09
18	01.09.2008	24.2	7.28	9.2	9.10
19	02.09.2008	31.6	8.05	11.11	11.50
20	07.09.2008	32.4	9.58	13.03	12.36
21	09.09.2008	26.4	6.52	8.43	8.53
22	04.10.2008	28.4	4.6	7.28	6.90
23	07.10.2008	46.4	8.05	9.58	9.96
24	23.10.2008	28.8	4.6	6.59	6.06
25	25.10.2008	28.8	6.9	9.2	8.00
	TOTAL	**798.6**	**242.23**	**297.11**	**294.55**

Total rainfall = 1053.6 mm

During 2009, the number of runoff causing rainfall events was 12 and the extent of runoff water was 10.2 per cent. The runoff was less during 2009 due to the fact that land was ploughed and passing of intercultural hoe to carry out intercultural operations (Table 7 and Fig.5).

Plate 1. Farm ponds: Traditional water harvesting structures

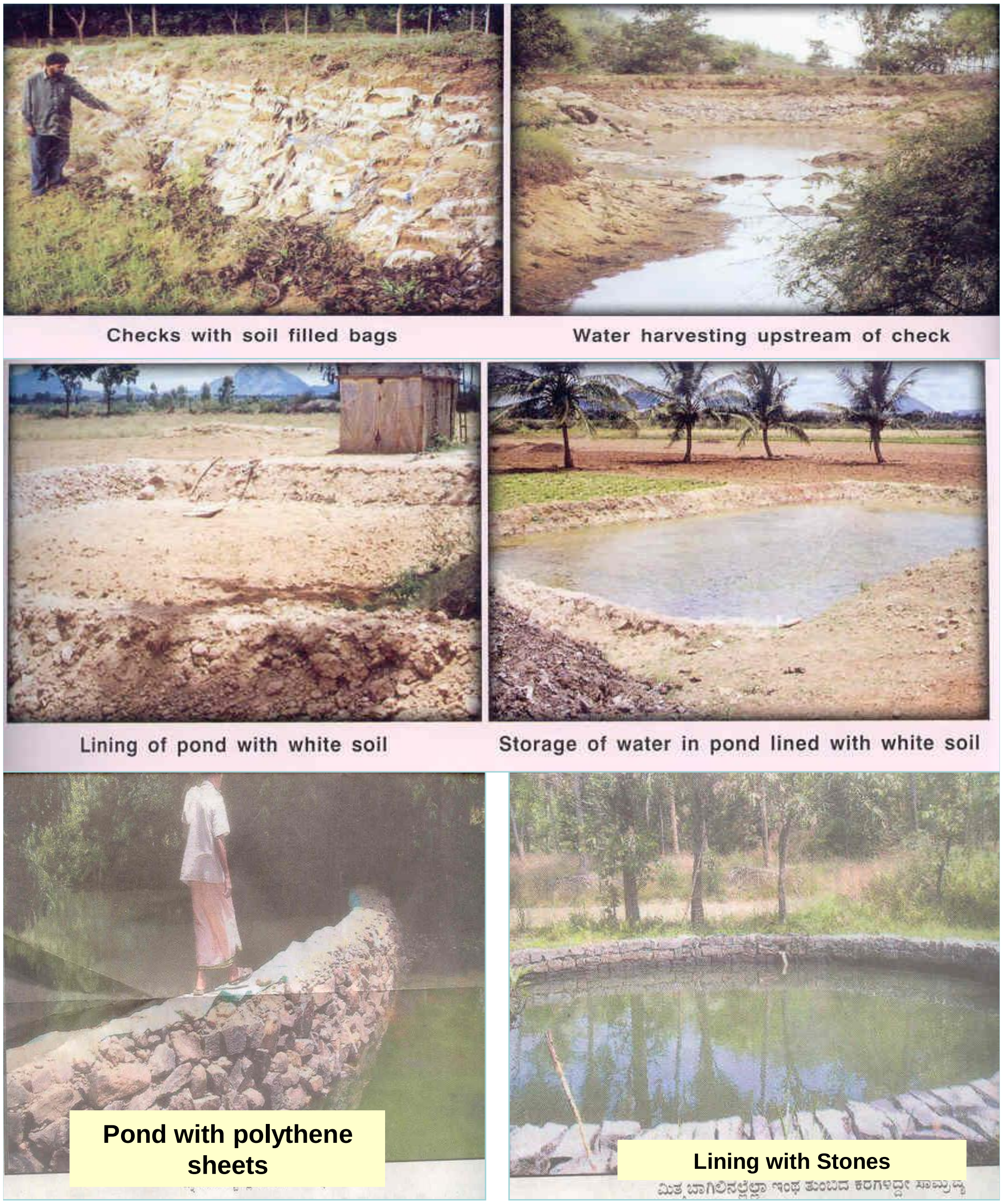

Plate 2. Traditional lining materials for the construction of farm ponds

Table 7: Run-off events, rainfall causing run-off and run-off during 2009 at Dry Land Agriculture Project, GKVK, Bengaluru

Sl No	Date of Runoff events	Rainfall causing runoff	Runoff (mm)	Remarks
1	20-04-2009	34.2	0.8	low runoff because of the first rain in the year
2	23-04-2009	65.6	17.31	
3	20-05-2009	36.2	0.74	
4	22-05-2009	26.8	4.99	
5	11-06-2009	23.8	0.30	
6	31-07-2009	43.6	0.68	
7	01-08-2009	40.2	0.77	Low runoff due to passing disc plough on 31-08-2009
8	19-08-2009	19.6	0.35	
9	14-09-2009	34.4	0.66	Low runoff due to passing inter cultural hoe on 9th ,10th and 11th November 2009
10	19-09-2009	24.8	0.60	Inter cultural hoe passing on 17-09-2009
11	20-09-2009	29.6	1.08	
12	25-09-2009	39.2	14.47	
	Total	418.0	42.75	

The runoff per cent was lower in natural vegetation land as compared to cultivated land. Whereas, in cultivated land live barrier of khus/nase grass along contour reduced the runoff even in high rainfall year. The extent of runoff reduced up to 15-20 per cent as compared to no live barrier.

Runoff and soil loss in *Alfisols* at GKVK during 2010

The runoff events and intensity of runoff depends on amount of rainfall in consecutive days, number of rainy days, soil type, extent of slope, vegetation cover, cultivable/

uncultivable land etc during 2010, the number of runoff causing rainfall events was 11 and the extent of runoff water was 16.7 per cent (Table 8 and Fig.6). Over the years (2005-2010), the no. of runoff events, runoff causing rainfall and runoff are given in Table 9. Information related to size of the farm pond and lining material is furnished in Table 10.

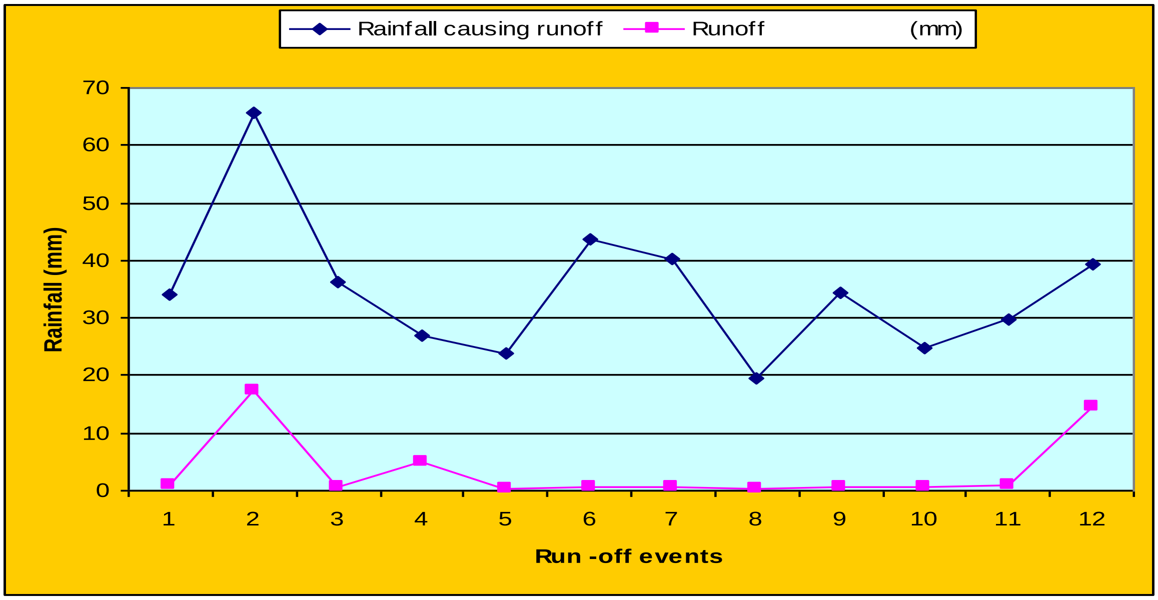

Fig.5: Runoff events, rainfall causing runoff and runoff during 2009 at Dry Land Agriculture Project, GKVK, Bengaluru

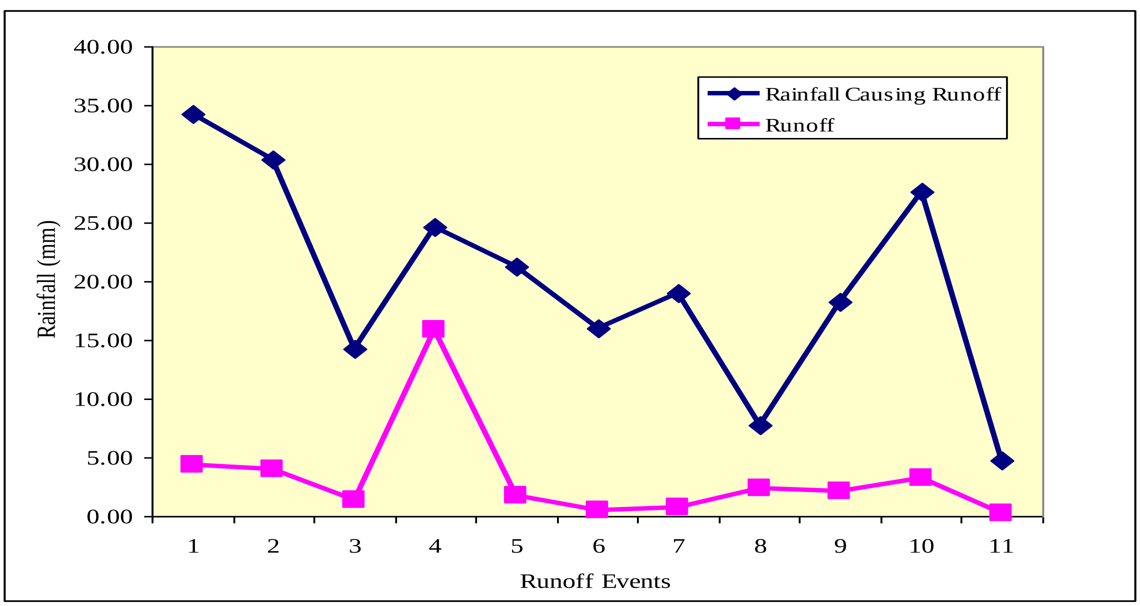

Fig. 6: Runoff events, rainfall causing runoff and runoff during 2010 at Dry Land Agriculture Project, GKVK, Bengaluru

Table 8: Runoff events, runoff causing rainfall and runoff during 2010 at Dry Land Agriculture Project, GKVK, Bengaluru

Sl.No	Date of runoff events	Runoff causing rainfall(mm)	Mean Runoff (mm)
1	31-Mar-10	34.20	4.43
2	13-Apr-10	30.40	3.96
3	15-Apr-10	14.20	1.41
4	04-Jun-10	24.60	15.9
5	10-Jun-10	21.20	1.77
6	29-Jul-10	16.00	0.45
7	31-Aug-10	19.00	0.71
8	27-Sep-10	7.80	2.33
9	28-Sep-10	18.20	2.12
10	11-Oct-10	27.60	3.30
11	11-Dec-10	4.80	0.20
Total		**218.00**	**36.58**

Table 9: Total rainfall (mm) and runoff (mm) during different years at the experimental site, GKVK, Bengaluru

Year	Total annual rainfall (mm)	No. of runoff events	Runoff causing rainfall(mm)	Runoff (mm)
2005	1358.7	19	868.4	353.0
2006	704.2	13	460.4	78.5
2007	920.3	16	523.4	129.5
2008	1053.6	24	798.6	294.5
2009	842.0	12	418.0	42.7
2010	1022.4	11	218.0	36.6

Construction of farm pond

A big farm pond (Fig. 2 and Table 5) was handed over to the INCID project during August, 2007 after putting *Kadapa* stone slabs as a lining material. The total cost is Rs.8.5 lakhs (out of which Rs.6.00 lakhs was borne by the UAS, Bangalore and Rs.2.5 lakhs was provided by INCID project. The farm pond has capacity to store 3200 Cubic mt. of water. Besides, other ponds with different lining materials are also being taken in to account for implementation of the project.

Table 10: Measurement details of Farm pond

Particulars/Pond dimensions	Big Farm pond	Small Farm pond (Micro-watershed)
Top dimensions (m)	Length – 35 m Width – 33 m	Length – 10.5 m Width – 10.5 m
Bottom dimensions	Length – 27 m Width – 26 m	Length – 6 m Width – 6 m
Pond depth	3.5 m	3 m
Farm pond capacity	3200 Cubic mt	180 Cubic mt
Lining	Kadapa slab	Soil + Cement (8:1)
Height of lining material	1.2 m	3.0 m
Area of lining	Bottom - 901 Sq. m 4 Sides - 155 Sq. m (34.2 x 2 sides = 68.4 sq. m & 43.2 x 2 sides = 86.4 sq. m)	Bottom - 36 Sq. m 4 Sides - 138 Sq. m (34.26 x 4 sides)
Total area lining	1056 Sq. m	175 Sq. m

PROJECT OBJECTIVE: II

To determine the utilization efficiency of stored water through drip system and to know the potentiality of fish culture through farm ponds besides, working out the economic feasibility.

Crop production activities by protective irrigation to improve water use efficiency with integrated nutrient management practices

I.FIELD CROPS:

Experiment 1:

Maize production under protective irrigation at Dry land agriculture project, GKVK, Bangalore during 2008-09

Crop: Sweet corn

The experimental site is situated at 12^0 58' N and 13^0 5' N latitude and 77^0 35' E and 77^0 34' E longitude at an altitude of 930 meters above the mean sea level Eastern Dry Zone (Zone-5) of Karnataka. The rainfall received during the crop growth period was 763mm in 40 rainy days (Appendix-I).

Varietal character: NAC-6004

The maize composite NAC-6004 was released in the year 1998 for irrigated as well as rainfed areas of southern Karnataka for all seasons. It matures in about 120 days during *Kharif* and 130 days in *rabi* season, belongs to late maturity group. The plant is medium green stalk with light pink base stem, dark green broad leaf, bold and semi dent orange yellow coloured grain grows to a height about 200 cm. It is resistant to lodging, turcicum leaf blight and Downey mildew diseases. It has a maximum potential yield of 8.32 t/ha.

Treatment details:

T_1: 100 % NPK (control)
T_2: 50 % N through fertilizer + 50% N through FYM + balance P and K as fertilizers
T_3: 50 % N through fertilizer + 50% N through city compost + balance P and K as fertilizers
T_4: 50 % N through fertilizer + 50% N through sewage sludge + balance P and K as fertilizers
T_5: 50 % N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers
T_6: 50 % N through fertilizer + 50% N through glyricidia + balance P and K as fertilizers
T_7: 50 % N through fertilizer + 50% N through parthenium + balance P and K as fertilizers
Plot size: 4.5 m X 5.4 m = 24.3 m^2
Recommended N, P_2O & K_2O: 100: 50: 25 kg/ha
No. of replications: 3

No. of protective irrigation from farm pond: 2
Depth of water: 4 cm
Dates of protective irrigation: 18-09-2008
30-09-2008
05-11-2008
Date of sowing: 10-07-2008
Date of harvest: 25-10-2008

Row spacing: 45 cm x 30 cm
Total rainfall received during cropping period: 763 mm

No. of rainy days during crop growth period: 40
Duration of dry spells: Three (3)
10-9-2008 to 03-10-2008 = 23 days
28-10-2008 to 17-11-2008 = 21 days
19-11-2008 to 26-11-2008 = 8 days

Table 11: Nutrient composition (%) in different organic manures used in the experiment

Organic manure	N	P_2O_5	K_2O
FYM	0.8	0.41	0.7
City compost	1.2	1.9	1.0
Sewage sludge	1.5	2.0	1.5
Poultry manure	2.89	2.9	2.4
Glyricidia	2.2	0.28	4.6
Composted Parthenium	2.5	0.7	1.0

Table 12: Grain yield (kg ha^{-1}), Stover yield (kg ha^{-1}) and harvest index in maize as influenced by different organic sources and fertilizer levels.

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
T_1	4374	6900	0.39
T_2	3645	6200	0.37
T_3	3201	5760	0.36
T_4	3810	6450	0.37
T_5	3996	6530	0.38
T_6	3594	6000	0.37
T_7	3539	5960	0.37
S.Em. ±	134.93	209.63	0.01
C.D @ 5%	381.07	592.04	0.04
CV %	10.8	10.1	10.4

Treatments:
T_1 = 100 % NPK (control)
T_2 = 50% N through fertilizer + 50%N through FYM + balance P and K as fertilizers.
T_3 = 50% N through fertilizer + 50% N through City compost + balance P and K as fertilizers.
T_4 = 50% N through fertilizer + 50% N through Sewage sludge + balance P and K as fertilizers.
T_5 = 50% N through fertilizer + 50% N through Poultry manure + balance P and K as fertilizers.
T_6 = 50% N through fertilizer + 50% N through *Glyricidia* + balance P and K as fertilizers.
T_7 = 50% N through fertilizer + 50% N through *Parthenium* + balance P and K as fertilizers.

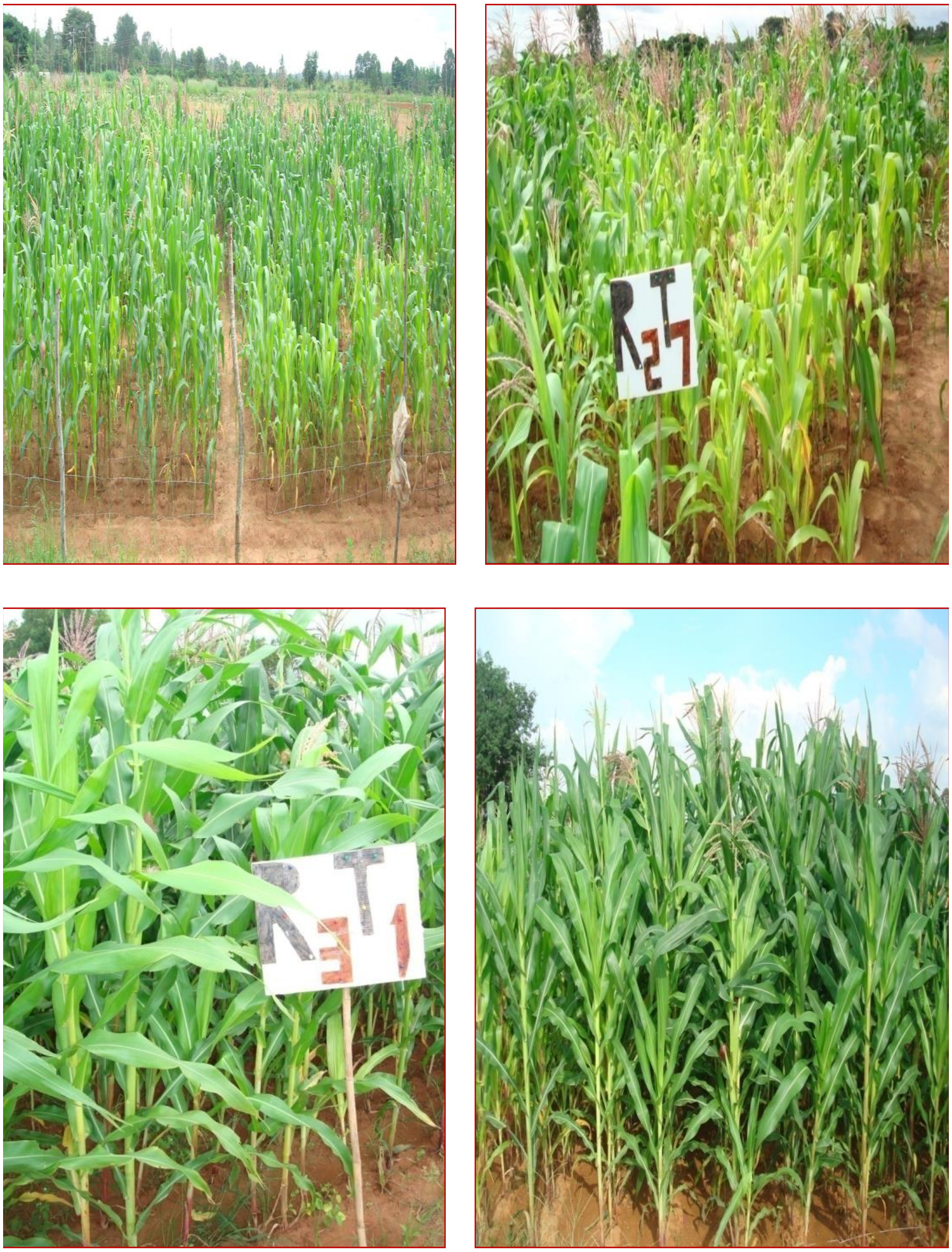

Plate 3: Maize Crop production though harvested farm pond water

Grain yield of maize

Grain yield was significantly influenced by different sources of manures in combination with fertilizers despite equivalent nutrients application.

Application of 100% recommended fertilizers resulted in significantly (4374 kg ha^{-1}) superior grain yield than all other integrated treatments. Among other treatments, integrating 50% N through fertilizer with 50% N through poultry manure (T_5) or sewage sludge (T_4) to supply balance N produced distinctly superior grain yield (3996 kg ha^{-1} and 3810 kg ha^{-1}), respectively. Use of poultry manure could result 8.5 per cent lesser grain yield than using fertilizer alone, while use of sewage sludge could result into 24 per cent lesser grain yield. Other treatments involving FYM, Glyricidia and composted parthenium had equivalent grain yield in the range of 3539-3645 kg ha^{-1}. However, use of city compost did not produce grain yield more than 3201 kg ha^{-1}, which accounted for 27 per cent lesser grain yield than use of recommended fertilizer alone.

Stover yield

Stover yield differed significantly due to the application of different combination of organic and inorganic nutrient sources. Maximum stover yield (6.683t ha^{-1}) registered with the application of recommended NPK through fertilizers (T_1) followed by 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (T_5) (6.463 t ha^{-1}). Despite application of 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers (T_3) gave lower stover yield (5.833 t ha^{-1}) than all treatments but was on par with the rest of treatments.

Harvest Index

Among the treatments application of recommended NPK through fertilizers (T_1) recorded higher harvest index (0.40) than other treatments and treatment applied 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers (T_3) had lower harvest index (0.35).

Effect of integrated nutrient management on economics of different sources of nutrient

Application 50% N through fertilizer + 50%N through FYM + balance P and K as fertilizers recorded maximum cost of cultivation (T_2) (Rs. 12,784 ha^{-1}) as compared to the other treatments. However, minimum cost of cultivation was noticed 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (T_5) (Rs. 9,910 ha^{-1}) followed by 50% N through fertilizer + 50% N through glyricidia + balance P and K as fertilizers (T_6) (Rs. 9,953 ha^{-1}).

Higher gross returns was obtained with the application of recommended NPK through fertilizers (T_1) (Rs. 40,521 ha^{-1}) followed by 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (T_5) (Rs. 37, 198 ha^{-1}) as compared to other treatments. Lower gross return was obtained in treatment received with 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers (T_3) (Rs. 30,125 ha^{-1}).

The highest net returns (Rs. 29,562 ha^{-1}) was obtained with the application of recommended NPK through fertilizers (T_1) followed by 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (T_5) (Rs. 27,288 ha^{-1}) and the lowest net returns was observed in 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers (T_3) (Rs. 19,370 ha^{-1}).

Benefit cost ratio of maize was differed with the combined application of organic and inorganic sources of nutrients. Among all the treatments application of 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (T_5) recorded the highest (2.75) B:C ratio, followed by application of recommended NPK through fertilizers (T_1) (2.70). However, application of 50% N through fertilizer + 50%N through FYM + balance P and K as fertilizers (T_2) recorded the lowest B: C ratio (1.67) among all the treatments.

Table 13: Cost of cultivation, gross returns, net returns and B: C ratio of maize as influenced by different organic sources and fertilizer levels

Treatment	Cost of cultivation (Rs./ha)	Gross Returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
T_1	10959	40521	29562	2.70
T_2	12784	34083	21299	1.67
T_3	10755	30125	19370	1.80
T_4	10339	35577	25238	2.44
T_5	9910	37198	27288	2.75
T_6	9953	33549	23596	2.37
T_7	10879	33045	22166	2.04

Maize grain (Rs. 8.5 kg^{-1}); Maize stover (Rs. 500 t^{-1})

Treatments:

T_1 = 100 % recommended NPK through fertilizers

T_2 = 50% N through fertilizer + 50%N through FYM + balance P and K as fertilizers.

T_3 = 50% N through fertilizer + 50% N through city compost + balance P and K as fertilizers.

T_4 = 50% N through fertilizer + 50% N through sewage sludge + balance P and K as fertilizers.

T_5 = 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers.

T_6 = 50% N through fertilizer + 50% N through glyricidia + balance P and K as fertilizers.

T_7 = 50% N through fertilizer + 50% N through composted parthenium + balance P and K as fertilizers.

Experiment-2 during 2009-10:

"Studies on utilization efficiency of harvested water through different methods of irrigation with integrated nutrient management practices for finger millet (Eleusine coracana) production in alfisols"

Objectives of the experiment:

- To estimate the quantum influence of irrigation methods on growth and yield of finger millet
- To know the growth and yield of finger millet under integrated nutrient management practices
- To know the interaction effect of irrigation methods and integrated nutrient management practices on growth and yield of finger millet
- To work out water and nutrient balance in finger millet production

Experiment details:

Crop: Finger millet *Plot size*: 4.5 m X 3.0 m *variety*: GPU-28

Recommended Dose of Fertilizer: 50:40:25: kg NPK ha^{-1}

No. of Replications: Three

No. of protective Irrigation: one irrigation on 27.10.2009

Depth of irrigation water: 5 cm

Date of sowing: 22.8.2009

Date of Harvest: 16.12.2009

Row spacing: 30 cm x 10 cm

Poultry manure: 3.03% N. (1.2 kg of poultry manure/plot)

Glyricidia: 2.76% N. (1.25 kg/plot)

Treatments details:

I. Main plots: Methods of irrigation (M)

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching

M_2: Moisture Conservation furrow + Protective Irrigation

M_3: Control

II. Sub-plots: Organic sources of nutrients (N)

N_1: Recommended dose of fertilizers

N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Treatment Interactions: (9)

M_1N_1	M_2N_1	M_3N_1
M_1N_2	M_2N_2	M_3N_2
M_1N_3	M_2N_3	M_3N_3

Observations:

- Periodic observation on growth, yield and yield attributing characters
- Water Consumptive Use (CU) and Water Use Efficiency
- Soil nutrient status before and after crop harvest and nutrient balance

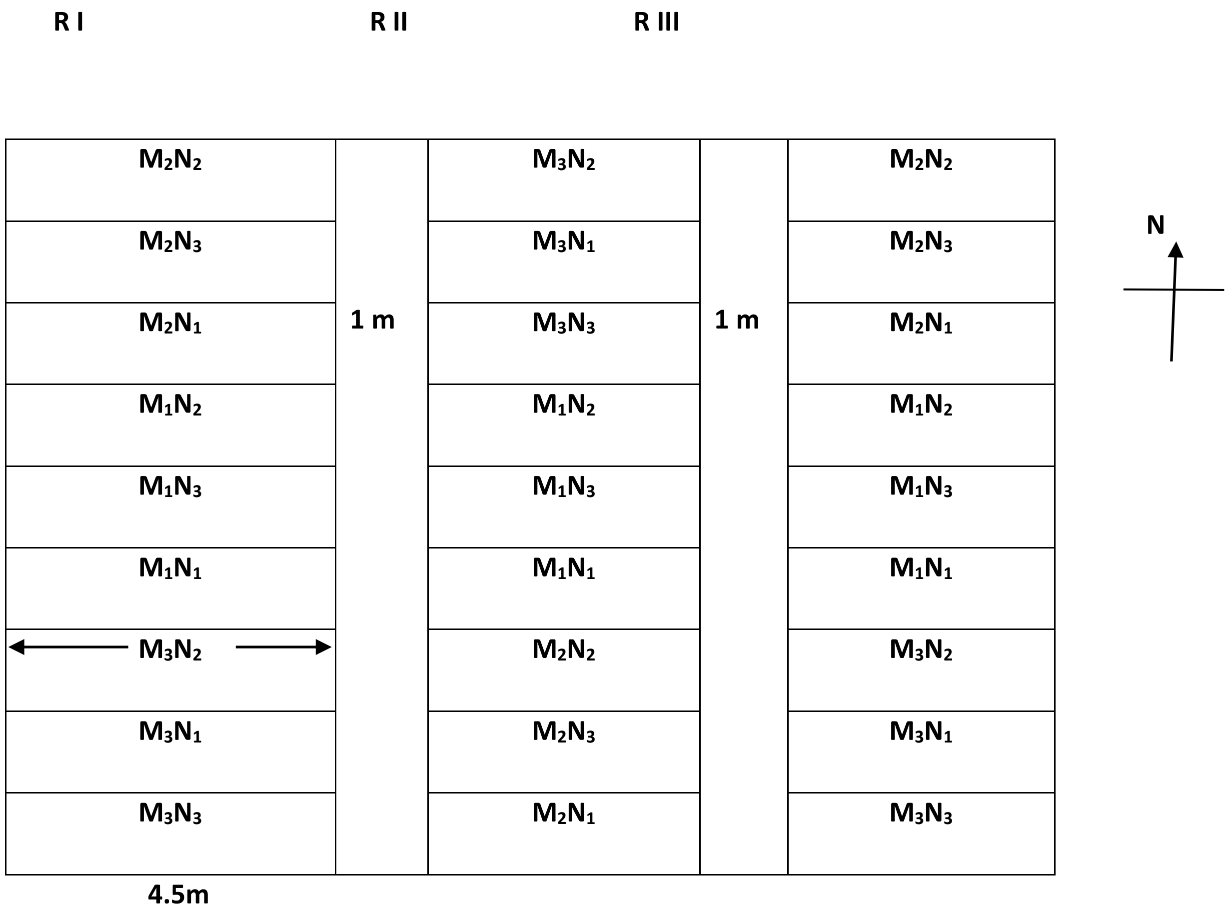

Fig. 7: Plan and layout of experiment

Materials and Methods

Experimental site is ploughed twice during April and May and bring it to fine tilth. The entire area is divided in to different blocks equal to number of main treatments and each block is divided into number of plots as many number of sub-plot treatments. The individual treatments to each plot were allotted randomly using random number table. The size of each plot is 4.5 m x 3.0 m. Separate buffer furrow is maintained between each plot. The soil moisture conserving furrows were formed for M_1 and M_2 treatments whereas, mulching was provided only for M_1 (5-6 dried straw). While, M_3 treatment was treated as control. Approximately 5 cm depth of water was provided during long dry spells of the crop growth.

For sub-plot treatments, the nutrient composition of organic manures was analyzed and quantity of manures required to supply 50 per cent recommended N (25 kg N) is worked out. All the organic manures are applied 30 days before planting. The 50 per cent of the recommended N and entire dose of P and K is applied at the time of transplanting and remaining 50 per cent N is applied at 30 days after transplanting.

Observations on the growth components of finger millet were recorded at 45 DAT, 90 DAT and at harvest. At harvest yield and yield attributes were recorded from sampling plants and mean values were worked out. The soil moisture was estimated in different soil depths before irrigating the crop during 45, 90 DAT and at harvest.

<u>Spad meter observation</u>: (SPAD: Soil and Plant Analysis Division of Minolta)

From each, randomly selected plants, top three leaves were chosen and spad meter's sample slot was placed between leaf blades (It was ensured that midrib is not placed in sample slot). From each leaf, three observations were recorded and total nine observations were recorded as follows;

Flag leaf: 3- different locations (end, middle, near tip) at each point
one observation was recorded

2nd leaf from top: 3-different locations (end, middle, near tip) at each point
one observation was recorded

3rd leaf from top: 3-different locations (end, middle, near tip) at each point
one observation was recorded

Totally nine observation were recorded per plant. Similarly, three plants were chosen for taking observation and all together 27-observations were taken from three plants per treatment and average of 27-observations was worked out.

Results and discussion

The results of the field experiment ***"Studies on utilization efficiency of harvested water through different methods of irrigation with integrated nutrient management practices for finger millet (Eleusine coracana) production in alfisols"*** during *Kharif* 2009-10 conducted at Dry Land Agriculture Project, GKVK, University of Agricultural Sciences, Bengaluru are presented below.

The experimental site is situated at 12^0 58' N and 13^0 5' N latitude and 77^0 35' E and 77^0 34' E longitude at an altitude of 930 meters above the mean sea level Eastern Dry Zone (Zone-5) of Karnataka. The rainfall received during the crop growth period was 310.9 mm in 18 rainy days (Appendix-I).The mean maximum and minimum temperature ranged between 22.8 ^{0}C and 31.0^{0}C and 14.2 ^{0}C and 20.0^{0}C respectively. The relative humidity during the crop growth period was ranged between 74% to 98%.

Plate 4: Finger millet production through harvested farm pond water

Performance of any crop is governed by genetic and environmental factors. Environmental factors individually or in combination determine the yield potentiality. In the present investigation different soil moisture conservation methods were tried in combination with different sources of nitrogen with a main objective to utilize the organic source of nutrients available on the farm and to attain sustainability in yield levels.

Among different *in-situ* soil moisture conservation, opening conservation furrow between rows and mulching in those rows proved to be better in attaining better growth parameters in finger millet.

Plant height and chlorophyll content were significantly higher in M_1 (68.6 cm, 38.0, 99.2 cm, 40.3 and 102.5 cm, 18.9 at 45 DAS, 90 DAS and at harvest respectively) as compared to M_2 and M_3 (without protective irrigation) (Table 14 &15). Significantly higher chlorophyll content was recorded in M_1 at 45DAS, 90 DAS and at harvest.

The dry matter production and its distribution among different plant parts differed significantly due to different irrigation methods. Significantly, higher dry matter accumulation in leaf (15.2 and 14.60 g/plant) and in stem (34.27 and 31.20 g/plant) were noticed in M_1 and M_2 as compared to control (11.57 and 26.23 g/plant) (Table 16). Similarly, significant difference was noticed with respect to dry matter accumulation in ear head of finger millet. Among the methods of in-situ moisture conservation, M_1(30.94 g/plant) and M_2 (28.59 g/plant) had recorded significantly higher dry matter accumulation in ear head as compared to control (21.62 g/plant). This significant variation in dry matter distribution and accumulation in various plant parts lead to significant variation with respect to total dry matter production per plant at harvest. Highest total dry matter accumulation plant was noticed in M_1 (80. g/plant) as compared to M_2 and $M_{3.}$

Application of nitrogen to finger millet by different sources had recorded differences in growth parameters in plant at various growth stages. Application of 100% of recommended dose of nitrogen through fertilizer recorded progressive plant height and chlorophyll content at all the growth stages of crop growth as compared to integrated approach of nitrogen application viz., 50% recommended does of nitrogen (RDN) through fertilizer and 50% RDN through poultry manure and 50% RDN through fertilizers and 50% through glyricidia (62.4 cm, 94.9 cm and 100.5 cm respectively) during 45 DAS, 90 DAS and at harvest. Significantly higher chlorophyll content was observed in treatment receiving 100% RDN through fertilizer at all the growth stages of finger millet (37.8, 39.5 and 18.6 during 45 DAS, 90 DAS and at harvest respectively)(Table 15). On the contrary, no significant difference with respect to chlorophyll content was observed in N_1 and N_2 during 45 DAS and at harvest, but at 90 DAS significant differences were noticed in all the nitrogen treatments.

Significant difference with respect to dry matter production and its accumulation in different plant parts was observed due to use of RDN with different sources. Application of 100% RDN through fertilizer recorded higher dry matter accumulation in leaf, stem and ear head of finger millet at harvest (14.60, 32.90, 28.53 g plant $^{-1}$ respectively) as compared to N_2 and N_3. Similar trends were noticed with respect to total dry matter production per plant at harvest (76.32 g/plant) as compared to integrated application in N_2 and N_3 (Table 16). Effect of different irrigation methods in combination with different sources of nitrogen did not reveal any significant variation with respect to growth parameters in finger millet viz., plant height, chlorophyll content, dry matter production and distribution to different plant parts. Finger millet yield differed significantly due to different methods of irrigation. Alternate furrow irrigation with mulching and furrow irrigation with mulching recorded significantly higher grain yield (3786 and 3235 kg/ha) as compared to control (with out protective irrigation) (2296 kg/ha)). The higher yield level in M_1 & M_2 could be attributed to alteration in land configuration by providing moisture conserving furrow + mulching and protective irrigation during long dry spell as compared to control. Apart from this, yield attributing parameters such as number of ear head per plant, number of productive tillers, 1000 seed weight and threshing percentage were significantly superior in M_1 (4.76, 5.18, 2.67 & 71.53 respectively) as compared to M_2 & M_3 (Table 17 & Table 18). Thus, owing to integrated effect of these yield parameters favorably influenced the grain yield of finger millet as well as straw yield. Differences observed in grain yield in finger millet due to different irrigation methods, production could be traced back to differences in dry matter production and its accumulation in different plant parts and relatively higher chlorophyll content was observed in alternate furrow irrigation with mulching at all the growth stages of plant.

Apart from the influence of growth and yield components uptake of nutrients also influenced the grain yield of finger millet, soil moisture conservation methods coupled with one protective irrigation helped the plant to take up higher amounts of macro nutrients which in turn helped for production of higher photosythates and its translocation from source to sink effectively.

Taking the obtained results in to consideration higher grain yield and net income in finger millet can be realized by adoption of in-situ soil moisture conservation practices along with application of recommended dose of fertilizers.

Conclusion

Better utilization and conservation of farm resources and yield sustainability of finger millet could be attained by adopting proper land configuration with recommended dose of fertilizers proved to be better in realizing higher yield in finger millet. Apart from this, both crop productivity and water productivity could be improved by storing the run off water in farm ponds and using the same during long dry spells / at critical crop growth stages as protective irrigation during *Kharif* in order to obtain higher grain yields.

Table 14: Effect of nitrogen sources and Moisture conservation practices with protective irrigation on plant height of finger millet at different growth stages.

Treatments	**Plant height (cm) at 45 DAP**				**Plant height (cm) at 90 DAP**				**Plant height (cm) at harvest**			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
N_1	70.5	64.4	52.2	**62.40**	102.3	97.1	85.4	**94.9**	107.3	102.1	92.2	**100.5**
N_2	67.5	54.3	51.2	**57.7**	98.2	88.8	83.3	**90.10**	101.2	93.8	88.3	**93.7**
N3	67.8	53.00	49.00	**56.60**	77.2	85.2	76.7	**86.4**	98.9	93.6	86.7	**93.8**
Mean	**68.6**	**57.3**	**50.8**	**58.9**	**99.2**	**90.4**	**81.8**	**90.5**	**102.5**	**96.5**	**89.1**	**96.0**
	S.Em. ±	**CD at 5%**		**CV (%)**	**S.Em. ±**	**CD at 5%**		**CV (%)**	**S.Em. ±**	**CD at 5%**		**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	1.82	7.146		9.27	0.993	3.901		3.29	1.235	4.851		3.86
Level of Nitrogen (N)	1.406	4.335		7.16	0.855	2.635		2.83	1.583	4.879		4.95
M at the same N	2.436	NS		-	1.480	NS		-	2.742	NS		-
N at the same or different M	2.696	NS		-	1.565	NS		-	2.557	NS		-

DAS: Days After Planting; **NS:** Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching

M_2: Moisture Conservation furrow + Protective Irrigation

M_3: Control

N_1: Recommended dose of fertilizers

N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

N_3: 50% recommended N through glyricidia manure+50% N through fertilize and Recommended P_2O_5 and K_2O

Table 15: Effect of nitrogen sources and moisture conservation practices with protective irrigation on chlorophyll content of finger millet at different growth stages.

Treatments	Chlorophyll content at 45 DAP				Chlorophyll content at 90 DAP				Chlorophyll content at harvest			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
N_1	40.13	37.20	36.23	**37.86**	42.77	40.67	35.53	**39.56**	20.57	18.47	16.93	**18.66**
N_2	37.90	36.53	35.33	**36.59**	40.27	38.67	30.33	**36.42**	18.10	17.87	16.00	**17.32**
N3	36.10	35.70	34.00	**36.27**	38.00	37.40	30.00	**35.13**	18.10	18.00	15.60	**17.23**
Mean	**38.04**	**36.48**	**35.19**	**36.57**	**40.34**	**38.91**	**31.96**	**37.07**	**18.92**	**18.11**	**16.18**	**17.74**

	S.Em. ±	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.208	0.816	1.70	0.314	1.233	2.54	0.324	1.271	5.48
Level of Nitrogen (N)	0.579	1.784	4.75	0.530	1.633	4.29	0.329	1.013	5.56
M at the same N	1.002	NS	NS	0.917	NS	-	0.569	NS	-
N at the same or different M	0.844	NS	NS	0.812	NS	-	0.567	NS	-

DAP: Days After Planting; **NS:** Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching

M_2: Moisture Conservation furrow + Protective Irrigation

M_3: Control

N_1: Recommended dose of fertilizers

N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

N_3: 50% recommended N through glyricidia manure+50% N through fertilize and Recommended P_2O_5 and K_2O

Table 16: Effect of nitrogen sources and moisture conservation practices with protective irrigation on dry matter accumulation of finger millet at different parts.

Treatments	DMA in Leaf (g/plant)				DMA in Stem (g/plant)				DMA in Ear head (g/plant)				TDMA (g/plant)			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
N_1	16.40	15.53	12.73	**14.90**	37.40	33.20	28.10	**32.90**	32.33	29.65	23.60	**28.53**	86.13	78.39	64.43	**76.32**
N_2	14.80	14.33	11.57	**13.57**	33.80	30.73	25.84	**30.13**	30.20	28.17	21.53	**26.64**	78.80	73.24	58.97	**70.34**
N_3	14.4	13.93	10.41	**12.92**	31.60	29.67	24.73	**28.67**	30.29	27.93	19.73	**25.98**	76.29	71.53	54.88	**67.57**
Mean	**15.2**	**14.60**	**11.57**	**13.79**	**34.27**	**31.20**	**26.23**	**30.57**	**30.94**	**28.59**	**21.62**	**27.05**	**80.41**	**74.39**	**59.43**	**71.41**

	S.Em. ±	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.235	0.924	5.12	0.810	3.183	7.95	0.336	1.319	3.72	0.935	3.670	3.93
Level of Nitrogen(N)	0.207	0.637	4.50	0.559	1.724	5.49	0.425	1.309	4.71	0.797	2.455	3.35
M at the same N	0.358	NS	-	0.969	NS	-	0.736	NS	-	1.380	NS	-
N at the same or different M	0.375	NS	-	1.132	NS	-	0.688	NS	-	1.464	NS	-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching

M_2: Moisture Conservation furrow + Protective Irrigation

M_3: Control

N_1: Recommended dose of fertilizers

N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

N_3: 50% recommended N through glyricidia manure+50% N through fertilize and Recommended P_2O_5 and K_2O and Recommended P_2O_5 and K_2O

Table 17: Effect of nitrogen sources and Moisture conservation practices with protective irrigation on yield components and yield of finger millet

Treatments	Number of tillers/plant				Number of Ear heads/plant				Finger millet grain yield (kg /ha)				Finger millet straw yield (kg /ha)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
N_1	5.70	5.20	4.37	5.10	5.15	4.62	3.12	4.28	4074	3605	2814	3498	7086	6605	4568	6086
N_2	5.01	4.60	3.87	4.51	5.40	4.15	2.82	3.87	3827	3234	2271	3111	6420	6049	4074	5514
N3	4.77	4.50	3.87	4.38	5.15	3.75	2.62	3.63	3457	2864	1802	2708	6370	5945	3889	5412
Mean	5.18	4.77	4.03	4.66	4.76	4.17	2.85	3.93	3786	3235	2296	3106	6625	6210	4177	5671

Treatments	S.Em. ±	CD at 5%	CV (%)	S.Em. ±	CD at5%	CV (%)	S.Em. ±	CD at 5%	CV (%)	S.Em. ±	CD at 5%	CV (%)
Moisture conservation practices with Protective Irrigation (M)	0.092	0.359	5.89	0.194	0.762	14.82	209.11	821.14	20.20	140.89	553.26	7.45
Level of Nitrogen (N)	0.153	0.472	9.87	0.135	0.417	10.33	157.32	484.90	15.20	157.67	485.97	8.34
M at the same N	0.266	NS	-	0.234	NS	-	272.49	NS	-	273.09	NS	-
N at the same or different M	0.235	NS	-	0.272	NS	-	305.33	NS	-	263.76	NS	-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching

M_2: Moisture Conservation furrow + Protective Irrigation

M_3: Control

N_1: Recommended dose of fertilizers

N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

N_3: 50% recommended N through glyricidia manure+50% N through fertilize and Recommended P_2O_5 and K_2O

Table 18: Effect of nitrogen sources and moisture conservation practices with protective irrigation on 1000 seed weight and threshing percentage of finger millet

Treatments	1000 seed weight (g)				Threshing percentage (%)			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
N_1	2.87	2.70	2.43	**2.82**	73.23	70.60	65.16	**69.66**
N_2	2.80	2.76	2.37	**2.73**	71.53	68.40	60.33	**66.75**
N3	2.80	2.73	2.33	**2.38**	69.83	65.80	54.58	**63.40**
Mean	**2.67**	**2.64**	**2.62**	**2.64**	**71.53**	**68.26**	**60.02**	**66.60**

	S.Em. ±	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.062	0.243	7.02	1.30	5.10	5.86
Level of Nitrogen (N)	0.039	NS	4.04	1.21	3.74	5.47
M at the same N	0.067	NS	-	2.10	NS	-
N at the same or different M	0.083	NS	-	2.15	NS	-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilize and Recommended P_2O_5 and K_2O

Table 19: Effect of nitrogen sources and moisture conservation practices with protective irrigation on Nitrogen (N) uptake in leaf, stem, grain and plant of finger millet

Treatments	N uptake in leaf (g)				N uptake in stem (g)				N uptake in grain (g)				N uptake in plant (g)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
N_1	27.66	25.00	20.66	24.44	20.66	19.00	14.66	18.11	52.66	50.00	44.66	49.11	101.0	94.0	80.0	94.6
N_2	25.00	22.33	19.33	22.22	18.66	17.33	12.00	16.00	49.33	47.33	43.33	46.66	93.0	87.0	74.6	88.8
N3	24.00	22.00	17.66	21.22	17.33	17.00	11.33	15.22	48.66	46.66	41.33	45.55	90.0	85.66	70.3	75.0
Mean	25.55	23.11	19.22	22.63	18.89	17.77	12.66	16.44	50.22	48.00	43.11	47.11	91.6	84.8	82.0	86.1

	S.Em. ±	CD at 5%	CV (%)	S.Em. ±	CDat5%	CV (%)	S.Em. ±	CD at 5%	CV (%)	S.Em. ±	CD at 5%	CV (%)
Moisture conservation practices with Protective Irrigation (M)	0.42	1.68	5.67	0.314	1.23	5.73	0.458	1.79	2.92	0.792	3.11	2.76
Level of Nitrogen (N)	0.66	2.05	8.84	0.625	1.97	11.41	0.568	1.75	3.62	1.337	4.12	4.65
M at the same N	1.15	NS	-	1.083	NS	-	0.984	NS	-	2.316	NS	
N at the same or different M	1.03	NS	-	0.938	NS	-	0.925	NS	-	2.050	NS	

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilize and Recommended P_2O_5 and K_2O

Table 20: Effect of nitrogen sources and moisture conservation practices with protective irrigation on Phosperous uptake in leaf, stem, grain and plant of finger millet

Treatments	P uptake in leaf (g)				P uptake in stem (g)				P uptake in grain (g)				P uptake in plant (g)			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
N_1	7.32	6.86	5.69	6.63	4.26	3.75	3.09	3.70	11.81	10.98	9.32	10.7	23.40	21.60	18.11	21.03
N_2	6.90	6.39	5.09	6.13	3.86	3.37	2.65	3.29	10.93	10.11	8.82	9.95	21.69	19.87	16.57	19.38
N3	6.66	6.07	4.73	5.82	3.70	3.15	2.57	3.14	10.50	9.92	8.81	9.74	20.86	19.15	16.11	18.71
Mean	696	6.44	5.17	6.19	3.94	3.42	3.77	3.18	11.08	10.34	8.98	10.13	21.98	20.21	16.93	19.71

	S.Em. ±	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.219	0.86	10.6	0.196	0.77	17.43	0.164	0.64	4.85	0.373	1.46	5.67
Level of Nitrogen (N)	0.189	0.58	9.17	0.116	0.35	10.46	0.241	0.74	7.13	0.413	1.27	6.28
M at the same N	0.328	NS	-	0.200	NS	-	0.417	NS	-	0.715		
N at the same or different M	0.346	NS	-	0.256	NS	-	0.378	NS	-	0.693		

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching

M_2: Moisture Conservation furrow + Protective Irrigation

M_3: Control

N_1: Recommended dose of fertilizers

N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

N_3: 50% recommended N through glyricidia manure+50% N through fertilize and Recommended P_2O_5 and K_2O

Table 21: Effect of nitrogen sources and method of irrigation on Potassium uptake in leaf, stem, grain and plant of finger millet

Treatments	K uptake in leaf (g)				K uptake in stem (g)				K uptake in grain (g)				K uptake in plant (g)			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
N_1	18.23	17.00	14.93	16.72	13.04	10.32	9.07	10.81	37.66	35.00	29.66	34.11	68.93	62.32	53.67	61.64
N_2	16.99	16.73	13.95	15.89	11.85	9.54	8.40	9.93	34.33	32.33	28.33	31.66	63.18	58.60	50.69	57.49
N3	16.66	16.22	13.03	15.30	11.04	9.17	8.15	9.45	33.33	31.00	26.33	30.22	61.04	56.39	47.51	54.98
Mean	17.29	16.65	13.97	15.97	11.98	9.67	8.54	10.06	35.11	32.77	28.11	32.00	64.38	59.10	50.62	58.04

	S.Em. ±	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**	**S.Em. ±**	**CD at 5%**	**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.288	1.12	5.40	0.325	1.27	9.68	0.351	1.38	3.29	0.491	1.93	2.54
Level of Nitrogen (N)	0.262	0.80	4.91	0.317	0.97	9.44	0.521	1.60	4.89	0.797	2.45	4.12
M at the same N	0.453	NS	-	0.549	NS	-	0.903	NS	-	1.381		
N at the same or diff. M	0.469	NS	-	0.554	NS	-	0.816	NS	-	1.230		

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Poultry manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilize and Recommended P_2O_5 and K_2O

Experiment-3 (2009-10)

"*Studies on utilization efficiency of harvested water through different methods and levels of irrigation for french bean (Phaseolus vulgaris) production in Alfisols* "

OBJECTIVES:

1. To know the effect of irrigation methods on growth and yield of french bean
2. To Validate the influence of irrigation levels on growth and yield of french bean
3. To know the performance of french bean growth and yield under integrated nutrient sources
4. To know the interaction effect of methods of irrigation, levels of irrigation and sources of nutrients on yield and quality of french bean
5. To work out nutrient and water balance in french bean production in *Alfisols*
6. To work out economics of french bean production under dry land condition

Experiment details:

Plot size: 4.5 m x 2.4 m (10.80 m^2)
Crop: French bean Variety: Arka Suvidha
Recommended Does of Fertilizer : 63:100:75 kg NPK ha^{-1}
No. of Replications: Three
Date of Sowing: 1.10.09
Date of mulching: 28.10.2009
Date of harvesting: 1st Picking – 23rd & 24th .11.2009
2nd Picking- 04.12.2009
Poultry manure : 1.15 kg/plot
Glyricidia : 1.25 kg/plot
Depth of irrigation: 4 cm or 40 mm rain fall

Details of micro-sprinkler and irrigation.

1. *Pump discharge at pump point* : 50 lit/second.
2. *Pump discharge at Field pipe end* : 3.0 lit/second.

1).SPAD / Chlorophyll meter reading: (SPAD: Soil and Plant Analysis Division of Minolta): In French bean fully expanded trifoliate leaves were chosen for recording chlorophyll content. The leaves which are nearer to flower bearing axils/pod bearing axils were chosen for estimation of chlorophyll content. The leaf blade of french bean plant was placed in between the sample slot and observations were recorded. From each leaf, 5 observations were recorded at different locations and from each plant total 30-observations were recorded. Thus, from each treatment 90 observations were recorded and their mean was worked out.

Total quantity of water applied for each plot at each time ranged from 540 -600 lit. Totally 6 irrigations were providing including two irrigations for establishment of french bean.

Rainy days: 10.10. 2010 (12.10 mm)
19.10. 2010 (23.6 mm).

Irrigation at critical stages

1. 05.10.2009 - Establishment
2. 20.10.2009 - Branching
3. 29.10.2009 - Flowering
4. 09.11.2009 - pod formation
5. 21.11.2009 - pod development
6. 01.12.2009 - pod development

0.9 IW: CPE ratio   Depth of irrigation = 4 cm

$$CPE = \frac{\text{Depth of irrigation}}{\text{I W: CPE}} = \frac{4\ \text{cm}}{0.9} = 4.44 \text{ cm } 44.4 \text{ mm}$$

CPE: Cumulative Pan Evaporation
IW: Irrigation water
So, next irrigation is to be scheduled when CPE reaches 44.4 mm.

Treatment details:

I. MAIN PLOTS: Methods of irrigation (M)

M_1 (Furrow irrigation),
M_2 (Alternate Furrow irrigation)
M_3 (Micro sprinkler)

II. SUB-PLOT: Levels of irrigation (L):

L_1 (At IW: CPE ratio of 0.9)
L_2 (At critical stages)

III. SUB–SUB PLOT: Sources of nutrients (N):

N_1: 100% RDN through Fertilizer
N_2: 50% RDN through Poultry manure + 50% through Fertilizer
N_3: 50% RDN through Glyricidia + 50% through Fertilizer

Treatment Interactions: (18)

1. $M_1L_1N_1$	7. $M_2L_1N_1$	13. $M_3L_1N_1$
2. $M_1L_1N_2$	8. $M_2L_1N_2$	14. $M_3L_1N_2$
3. $M_1L_1N_3$	9. $M_2L_1N_3$	15. $M_3L_1N_3$
4. $M_1L_2N_1$	10. $M_2L_2N_1$	16. $M_3L_2N_1$
5. $M_1L_2N_2$	11. $M_2L_2N_2$	17. $M_3L_2N_2$
6. $M_1L_2N_3$	12. $M_2L_2N_3$	18. $M_3L_2N_3$

Observations:

- Periodic observation on growth, yield and yield attributing characters
- Nutrient uptake by crop at harvest (N, P & K)

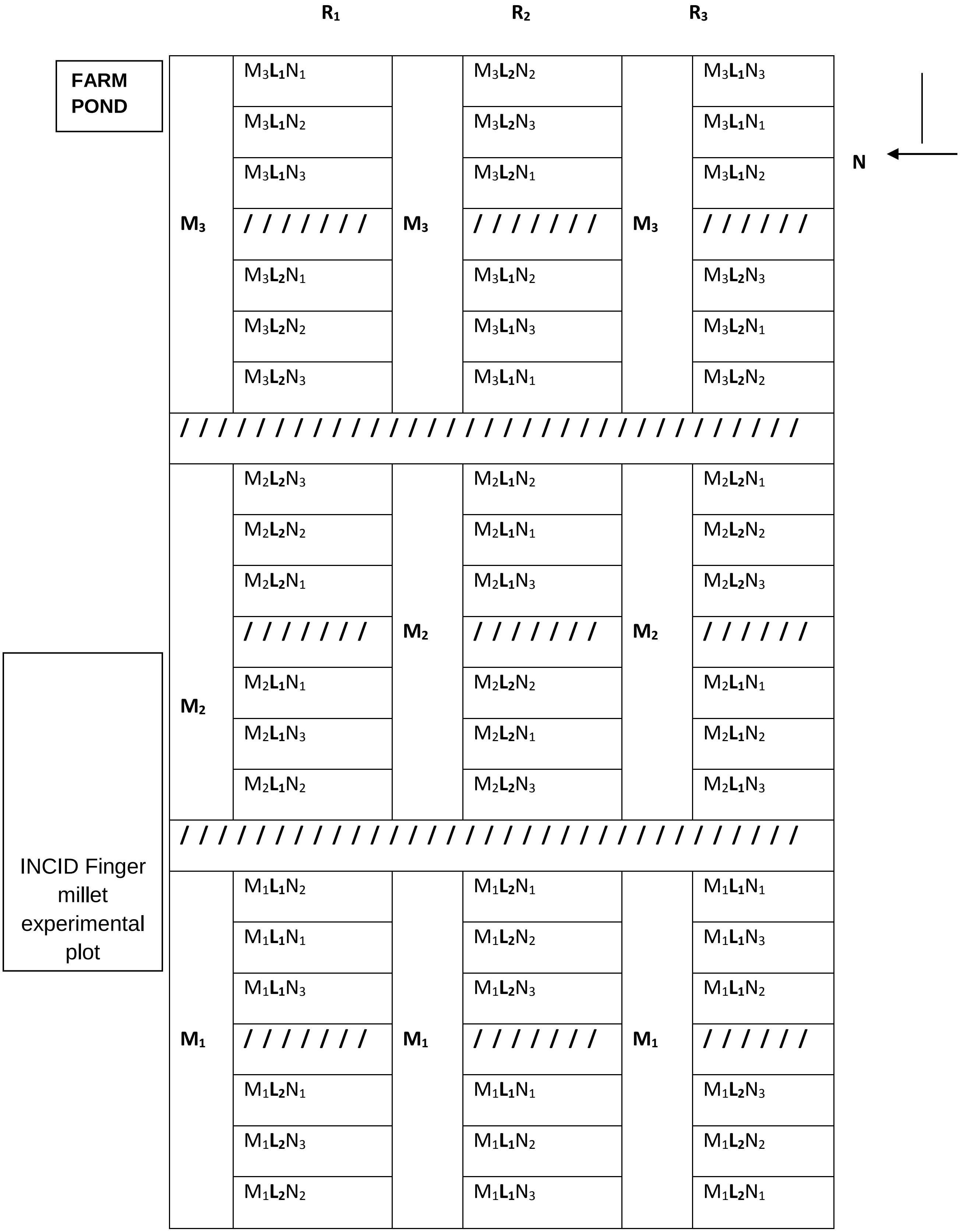

Fig. 8: Plan and layout of experiment

Material and Methods:

The experiment is laid out in split-split plot design with two replications. The land is ploughed twice with cultivator and one harrowing to bring it into fine tilth. The main plot treatments consist of methods of irrigations, sub plots with time/level of irrigation and sources of nutrients in sub-sub plot treatments. There are 36 treatment combinations with interactions. The french bean crop cv. Arka Suvidha is selected for testing. The entire experimental site is divided into three blocks across the slope. The three methods of irrigation are allotted randomly to each block. Each block is divided into three sub blocks that is equal to number of sub plots. The treatments *viz.,* time/level of irrigation was allotted randomly to each sub plots. Then each sub plot is divided into three sub-sub plots wherein the treatments of sources of nutrients are allotted randomly.

The french bean seeds were treated with *Trichoderma viridae* @ 10g/kg seeds and they were sown at a row spacing of 75 cm and 30 cm intra row with two seedlings planted per hill. Each plot size is 4.5 m x 4.5 m with a minimum of six rows of french bean. Organic manures were applied 21 days before sowing and inorganic sources of nutrients supplied at the time of sowing. Fifty per cent of the recommended dose of nitrogen in the form of inorganic fertilizers is applied at the time of planting, while remaining 50 per cent at 30 DAT. The intercultivation was done as per the package of practices

Two micro-sprinklers were installed per plot which has a discharge rate of 3lt/hr. Water harvested in the farm ponds was lifted by using diesel engine and same was supplied to experimental plot with micro-sprinkles.

Furrows were opened in between the plant rows and they were mulched using dried straw @ 6-7 kg/ plot and irrigation treatments were imposed as per main plot and sub-plot treatments.

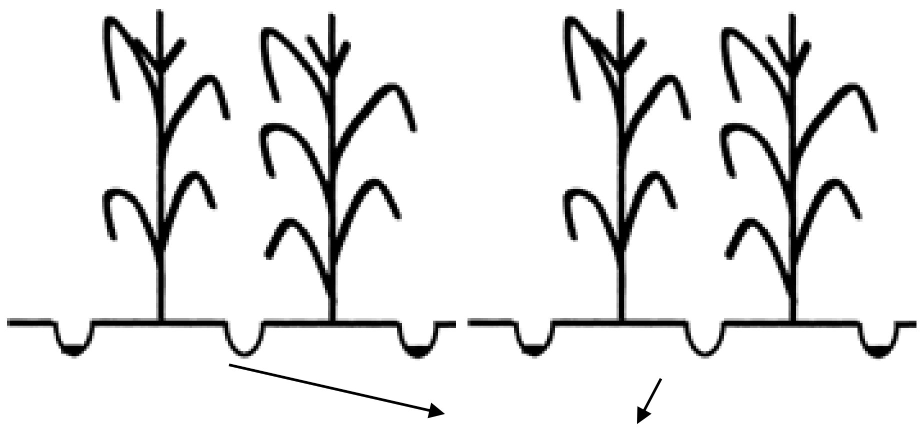

Fig. 9: Alternate furrow irrigation

Taking sub-plot treatments in to consideration, irrigation was provided to crop when pan evapo meter reading reaches 55.5mm (SI) and at critical stages of crop (S2) Viz., branching, flowering, pod development stages.

Table 22: Nutrient composition of different organic manures used in the experiment

Sl. No.	Organic manure	Nutrient composition (%)		
		N	P_2O_5	K_2O
1	Poultry Manure	2.9	2.9	2.4
2	Glyricidia green manure	2.2	0.3	4.6

Results and Discussion

Results of the field experiment "Effect of different methods of irrigation and sources of nitrogen on growth and yield of French bean" conducted at the Dry Land Agriculture Centre, UAS, GKVK, Bengaluru during late *kharif* 2009-10 by utilizing stored/harvested rain water are presented below.

The experimental site is situated at 12^0 58' N and 13^0 5' N latitude and 77^0 35' E and 77^0 34' E longitude at an altitude of 930 meters above the mean sea level Eastern Dry Zone (Zone-5) of Karnataka. The rainfall received during the crop growth period was 310.9 mm in 18 rainy days (Appendix-1). The mean maximum and minimum temperature ranged between 22.8 ^{0}C and 31.0^{0}C and 14.2 ^{0}C and 20.0^{0}C respectively. The relative humidity during the crop growth period was ranged between 74% to 98%.

Plate 5: French bean production though micro-sprinklers by recycling harvested farm pond water

French bean responded differently to methods of irrigation at all the growth stages of crop. Among growth components progressive increase in plant height was noticed in plots receiving irrigation through micro-sprinklers (20.1 cm and 28.6 cm during 45th and at harvest respectively) as compared to furrow irrigation and alternate furrow irrigation (Table 23). Similarly, higher number of branches per plant was noticed in treatment receiving furrow irrigation and micro- sprinkler irrigation (2.67, 2.60 and 3.67 and 3.60 during 45 DAS and at harvest respectively) as compared to alternate furrow irrigation (Table 24). Similar trends were noticed with respect to dry matter production and its distribution in to different plant parts at harvest. Among different methods of irrigation, micro-sprinklers recorded significantly higher dry matter accumulation in leaf, stem and in pods at harvest (2.91, 6.78 and 14.28 g plant $^{-1}$ respectively) as compared to furrow irrigation and alternate furrow irrigation (Table 26&27). On the contrary, Method of irrigation did not influenced on chlorophyll content at 45 DAS and at harvest (Table 25). The combined impact of higher DMA in leaf, stem and at reproductive part at harvest helped the french bean plants to attain higher total dry matter production per plant at harvest (23.73 g plant $^{-1}$) as compared to other methods of irrigation (Table 27)

Stage of irrigation had significant impart on growth components of french bean through out the crop growth. Providing irrigation at 0.9 IW: CPE recorded significantly better growth components viz., plant height, number of branches, dry matter production and distribution in to different plant parts and chlorophyll content at 45 DAS and at harvest (Table 23 to 27).

Higher plant height, number of branches and chlorophyll content was recorded in S_1 (irrigation at 0.9 IW: CPE ratio) at all the growth stages as compared to irrigating at critical stages (S_2). Irrigating french bean at 0.9: IW: CPE ratio recorded higher plant height (20.2 cm and 29.2 cm at 45 DAS and harvest respectively) and number of branches (2.7 and 3.71) at 45 DAS and at harvest respectively). At harvest, significantly higher dry matter accumulation was noticed in leaf, stem and at pods where plots were provided with irrigation at 0.9 IW: CPE ratio (2.96, 7.24 and 14.34 g plant $^{-1}$

respectively). This variation was noticed in dry matter partitioning had ultimately resulted in 64.88% higher total dry matter accumulation (24.53 g plant $^{-1}$) in S_1 as compared to irrigating plots at critical stages of irrigation. Similar trend of observation was noticed with respect to chlorophyll content at 45 DAS and at harvest. Higher chlorophyll content was observed in S_1 (28.69 and 24.01 at 45 DAS and at harvest respectively) as compared to S_2 (Table 25).

Stage of irrigation also had significant impact on uptake of nutrients. Relatively higher nutrient uptake of N, P, and K in leaf, stem, and pod were recorded due to irrigating french bean at 0.9 IW: CPE ratio as compared to S_2.

Application of nitrogen through different sources had recorded significant variation in plant growth parameters. Higher plant height was noticed in treatment where 100% RDN was applied through fertilizer (N_1) as compared to N_2 and N_3 at all the growth stages (20.6 cm and 29.4 cm respectively) at 45 DAS and at harvest. Similarly, higher number of braches/plant at 45 DAS (3.05) and at harvest (4.06) was observed in $N_{1.}$ Positive response was observed with respect to chlorophyll content and application of 100% RDN through fertilizer at 45 DAS (29.16) and at harvest (27.15) as compared application of RDN in combination with organic source (N_2 and N_3). These variations in plant height, number of branches and chlorophyll content had helped to accumulate higher total dry matter per plant and dry matter in different plat parts

Higher dry matter accumulation was noticed in leaf, stem and pods at harvest, (2.91, 6.49, 13.22 g plant $^{-1}$ respectively) due to application of 100% RDN through fertilizer as compared to other irrigated treatments. On the contrary, variation was noticed among growth component of french bean plants among the N_2 and N_3 where 50% of RDN was supplied through poultry manure and glyricidia. Due to better dry matter accumulation and distribution in french bean plants where 100% RDN was applied with fertilizer recorded significantly higher total dry matter per plant (22.63 plant $^{-1}$) as compared to N_2 and N_3.

Methods of irrigation had recorded significant difference with respect to bean yield. Higher green bean yield (9290 kg ha^{-1}) was obtained in treatment receiving irrigation by micro-sprinkler. The higher yield is a cumulative effect of yield components viz., number of beans per plant and yield per plant. Relatively higher number of beans per plant (17.48) and yield per plant (76.56 g plant^{-1}) was observed in M_3 (micro-sprinkler). So better yield and yield components are the result of better growth components viz., plant height, number of branches, dry matter production and its distribution in to different plant parts at various sages of plant growth were observed in treatment receiving irrigation through micro-sprinkler.

Significant variation was observed with respect to stage of irrigation. French bean plants responded positively for providing irrigation at 0.9 IW: CPE ratio and recorded higher bean yield (9754 kg/ha) as compared to providing irrigation at critical stages for irrigation (Table 28). Similar trend was noticed with respect to number of beans per plant (18.33/plant) and yield per plant (79.24 g plant^{-1}).

Application of Nitrogen (100% RDN) through fertilizer recorded higher green bean yield (9374 kg ha^{-1}) as compared to N_2 and N3. The trend was similar in number of beans per plant (17.02) and yield per plant (73.33g/plant). Better performance of french bean plant and attaining high yield in N_2 is a cumulative effect of better growth and yield components observed during different growth phases.

Differential response of french bean plants to different methods of irrigation, stages of irrigation and sources of nitrogen was found to be non significant.

Application of 100% RDN through fertilizer had significant effect with respect to uptake of plant nutrients (Table 29 to 34). Significantly higher nitrogen, phosphorus and potassium content in leaf (38.65, 5.06, and 26.00 1g ha^{-1} respectively) stem (18.82, 2.42 and 15.50 kg ha^{-1} respectively) and in pod (55.53, 9.17 and 45.33 kg ha^{-1} respectively) were observed in treatment receiving 100% RDN through fertilizer. Similarly, total dry matter production per plant was higher in N_1 (100% RDN through fertilizer) as compared to N_2 and N3.

Table 23: Effect of nitrogen sources, irrigation levels and methods of irrigation on plant height of french bean at different growth stages.

Stages of Irrigation (S)	**Method of irrigation (M)**							
	Plant height (cm) at 45 DAS				Plant height (cm) at harvest			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	23.7	18.0	17.3	**19.7**	31.3	27.9	26.0	**28.4**
S_2 Critical Stage approach	17.0	16.3	16.3	**16.7**	27.7	25.3	25.0	**26.0**
Mean	**20.3**	**17.1**	**16.8**	**18.0**	**29.5**	**26.6**	**25.5**	**27.2**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	22.0	17.2	16.1	**18.4**	29.9	28.2	26.5	**28.2**
S_2 Critical Stage approach	17.5	16.	16.0	**16.6**	26.3	24.7	23.3	**24.8**
Mean	**19.7**	**16.8**	**16.1**	**17.5**	**28.1**	**26.5**	**25.0**	**26.5**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	25.2	22.0	20.0	**22.4**	34.4	30.0	28.3	**30.9**
S_2 Critical Stage approach	18.3	18.0	17.0	**17.9**	27.0	26.5	25.7	**26.2**
Mean	**21.8**	**20.0**	**18.5**	**20.1**	**31.0**	**28.2**	**26.8**	**28.6**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	23.6	19.0	17.8	**20.2**	31.9	28.7	26.9	**29.2**
S_2 Critical Stage approach	17.6	16.9	16.5	**17.0**	27.0	25.5	24.5	**25.7**
Mean	**20.6**	**18.0**	**17.2**	**18.6**	**29.4**	**27.1**	**25.7**	**27.4**
For Comparing means of	SEm±	CV (%)	CD at 5%		SEm±	CV (%)	CD at 5%	
Method of Irrigation **(M)**	0.278	6.43	1.091		0.420	6.50	1.649	
Stages of Irrigation **(S)**	0.213	5.95	0.736		0.289	5.48	1.00	
Nitrogen Source **(N)**	0.337	7.69	0.983		0.458	7.09	1.337	
M x S	0.381		NS		0.549		NS	
S x N	0.443		NS		0.603		NS	
M x N	0.584		NS		0.793		NS	
M x S x N	0.768		NS		2.847		NS	

Table 24: Effect of nitrogen sources, irrigation levels and methods of irrigation on number of branches of french bean at different growth stages.

Stages of Irrigation (S)	**Method of irrigation (M)**							
	Number of Branches at 45 DAS				Number of Branches at Harvest			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	3.3	2.5	2.3	**2.7**	4.27	3.53	3.27	**3.69**
S_2 Critical Stage approach	3.1	2.5	2.3	**2.64**	4.13	3.53	3.27	**3.64**
Mean	**3.2**	**2.5**	**2.3**	**2.67**	**4.20**	**3.53**	**3.27**	**3.67**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	3.0	2.5	2.3	**2.58**	4.0	3.47	3.27	**3.58**
S_2 Critical Stage approach	2.7	2.3	2.1	**2.36**	3.67	3.27	3.13	**3.35**
Mean	**2.83**	**2.4**	**2.2**	**2.47**	**3.83**	**3.37**	**3.20**	**3.47**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	3.6	2.6	2.4	**2.87**	4.6	3.6	3.4	**3.87**
S_2 Critical Stage approach	2.7	2.3	2.1	**2.33**	3.67	3.3	3.10	**3.33**
Mean	**3.13**	**2.43**	**2.23**	**2.60**	**4.13**	**3.43**	**3..23**	**3.60**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	3.3	2.5	2.3	**2.7**	4.29	3.53	3.31	**3.71**
S_2 Critical Stage approach	2.8	2.35	2.16	**2.4**	3.82	3.36	3.16	**3.44**
Mean	**3.05**	**2.44**	**2.23**	**2.58**	**4.06**	**3.44**	**3.23**	**3.58**
For Comparing means of	SEm±		CV (%)	CD at 5%	SEm±		CV (%)	CD at 5%
Method of Irrigation **(M)**	0.018		2.89	0.069	0.026		3.09	0.102
Stages of Irrigation **(S)**	0.041		8.31	0.143	0.049		7.08	0.169
Nitrogen Source **(N)**	0.035		5.73	0.138	0.042		4.94	0.122
M x S	0.053		-	NS	0.084		-	NS
S x N	0.058		-	NS	0.069		-	NS
M x N	0.071		-	NS	0.072		-	NS
M x S x N	0.231		-	NS	0.279		-	NS

Table 25: Effect of nitrogen sources, irrigation levels and methods of irrigation on chlorophyll content of french bean at different growth stages.

Stages of Irrigation (S)	Method of irrigation (M)							
	Chlorophyll meter reading at 45 DAS				Chlorophyll meter reading at harvest			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	30.77	27.30	26.73	**28.27**	28.77	25.30	24.73	**26.27**
S_2 Critical Stage approach	27.90	27.06	26.17	**27.04**	25.90	25.07	24.17	**25.04**
Mean	**29.33**	**27.18**	**26.45**	**27.45**	**27.33**	**25.18**	**24.45**	**25.66**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	29.77	27.47	26.93	**28.05**	27.77	25.47	27.93	26.06
S_2 Critical Stage approach	26.17	24.60	23.90	**24.88**	24.17	22.60	21.87	22.88
Mean	**27.97**	**26.03**	**25.4**	**26.46**	**25.97**	**24.03**	**23.40**	**24.47**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	32.10	29.10	28.00	**29.75**	30.10	27.10	26.03	**27.75**
S_2 Critical Stage approach	28.03	28.23	25.40	**26.12**	26.23	23.37	22.77	**24.12**
Mean	**30.17**	**27.23**	**26.40**	**27.93**	**28.17**	**25.23**	**24.40**	**25.93**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	30.88	27.95	27.23	**28.69**	28.88	25.96	25.23	**26.70**
S_2 Critical Stage approach	27.43	25.68	27.23	**24.93**	25.43	23.68	22.93	**24.01**
Mean	**29.16**	**26.82**	**26.08**	**27.35**	**27.15**	**24.82**	**24.08**	**25.35**

For Comparing means of	SEm±	CV (%)	CD at 5%	SEm±	CV (%)	CD at 5%
Method of Irrigation **(M)**	0.699	10.85	NS	0.590	9.88	NS
Stages of Irrigation **(S)**	0.413	7.85	1.43	0.324	6.63	1.12
Nitrogen Source **(N)**	0.354	5.49	1.03	0.247	4.13	0.720
M x S	0.715		NS	0.561		NS
S x N	0.581		NS	0.431		NS
M x N	0.613		NS	0.604		NS
M x S x N	2.869		NS	2.024		NS

Table 26: Effect of nitrogen sources, irrigation levels and methods of irrigation on DMA of french bean at different growth stages.

Stages of Irrigation (S)	**Method of irrigation (M)**							
	DMA leaf (g)				DMA stem (g)			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	3.67	2.44	2.27	**2.79**	7.00	6.90	6.63	**6.844**
S_2 Critical Stage approach	2.53	2.20	2.0	**2.24**	5.60	4.00	3.47	**4.36**
Mean	**3.10**	**2.32**	**2.13**	**2.52**	**6.30**	**5.45**	**5.50**	**5.60**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	2.73	2.5	2.37	**2.53**	6.80	6.004.27	5.93	**6.24**
S_2 Critical Stage approach	2.17	1.5	1.43	**1.70**	4.53	5.14	3.93	**4.25**
Mean	**2.45**	**2.00**	**1.90**	**2.11**	**5.67**		**4.93**	**5.25**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	4.00	3.50	3.20	**3.57**	9.00	8.53	8.30	**8.62**
S_2 Critical Stage approach	2.4	2.23	2.14	**2.26**	6.00	4.80	4.00	**4.93**
Mean	**3.2**	**2.87**	**2.67**	**2.91**	**7.50**	**6.67**	**6.17**	**6.78**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	3.47	2.81	2.61	**2.96**	7.60	7.14	6.97	**7.24**
S_2 Critical Stage approach	2.37	1.98	1.86	**2.07**	5.38	4.36	3.80	**4.51**
Mean	**2.917**	**2.39**	**2.23**	**2.52**	**6.49**	**5.75**	**5.38**	**5.87**
For Comparing means of	SEm±	CV (%)	CD at 5%		SEm±	CV (%)	CD at 5%	
Method of Irrigation **(M)**	0.121	20.46	0.476		0.29	20.98	1.141	
Stages of Irrigation **(S)**	0.038	7.86	0.132		0.224	19.85	0.77	
Nitrogen Source **(N)**	0.130	21.85	0.378		0.239	17.28	0.70	
M x S	0.066		NS		0.389		NS	
S x N	0.154		NS		0.356		NS	
M x N	0.224		NS		0.414		NS	
M x S x N	0.778		NS		1.636		NS	

Table 27: Effect of nitrogen sources, irrigation levels and methods of irrigation on DAM pod (g) and TDM (g) of French bean at different growth stages.

Stages of Irrigation (S)	**Method of irrigation (M)**							
	DAM pod (g)				TDM (g)			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	15.00	13.11	12.33	**13.48**	25.67	22.45	21.23	**23.12**
S_2 Critical Stage approach	9.93	8.80	8.50	**9.07**	118.07	15.00	13.93	**15.67**
Mean	**12.47**	**10.95**	**10.40**	**11.27**	**21.87**	**18.72**	**17.58**	**19.39**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	13.33	11.27	10.07	**11.56**	22.87	19.77	18.37	**20.33**
S_2 Critical Stage approach	9.07	8.20	7.77	**8.34**	15.77	13.97	13.13	**14.29**
Mean	**11.20**	**9.73**	**8.92**	**9.95**	**19.32**	**16.87**	**15.75**	**17.31**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	20.00	17.53	16.53	**18.02**	33.00	29.57	28.07	**30.12**
S_2 Critical Stage approach	12.00	10.53	9.10	**10.54**	20.40	17.57	15.24	**17.73**
Mean	**16.00**	**14.03**	**12.82**	**14.28**	**26.70**	**23.57**	**21.65**	**23.73**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	16.11	13.97	12.98	**14.35**	27.18	23.93	22.56	**24.53**
S_2 Critical Stage approach	10.33	9.18	8.44	**9.32**	18.08	15.51	14.10	**15.89**
Mean	**13.22**	**11.57**	**10.71**	**11.84**	**22.63**	**19.72**	**18.33**	**20.22**
For Comparing means of	SEm±	CV (%)	CD at 5%		SEm±	CV (%)	CD at 5%	
Method of Irrigation **(M)**	0.370	13.28	1.45		0.453	9.49	1.77	
Stages of Irrigation **(S)**	0.289	12.68	0.99		0.271	6.95	0.94	
Nitrogen Source **(N)**	0.402	14.42	1.174		0.487	10.22	1.42	
M x S	0.500		NS		0.469		NS	
S x N	0.547		NS		0.624		NS	
M x N	0.697		NS		0.843		NS	
M x S x N	2.535		NS		3.00		NS	

Table 28: Effect of nitrogen sources, irrigation levels and methods of irrigation on number of beans per plant, yield per plant and yield per hectare of french bean.

Stages of Irrigation (S)	Method of irrigation (M)											
	Number of Beans/plant				Yield/ plant (g)				Yield (kg/ha)			
	Nitrogen source (N)				**Nitrogen source (N)**				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
M_1 Furrow irrigation												
S_1 IW:CPE Ratio	19.67	17.67	17.33	18.22	88.30	75.53	71.67	78.51	10256	9414	9336	**9669**
S_2 Critical Stage approach	15.67	14.53	14.27	14.82	63.00	55.00	52.33	56.78	8568	8293	8071	**8311**
Mean	17.67	16.10	15.80	16.52	75.67	65.27	62.00	67.64	**9412**	**8853**	**8704**	**8980**
M_2 Alternate Furrow irrigation												
S_1 IW:CPE Ratio	17.60	16.73	16.27	16.87	75.33	62.33	59.67	65.78	9620	8898	8735	**9084**
S_2 Critical Stage approach	15.13	14.73	14.00	14.62	52.00	49.20	47.00	69.40	8241	7966	7395	**7867**
Mean	16.37	15.73	15.13	15.74	63.67	55.77	53.33	57.59	**8930**	**8432**	**8065**	**8475**
M_3 Micro sprinkler												
S_1 IW:CPE Ratio	21.27	19.67	18.73	19.89	108.3	87.67	84.33	93.44	11380	10154	9997	**10510**
S_2 Critical Stage approach	15.80	14.93	14.50	15.07	65.00	59.00	55.00	59.67	8179	8040	7990	**8070**
Mean	18.53	17.30	16.00	17.48	86.67	73.33	69.67	76.56	**9779**	**9097**	**8994**	**9290**
Stages of Irrigation and nitrogen source interaction over method of irrigation												
S_1 IW:CPE Ratio	19.51	18.02	17.44	18.33	90.67	75.18	71.89	79.24	10419	9489	9356	**9754**
S_2 Critical Stage approach	15.53	14.73	14.24	14.84	60.00	54.40	51.44	55.28	8329	8100	7819	**8083**
Mean	17.52	16.38	15.84	16.58	75.33	64.79	61.67	67.26	**9374**	**8794**	**8587**	**8919**

For Comparing means of	SEm±	CV (%)	CD at 5%	SEm±	CV (%)	CD at 5%	SEm±	CV (%)	CD at 5%
Method of Irrigation **(M)**	0.141	3.61	0.554	1.763	11.12	6.92	93.18	4.43	365.9
Stages of Irrigation **(S)**	0.133	4.16	0.459	2.645	20.43	9.15	67.39	3.93	233.3
Nitrogen Source **(N)**	0.102	2.62	0.299	2.471	15.59	7.21	133.09	6.33	388.5
M x S	0.230		NS	3.688		NS	116.72	-	NS
S x N	0.251		NS	3.494		NS	167.81	-	NS
M x N	0.177		NS	4.280		NS	124.78	-	NS
M x S x N	0.769		NS	16.27		NS	790.18	-	NS

Table 29: Effect of nitrogen sources, irrigation levels and methods of irrigation on N uptake in leaf and stem of french bean at different growth stages.

Stages of Irrigation (S)	Method of irrigation (M)							
	N uptake leaf				N uptake stem			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	40.77	37.30	36.73	**38.27**	20.43	16.97	16.40	**17.93**
S_2 Critical Stage approach	37.90	36.73	34.83	**36.15**	17.90	16.73	15.17	**16.60**
Mean	**39.33**	**36.52**	**35.78**	**37.21**	**19.17**	**16.85**	**15.78**	**17.27**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	38.10	36.90	36.27	**37.09**	19.77	16.80	16.60	**17.72**
S_2 Critical Stage approach	35.5	32.9	32.5	**33.65**	15.17	14.27	13.87	**14.43**
Mean	**36.8**	**34.92**	**34.40**	**3.5.37**	**17.47**	**15.53**	**15.23**	**16.08**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	42.10	39.10	37.37	**39.52**	22.10	19.10	18.04	**19.74**
S_2 Critical Stage approach	37.57	35.37	34.77	**35.90**	17.57	15.37	14.77	**15.90**
Mean	**39.83**	**37.23**	**36.07**	**37.71**	**19.83**	**17.23**	**16.40**	**17.82**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	40.32	37.77	36.79	**38.29**	20.77	17.62	17.01	**18.47**
S_2 Critical Stage approach	36.99	34.68	34.04	**35.24**	16.88	15.45	14.60	**15.64**
Mean	**38.65**	**36.22**	**35.42**	**35.76**	**18.82**	**16.54**	**15.80**	**17.50**
For Comparing means of	SEm±	CV (%)	CD at 5%		SEm±	CV (%)	CD at 5%	
Method of Irrigation **(M)**	0.805	9.29	NS			10.63	NS	
Stages of Irrigation **(S)**	0.284	4.01	0.983		0.333	10.15	1.15	
Nitrogen Source **(N)**	0.342	3.95	0.999		0.319	7.94	0.93	
M x S	0.492		NS		0.577		NS	
S x N	0.487		NS		0.497		NS	
M x N	0.593		NS		0.533		NS	
M x S x N	2.852		NS		2.269		NS	

Table 30: Effect of nitrogen sources, irrigation levels and methods of irrigation on N uptake in pods and total N uptake plant of french bean at different growth stages.

Stages of Irrigation (S)	Method of irrigation (M)							
	N uptake pods				Total N uptake plant			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	58.43	52.63	52.73	**54.60**	119.63	106.90	105.87	**110.80**
S_2 Critical Stage approach	53.90	51.73	50.83	**52.16**	109.70	104.20	100.83	**104.91**
Mean	**56.17**	**52.18**	**51.78**	**53.38**	**114.67**	**105.55**	**103.35**	**107.86**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	54.10	52.90	51.60	**52.87**	111.97	106.60	104.47	**107.68**
S_2 Critical Stage approach	51.50	49.93	47.87	**49.43**	102.17	96.13	94.27	**97.52**
Mean	**52.80**	**50.92**	**49.73**	**51.15**	**107.07**	**101.37**	**99.37**	**102.60**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	61.13	55.10	53.3100.707	**56.53**	125.33	113.3	108.77	**115.80**
S_2 Critical Stage approach	52.90	49.99	47.87107.00	**50.24**	108.03	100.70	97.40	**102.04**
Mean	**57.02**	**52.53**	**50.62**	**53.39**	**116.60**	**107.00**	**103.08**	**108.92**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	57.89	53.54	52.57	**54.67**	118.98	108.93	106.37	**114.43**
S_2 Critical Stage approach	52.77	50.21	48.85	**50.61**	106.63	100.34	97.50	**101.49**
Mean	**55.33**	**51.88**	**50.71**	**52.64**	**112.80**	**104.64**	**101.93**	**106.46**

For Comparing means of	SEm±	CV (%)	CD at 5%	SEm±	CV (%)	CD at 5%
Method of Irrigation **(M)**	0.777	6.26	NS	1.839	7.33	NS
Stages of Irrigation **(S)**	0.515	5.08	1.78	1.030	5.03	3.56
Nitrogen Source **(N)**	0.389	3.14	1.13	0.862	3.44	2.51
M x S	0.892		NS	1.784		NS
S x N	0.683		NS	1.432		NS
M x N	0.674		NS	1.493		NS
M x S x N	3.248		NS	7.221		NS

Table 31: Effect of nitrogen sources, irrigation levels and methods of irrigation on p uptake in leaf and stem of french bean at different growth stages.

Stages of Irrigation (S)	**Method of irrigation (M)**							
	P uptake leaf				P uptake stem			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	6.00	5.40	5.40	**5.60**	3.00	2.40	2.40	**2.60**
S_2 Critical Stage approach	4.57	4.30	4.00	**4.29**	2.23	2.03	1.90	**2.06**
Mean	**5.28**	**4.85**	**4.70**	**4.94**	**2.62**	**2.22**	**2.15**	**2.33**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	5.43	5.30	5.13	**5.29**	2.43	2.10	2.00	**2.18**
S_2 Critical Stage approach	4.10	3.70	3.60	**3.80**	2.00	2.03	1.83	**1.95**
Mean	**4.77**	**4.50**	**4.37**	**4.54**	**2.22**	**2.07**	**1.92**	**2.07**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	6.23	5.43	5.23	**5.63**	2.92	2.43	2.23	**2.54**
S_2 Critical Stage approach	4.03	3.57	3.47	**3.69**	1.87	1.73	1.63	**1.74**
Mean	**5.13**	**4.50**	**4.35**	**4.66**	**2.42**	**2.08**	**1.93**	**2.14**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	5.90	5.38	5.25	**5.50**	2.80	2.31	2.21	**2.44**
S_2 Critical Stage approach	4.23	3.85	3.69	**3.92**	2.03	1.93	1.79	**1.92**
Mean	**5.06**	**4.61**	**4.47**	**4.72**	**2.42**	**2.12**	**2.00**	**2.18**

For Comparing means of	SEm±	CV (%)	CD at 5%	SEm±	CV (%)	CD at 5%
Method of Irrigation **(M)**	0.066	5.97	NS	0.095	18.43	NS
Stages of Irrigation **(S)**	0.147	16.25	0.510	0.110	26.13	0.38
Nitrogen Source **(N)**	0.160	14.42	0.47	0.117	22.85	0.34
M x S	0.255		NS	0.190		NS
S x N	0.237		NS	0.174		NS
M x N	0.278		NS	0.203		NS
M x S x N	0.997		NS	0.759		NS

Table 32: Effect of nitrogen sources, irrigation levels and method of irrigation on p uptake in pod and plant of french bean at different growth stages.

Stages of Irrigation (S)	**Method of irrigation (M)**							
	P uptake pod				P uptake plant			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	10.00	9.40	9.40	**9.60**	19.00	17.20	17.20	**17.80**
S_2 Critical Stage approach	8.57	8.30	8.00	**8.29**	15.37	14.63	13.90	**14.63**
Mean	**9.28**	**8.85**	**8.70**	**8.94**	**17.18**	**15.92**	**15.55**	**16.22**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	9.43	9.50	9.13	**9.29**	17.30	16.70	16.27	**16.75**
S_2 Critical Stage approach	8.30	8.23	8.00	**8.18**	14.40	13.97	13.43	**13.93**
Mean	**8.87**	**8.77**	**8.57**	**8.73**	**15.85**	**15.33**	**14.85**	**15.34**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	10.23	9.43	8.97	**9.55**	19.43	17.30	16.44	**17.72**
S_2 Critical Stage approach	8.50	7.90	7.80	**8.07**	14.40	13.20	13.17	**13.59**
Mean	**9.37**	**8.67**	**8.40**	**8.806**	**16.92**	**15.25**	**14.80**	**15.65**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	9.90	9.38	9.20	**9.50**	18.58	17.07	16.63	**17.43**
S_2 Critical Stage approach	8.45	8.14	7.93	**8.20**	14.72	13.93	13.50	**14.05**
Mean	**9.17**	**8.76**	**8.55**	**8.82**	**16.65**	**15.50**	**15.07**	**15.74**
For Comparing means of	SEm±	CV (%)	CD at 5%		SEm±	CV (%)	CD at 5%	
Method of Irrigation **(M)**	0.317	15.21	NS		0.408	11.00	NS	
Stages of Irrigation **(S)**	0.099	5.80	0.34		0.278	9.16	0.961	
Nitrogen Source **(N)**	0.148	7.14	0.43		0.373	10.07	1.09	
M x S	0.171		NS		0.481		NS	
S x N	0.198		NS		0.515		NS	
M x N	0.257		NS		0.647		NS	
M x S x N	1.162		NS		2.424		NS	

Table 33: Effect of nitrogen sources, irrigation levels and methods of irrigation on K uptake in leaf and stem of french bean at different growth stages.

Stages of Irrigation (S)	**Method of irrigation (M)**							
	K uptake leaf				K uptake stem			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	28.43	25.30	24.73	**26.15**	17.43	13.97	13.40	**14.93**
S_2 Critical Stage approach	25.90	23.73	22.83	**24.15**	14.90	13.73	12.17	**13.60**
Mean	**27.17**	**24.52**	**23.78**	**25.15**	**16.17**	**13.85**	**12.78**	**14.27**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	26.10	24.90	24.27	**25.09**	16.77	13.80	13.60	**14.72**
S_2 Critical Stage approach	23.50	20.93	20.53	**21.65**	12.17	11.27	10.87	**11.43**
Mean	**24.80**	**22.92**	**22.40**	**23.37**	**14.47**	**12.53**	**12.23**	**13.08**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	30.10	27.10	25.57	**27.52**	17.53	16.10	15.04	**16.22**
S_2 Critical Stage approach	25.57	23.37	22.77	**23.90**	14.57	12.57	11.77	**12.90**
Mean	**27.83**	**25.23**	**24.07**	**25.71**	**16.05**	**14.23**	**13.40**	**19.56**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	28.21	25.77	24.79	**26.25**	17.24	14.62	14.01	**15.29**
S_2 Critical Stage approach	24.99	22.68	22.04	**23.24**	13.88	12.45	11.60	**12.64**
Mean	**26.00**	**24.22**	**23.42**	**24.75**	**15.50**	**13.54**	**12.80**	**13.97**
For Comparing means of	SEm±	CV (%)	CD at 5%		SEm±	CV (%)	CD at 5%	
Method of Irrigation **(M)**	0.799	13.69	NS		0.447	13.59	NS	
Stages of Irrigation **(S)**	0.292	6.13	1.01		0.441	15.30	1.42	
Nitrogen Source **(N)**	0.352	6.03	1.02		0.273	8.28	0.79	
M x S	0.59		NS		0.712		NS	
S x N	0.500		NS		0.518		NS	
M x N	0.875		NS		0.472		NS	
M x S x N	2.883		NS		2.225		NS	

Table 34: Effect of nitrogen sources, irrigation levels and methods of irrigation on K uptake in pods and plant of French bean at different growth stages.

Stages of Irrigation (S)	Method of irrigation (M)							
	K uptake pods				K uptake/plant			
	Nitrogen source (N)				**Nitrogen source (N)**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
	M_1 Furrow irrigation							
S_1 IW:CPE Ratio	48.43	42.63	42.73	**44.60**	94.30	81.90	80.87	**85.69**
S_2 Critical Stage approach	43.90	41.73	40.83	**42.15**	84.70	79.20	75.83	**79.91**
Mean	**46.17**	**42.18**	**41.78**	**43.38**	**89.50**	**80.55**	**78.35**	**82.80**
	M_2 Alternate Furrow irrigation							
S_1 IW:CPE Ratio	44.10	42.90	41.60	**42.87**	86.97	81.60	79.47	**82.68**
S_2 Critical Stage approach	41.50	38.93	37.87	**39.43**	77.17	71.13	69.27	**75.52**
Mean	**42.80**	**40.92**	**39.73**	**41.15**	**82.07**	**76.37**	**74.37**	**77.60**
	M_3 Micro sprinkler							
S_1 IW:CPE Ratio	51.13	45.10	43.37	**46.53**	98.77	88.30	83.77	**90.28**
S_2 Critical Stage approach	42.90	39.97	37.87	**40.24**	83.03	75.70	72.40	**77.04**
Mean	**47.02**	**42.53**	**40.62**	**43.39**	**90.90**	**82.0**	**78.08**	**83.66**
	Stages of Irrigation and nitrogen source interaction over method of irrigation							
S_1 IW:CPE Ratio	47.89	43.54	42.56	**44.67**	93.34	83.93	81.37	
S_2 Critical Stage approach	42.77	40.21	38.85	**40.61**	81.63	75.34	72.50	
Mean	**45.33**	**41.88**	**40.71**	**42.64**	**87.49**	**79.64**	**76.93**	

For Comparing means of	SEm±	CV (%)	CD at 5%	SEm±	CV (%)	CD at 5%
Method of Irrigation **(M)**	0.777	7.73	NS	1.828	9.53	NS
Stages of Irrigation **(S)**	0.515	6.27	1.782	1.124	7.18	3.89
Nitrogen Source **(N)**	0.389	3.87	1.136	0.823	4.29	2.40
M x S	0.892		NS	1.947	-	NS
S x N	0.682		NS	1.472	-	NS
M x N	0.974		NS	1.426	-	NS
M x S x N	3.248		NS	7.194	-	NS

Experiment – 4 (2010-11)

"Studies on utilization efficiency of harvested water with moisture conservation practices and integrated nutrient management practices for radish (Raphanus sativus L.) production in Alfisols"

Objectives of the experiment:

- To estimate the quantum influence of protective irrigation and mulching on growth and yield of radish
- To know the growth and yield of radish under integrated nutrient management practices
- To know the interaction effect of moisture conservation practices with protective irrigation and integrated nutrient management practices on growth and yield of radish
- To work out economics of radish production in *Alfisols*

Summary of experimental layout

Plot size: 4.5 m X 3.0 m ***Crop***: Radish ***variety*****:** Pusa Chetki
Recommended Dose of Fertilizer**:** 75:38:38 NPK kg /ha
No. of Replications**:** Three
No. of protective Irrigation**:** Two irrigations (30.11.2010 and 9.12.2010)
Depth of irrigation water**:** 5 cm
Date of sowing**:** 02.11.2010
Date of Harvest**:** 13.12.2010 and 22.12.2010
Row spacing**:** 30 cm x 10 cm
Farm Yard Manure: 0.5% N (10.26 kg farm yard manure/plot)
Glyricidia**:** 2.76% N. (1.9 kg glyricidia/plot)

Varietal description:

Variety Pusa chetki is a selection from exotic material, its roots are medium-large (12-20 cm), stumpy, pure white, tender, smooth and mildly pungent. It matures in 40-45 days. It is tolerant to high temperature.

Treatments details:

I. Main plots: Methods of irrigation (M)

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control (No moisture conservation furrow and no protective irrigation)

II. Sub-plots: Sources of Nutrients (N)

N_1: Recommended dose of fertilizers

N_2: 50% recommended N through Farm yard manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

N_3: 50% recommended N through glyricidia leaf manure+50% N through Fertilizer and Recommended P_2O_5 and K_2O

Treatment Interactions: (9)

M_1N_1	M_2N_1	M_3N_1
M_1N_2	M_2N_2	M_3N_2
M_1N_3	M_2N_3	M_3N_3

R I		R II		R III
M_2N_2		M_3N_2		M_2N_2
M_2N_3		M_3N_1		M_2N_3
M_2N_1	1m	M_3N_3	1 m	M_2N_1
M_1N_2		M_1N_2		M_1N_2
M_1N_3		M_1N_3		M_1N_3
M_1N_1		M_1N_1		M_1N_1
M_3N_2		M_2N_2		M_3N_2
M_3N_1		M_2N_3		M_3N_1
M_3N_3		M_2N_1		M_3N_3

N →

← 4.5m →

Fig. 3: Plan and layout of experiment

Observations:

- Periodic observation on growth, yield and yield attributing characters
- Nutrient (N,P, K) content of roots and shoot
- To work out the economics of radish production

Material and Methods

The soil was low in available nitrogen (237.8 kg ha^{-1}), low in available phosphorus (18.3 kg ha^{-1}) and potassium (195.8 kg ha^{-1}). The electrical conductivity was 0.22 dS m^{-1} which indicated no salinity hazard. Experimental land was ploughed twice during September to bring it to fine tilth. The entire area was divided in to different blocks equal to number of main treatments and each block was divided into number of plots as many number of sub-plot treatments. The individual treatments to each plot were allotted randomly using random number table. The size of each plot was 4.5 m x 3.0 m. Separate buffer furrow was maintained between each plot. The moisture conservation practices with protective irrigation were followed for M_1 and M_2 treatments whereas, mulching was provided only for M_1 (5-6 kg dried straw/plot). While, M_3 treatment was treated as control. Approximately 5 cm depth of irrigation was provided during long dry spells of the crop growth.

For sub-plot treatments, the nutrient composition of organic manures was analyzed and quantity of manures required to supply 50 per cent recommended N (37.5 kg N) was worked out and all the organic manures were applied 15 days before sowing as per treatments. Entire dose recommended N, P_2O_5 and K_2O was applied at the time of sowing. Thinning was done 15 DAS and hand weeding and intercultivation were carried out at 20 DAS. Two protective irrigation was provided during critical stages of the crop growth period except for M_3 (control).

Observations on the growth components of radish were recorded at 30 DAS and at harvest. At harvest, the root yield and yield attributes were recorded from sampling plants and mean values were worked out.

Results and discussion

The results of the field experiment **"Studies on utilization efficiency of harvested water with moisture conservation practices and integrated nutrient management practices for radish (*Raphanus sativus* L.) production in *Alfisols*"** during *Rabi* 2010-11 conducted at Dry Land Agriculture Project, GKVK, University of Agricultural Sciences, Bengaluru are presented below.

The experimental site was situated at 12^0 58' N and 13^0 5' N latitude and 77^0 35' E and 77^0 34' E longitude at an altitude of 930 meters above the mean sea level Eastern Dry Zone (Zone-5) of Karnataka. The rainfall received during the crop growth period was 137.5 mm in 7 rainy days (Appendix-I).The mean maximum and minimum temperature ranged between 22.6^0C and 29.2^0C and 11.8^0C and 19.8^0C respectively. November was the most humid month with the highest mean daily relative humidity of 77 per cent as against 73 per cent.

In the present investigation, protective irrigation with and with out soil moisture conservation practices were tried in combination with different sources of nitrogen with a main objective to utilize the organic source of nutrients available on the farm and to attain sustainability in yield levels.

Plant height (18.0cm and 29.5cm) and number of leaves (6.4 and 9.6) were significantly higher in M_1 at 30 DAS and at harvest (Table 35&36) respectively as compared to M_2 and M_3 (without protective irrigation). Significantly higher leaf area 142.4 cm^2 and 338.9 cm^2 were recorded in M_1 at 30DAS and at harvest respectively (Table 37).

The dry matter production and its distribution among different plant parts differed significantly due to moisture conservation furrow+protective irrigation and mulching. Higher dry matter accumulation in leaves (1.19 and 1.0 g/plant) and in root (0.57 and 0.46 g/plant) were noticed in M_1 and M_2 as compared to control (0.64 and 0.26 g/plant) respectively (Table 38&39). The trends were similar at harvest also. This significant variation in dry matter distribution and accumulation in various plant parts lead to significant variation with respect to total dry matter production per plant at harvest. Highest total dry matter accumulation per plant at harvest significantly was noticed in M_1 (7.30 g/plant) as compared to M_2 and M_3.

Application of nitrogen to radish by different sources (sub-plot treatments) had recorded differences in growth parameters of plant at various growth stages. Application of 100% of recommended dose of nitrogen through fertilizer recorded significant progressive plant height and no. of leaves (16.6 cm & 5.8 and 26.6 cm & 8.8 at 30 DAS and at harvest respectively) as compared to integrated approach of nitrogen application *viz.*, 50% recommended dose of nitrogen (RDN) through farm yard manure and 50% recommended dose of nitrogen (RDN) through fertilizer and 50% through glyricidia and 50% RDN through fertilizers both are on par with each other during 30 DAS and at harvest(Table 35&36). Significantly higher leaf area (Table 37) was observed in treatment receiving 100% RDN through fertilizer at all the growth stages of radish (132.6 cm^2 and 310.2 cm^2 during 30 DAS and at harvest respectively).

Significant differences with respect to dry matter production and its accumulation in different plant parts was observed due to application of RDN with different sources. Application of 100% RDN through fertilizer recorded significantly higher dry matter accumulation in leaves (1.02g and 2.77g/plant respectively) and root (0.47g and 3.58 g/plant respectively) of radish both at 30 DAS and at harvest as compared to N_2 and N_3. Similar trends were noticed with respect to total dry matter production per plant at 30 DAS and at harvest (1.50 g and 6.35 g/plant respectively) as compared to integrated application in N_2 and N_3 (Table 38&39).

Plate 6. Radish crop stand under moisture conservation furrow + protective irrigation + mulching

Plate 7. Radish crop stand under moisture conservation furrow + protective irrigation

Plate 8. Radish crop stand under without conservation furrow and with out protective irrigation

Radish yield differed significantly among main plot treatments, moisture conservation furrow + protective irrigation + mulching recorded significantly higher root and biomass yield (14287 and 28228 kg ha^{-1} respectively) as compared to M_2 and control (with out protective irrigation). The higher yield level in M_1 could be attributed to alteration in land configuration by providing moisture conserving furrow + mulching and protective irrigation during long dry spell as compared to control. Apart from this, yield attributing parameters such as root length per plant (15.5 cm), root diameter (3.43cm) significantly higher in M_1, as compared to M_2 & M_3 (Table 40 & Table 41). Thus, owing to integrated effect of these yield parameters favorably influenced the root yield of radish. Differences observed in root yield of radish due to moisture conservation practices with protective irrigation, production could be traced back to differences in dry matter production and its accumulation in different plant parts and relatively higher leaf area was observed in moisture conservation furrow + protective irrigation with mulching at all the growth stages of plant.

Root and shoot N, P and K contents varied significantly by the soil moisture conservation furrow+protective irrigation +with and without mulching were tried in combination with different sources of nitrogen (Table 42-44). Root and leaf content were maximum with moisture conservation furrow + protective irrigation + mulching among main plots and application of 100% recommended dose of nitrogen through fertilizer. Soil moisture conservation practices coupled with the protective irrigation helped the plant to take up higher amounts of macro nutrients which in turn helped for production of higher photosythates and its translocation from source to sink effectively.

Yield maximization of any crop depends on the processes associated with content/concentration of nutrients, translocation, partitioning, assimilation and mobilization of nutrients at different growth stages of crop. These multitudes of processes are influenced by genetic potential of the crop variety, cultural practices, soil manipulations, climatic factors and efficient management of inputs.

The growth and yield of crop plants are determined by the presence of sufficient quantities of nutrients in the soil in available form for plant uptake. Crops often respond quickly to fertilizer application due to higher concentration of nutrients present in them.

Among soil moisture conservation practices with protective irrigation, treatment moisture conservation furrow + protective irrigation + mulching resulted in higher net returns and benefit: cost (B: C) ratio than compared other treatments. Application of 100% of recommended dose of nitrogen through fertilizer recorded the highest net returns and benefit: cost (B: C) ratio (Table 45).

Taking the obtained results in to consideration higher root yield and net income in radish can be realized by adoption of soil moisture conservation practices with protective irrigation along with application of recommended dose of fertilizers.

Conclusion

Better utilization and conservation of farm resources and yield sustainability of radish could be attained by adopting proper land configuration with recommended dose of fertilizers proved to be better in realizing higher yield in radish. Apart from this, both crop productivity and water productivity could be improved by storing the run off water in farm ponds and using the same during long dry spells / at critical crop growth stages as protective irrigation during *rabi* in order to obtain higher root yields.

Table 35: Effect of nitrogen sources and moisture conservation practices with protective irrigation on plant height of radish at 30DAS and at harvest.

Treatments	Plant height (cm) at 30 DAS				Plant height (cm) at harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	18.7	17.8	17.4	**18.0**	31.2	29.0	28.4	**29.5**
M_2	17.1	16.6	16.2	**16.6**	27.3	26.2	25.3	**26.2**
M_3	13.9	13.6	13.2	**13.6**	21.2	20.5	19.4	**20.3**
Mean	**16.6**	**16.0**	**15.6**	**16.0**	**26.6**	**25.2**	**24.4**	**25.4**
	S.Em. ±	**CD (P=0.05)**		**CV (%)**	**S.Em. ±**	**CD (P=0.05)**		**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.14	0.56		2.67	0.35	1.37		4.1
Nitrogen Sources (N)	0.13	0.43		2.58	0.15	0.46		1.7
'M' at the same 'N'	0.24	NS		-	0.40	NS		-
'N' at the same or different 'M'	0.23	NS		-	0.25	NS		-

DAS: Days After Sowing; **NS:** Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 36: Effect of nitrogen sources and moisture conservation practices with protective irrigation on number of leaves of radish at 30DASand at harvest.

Treatments	Number of leaves at 30 DAS				Number of leaves at harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	6.8	6.3	6.1	**6.4**	10.2	9.5	9.3	**9.6**
M_2	6.0	5.7	5.6	**5.8**	9.0	8.6	8.5	**8.7**
M_3	4.5	4.4	4.2	**4.3**	7.1	7.1	6.9	**7.0**
Mean	**5.8**	**5.4**	**5.3**	**5.5**	**8.8**	**8.4**	**8.2**	**8.5**

	S.Em. ±	CD (P=0.05)	CV (%)	S.Em. ±	CD (P=0.05)	CV (%)
Moisture conservation practices with Protective Irrigation (M)	0.05	0.21	2.99	0.18	0.70	6.36
Nitrogen Sources (N)	0.04	0.13	2.40	0.13	0.39	4.54
'M' at the same 'N'	0.08	NS	-	0.25	NS	-
'N' at the same or different 'M'	0.08	NS	-	0.22	NS	-

DAS: Days After Sowing **NS:** Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 37: Effect of nitrogen sources and moisture conservation practices with protective irrigation on leaf area of radish at 30DAS and at harvest.

Treatments	leaf area (cm^2) at 30 DAS				leaf area (cm^2) at harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	148.4	140.2	138.6	**142.4**	349.5	336.1	331.3	**338.9**
M_2	135.9	131.8	129.6	**132.4**	326.1	319.1	314.8	**319.8**
M_3	113.5	110.8	107.6	**110.6**	255.1	239.3	226.1	**240.2**
Mean	**132.6**	**127.6**	**125.3**	**128.5**	**310.2**	**298.2**	**290.5**	**299.6**
	S.Em. ±	**CD (P=0.05)**		**CV (%)**	**S.Em. ±**	**CD (P=0.05)**		**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.85	3.34		1.99	4.79	18.83		4.80
Nitrogen Sources (N)	1.27	3.91		2.97	2.96	9.12		2.96
'M' at the same 'N'	1.99	NS		-	6.37	NS		-
'N' at the same or different 'M'	2.20	NS		-	5.13	NS		-

DAS: Days After Sowing **NS:** Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching

M_2: Moisture Conservation furrow + Protective Irrigation

M_3: Control

N_1: Recommended dose of fertilizers

N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 38: Effect of nitrogen sources and moisture conservation practices with protective irrigation on dry matter accumulation of radish at 30 days after sowing.

Treatments	DMA in Leaf (g/plant)				DMA in Root (g/plant)				TDMA (g/plant)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	1.31	1.16	1.10	**1.19**	0.62	0.55	0.53	**0.57**	1.94	1.71	1.63	**1.76**
M_2	1.06	0.99	0.98	**1.0**	0.51	0.46	0.43	**0.46**	1.57	1.45	1.41	**1.5**
M_3	0.70	0.67	0.56	**0.64**	0.29	0.27	0.22	**0.26**	0.99	0.94	0.78	**0.90**
Mean	**1.02**	**0.94**	**0.88**	**0.95**	**0.47**	**0.43**	**0.39**	**0.43**	**1.50**	**1.37**	**1.27**	**1.38**

	S.Em. ±	CD (P=0.05)	CV (%)	S.Em.±	CD (P=0.05)	CV (%)	S.Em. ±	CD (P=0.05)	CV (%)
Moisture conservation practices with Protective Irrigation (M)	0.02	0.08	6.52	0.04	0.15	16.3	0.02	0.11	6.39
Nitrogen Sources (N)	0.02	0.07	8.14	0.01	0.042	9.45	0.03	0.09	6.74
'M' at the same 'N'	0.04	NS	-	0.04	NS	-	0.05	NS	-
'N' at the same or different 'M'	0.04	NS	-	0.02	NS	-	0.05	NS	-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 39: Effect of nitrogen sources and moisture conservation practices with protective irrigation on dry matter accumulation of radish at harvest.

Treatments	DMA in Leaf (g/plant)				DMA in Root (g/plant)				TDMA (g/plant)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	3.54	3.14	3.04	**3.24**	4.35	3.96	3.87	**4.06**	7.89	7.10	6.92	**7.30**
M_2	2.96	2.73	2.60	**2.76**	3.76	3.55	3.42	**3.57**	6.72	6.29	6.02	**6.34**
M_3	1.81	1.72	1.60	**1.71**	2.63	2.54	2.42	**2.53**	4.45	4.27	4.02	**4.24**
Mean	**2.77**	**2.53**	**2.41**	**2.57**	**3.58**	**3.35**	**3.24**	**3.39**	**6.35**	**5.89**	**5.65**	**5.96**

	DMA in Leaf S.Em. ±	DMA in Leaf CD (P=0.05)	DMA in Leaf CV (%)	DMA in Root S.Em. ±	DMA in Root CD (P=0.05)	DMA in Root CV(%)	TDMA S.Em. ±	TDMA CD (P=0.05)	TDMA CV(%)
Moisture conservation practices with Protective Irrigation (M)	0.03	0.10	3.03	0.07	0.28	6.3	0.14	0.54	6.98
Nitrogen Sources (N)	0.04	0.13	5.07	0.05	0.16	4.6	0.14	0.43	7.06
'M' at the same 'N'	0.07	NS	-	0.10	NS	-	0.24	NS	-
'N' at the same or different 'M'	0.07	NS	-	0.09	NS	-	0.24	NS	-

NS: Non-Significant
M_1: Moisture Conservation furrow + Protective Irrigation + Mulching

M_2: Moisture Conservation furrow + Protective Irrigation

M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 40: Effect of nitrogen sources and moisture conservation practices with protective irrigation on Root Length and Root diameter of radish at harvest.

	Root Length (cm) at harvest				**Root diameter (cm) at harvest**			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
M_1	16.8	15.2	14.4	**15.5**	3.74	3.29	3.26	**3.43**
M_2	14	13.5	12.7	**13.4**	3.17	2.96	2.90	**3.01**
M_3	8.8	8.6	8.3	**8.6**	2.03	2	1.67	**1.90**
Mean	**13.2**	**12.4**	**11.8**	**12.5**	**2.98**	**2.75**	**2.61**	**2.78**
	S.Em. ±	**CD (P=0.05)**		**CV (%)**	**S.Em. ±**	**CD (P=0.05)**		**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.19	0.76		4.63	0.026	0.10		2.77
Nitrogen Sources (N)	0.19	0.60		4.70	0.042	0.16		5.47
'M' at the same 'N'	0.34	NS		-	0.067	NS		-
'N' at the same or different 'M'	0.34	NS		-	0.018	NS		-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 41: Effect of nitrogen sources and moisture conservation practices with protective irrigation on root and biomass yield of radish at harvest.

Treatments	Root yield (kg/ha)				Biomass yield (kg/ha)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	15959	13737	13167	**14287**	31746	27128	25811	**28228**
M_2	12731	11634	11010	**11792**	25324	23340	21879	**23515**
M_3	6746	6169	5357	**6090**	12680	11508	10516	**11568**
Mean	**11812**	**10513**	**9845**	**10723**	**23250**	**20659**	**19402**	**21104**
	S.Em. ±	**CD (P=0.05)**		**CV (%)**	**S.Em. ±**	**CD (P=0.05)**		**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	616.2	2418.9		17.2	1074.9	4220.8		15.28
Nitrogen Sources (N)	341.3	1051.8		9.5	764.7	2356.3		10.87
'M' at the same 'N'	782.7	NS		-	1524.8	NS		-
'N' at the same or different 'M'	591.3	NS		-	1324.5	NS		-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 42: Effect of nitrogen sources and moisture conservation practices with protective irrigation on nitrogen content in root and shoot of radish at harvest.

Treatments	Nitrogen content in root (%)				Nitrogen content in shoot (%)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	1.46	1.41	1.40	**1.42**	2.23	2.18	2.16	**2.19**
M_2	1.40	1.37	1.36	**1.37**	2.16	2.13	2.12	**2.13**
M_3	1.27	1.26	1.24	**1.25**	2.04	2.02	1.99	**2.02**
Mean	**1.37**	**1.34**	**1.33**	**1.35**	**2.14**	**2.11**	**2.09**	**2.11**
	S.Em. ±	**CD (P=0.05)**		**CV (%)**	**S.Em. ±**	**CD (P=0.05)**		**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.013	0.04		2.98	0.014	0.05		7.77
Nitrogen Sources (N)	0.003	0.02		0.73	0.005	0.02		3.19
'M' at the same 'N'	0.02	NS		-	0.03	NS		-
'N' at the same or different 'M'	0.008	NS		-	0.009	NS		-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 43: Effect of nitrogen sources and moisture conservation practices with protective irrigation on phosphorus (P) content in root and shoot of radish at harvest.

Treatments	P content in root (%)				P content in shoot (%)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	0.42	0.38	0.37	**0.39**	0.36	0.34	0.34	**0.35**
M_2	0.37	0.34	0.33	**0.35**	0.34	0.32	0.31	**0.32**
M_3	0.25	0.24	0.22	**0.23**	0.26	0.25	0.23	**0.25**
Mean	**0.35**	**0.32**	**0.31**	**0.32**	**0.32**	**0.30**	**0.29**	**0.30**

	S.Em. ±	CD (P=0.05)	CV (%)	S.Em. ±	CD (P=0.05)	CV (%)
Moisture conservation practices with Protective Irrigation (M)	0.011	0.03	14.96	0.006	0.022	16.54
Nitrogen Sources (N)	0.003	0.01	3.11	0.003	0.012	2.60
'M' at the same 'N'	0.017	NS	-	0.017	NS	-
'N' at the same or different 'M'	0.006	NS	-	0.004	NS	-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 44: Effect of nitrogen sources and moisture conservation practices with protective irrigation on potassium content of Root and shoot radish at harvest.

Treatments	K content in root (%)				K content in shoot (%)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	3.62	3.5	3.47	**3.53**	3.28	3.16	3.12	**3.18**
M_2	3.45	3.39	3.36	**3.40**	3.09	3.04	2.99	**3.04**
M_3	3.13	3.10	3.06	**3.09**	2.77	2.74	2.70	**2.74**
Mean	**3.4**	**3.33**	**3.29**	**3.34**	**3.05**	**2.98**	**2.94**	**2.99**
	S.Em. ±	**CD (P=0.05)**		**CV (%)**	**S.Em. ±**	**CD (P=0.05)**		**CV (%)**
Moisture conservation practices with Protective Irrigation (M)	0.039	0.12		5.50	0.010	0.040		1.03
Nitrogen Sources (N)	0.015	0.047		1.37	0.014	0.048		1.24
'M' at the same 'N'	0.065	NS		-	0.020	NS		-
'N' at the same or different 'M'	0.026	NS		-	0.021	NS		-

NS: Non-Significant

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control

N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Table 45: Effect of nitrogen sources and moisture conservation practices with protective irrigation on economics of radish.

Treatments	Cost of cultivation/ha				Gross returns/ha			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	18786	22094	19065	**19982**	79795	68685	65835	**71438**
M_2	17285	20594	17565	**18481**	63655	58170	55050	**58958**
M_3	16826	20134	17105	**18022**	33730	30845	26785	**30453**
Mean	**17632**	**20941**	**17912**	**18828**	**59060**	**52567**	**49223**	**53616**

Treatments	Net returns/ha				B: C Ratio			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
M_1	61009	46591	46770	**51457**	3.25	2.11	2.45	**2.60**
M_2	46370	37576	37485	**40477**	2.68	1.82	2.13	**2.21**
M_3	16904	10711	9680	**12432**	1.00	0.53	0.57	**0.7**
Mean	**41428**	**31626**	**31312**	**34789**	**2.31**	**1.49**	**1.72**	**1.84**

M_1: Moisture Conservation furrow + Protective Irrigation + Mulching
M_2: Moisture Conservation furrow + Protective Irrigation
M_3: Control
N_1: Recommended dose of fertilizers
N_2: 50% recommended N through Farm Yard Manure+50% N through fertilizer and Recommended P_2O_5 and K_2O
N_3: 50% recommended N through glyricidia manure+50% N through fertilizer and Recommended P_2O_5 and K_2O

Expt. 1: ***Potentaility and Economic feasibility of fish culture in stored water***

For the first time different fish fingerlings were released in to the pond by the Vice Chancellor, UAS, Bangalore on 14-08-2007. The same ratio of fish fingerlings was released in to the pond in the subsequent years.

Table 46: Number of fish fingerlings released into farm ponds

Species	Big farm pond	Small pond
Common carp	200 (40%)	80 (40%)
Catla	150 (30%)	60 (30%)
Rohu	100 (20%)	40 (20%)
Grass carp	50 (10%)	20 (10%)
Total	500	200

Figures in parenthesis indicates per cent to the total number of fish fingerlings

As part of the research programme (all the three years) fish species viz., Common Carp, Catla, Rohu and Grass Carp were released in 4:3:2:1 proportion to the farm ponds (Table 46). Before release of fishes 15 days in advance farm ponds were neutralized with lime and cow dung. The feeding was done at the rate of 5 per cent of the average body weight of fish fingerlings. The body weight was measured once in 15 days. The mortality rate and disease incidence of different species was recorded during each observation. Mortality rate is worked out by considering the number of dead fishes to the total number fishes released into farm pond and expressed in percentage. The feeding material was supplied by fishing rearing unit, Hebbal during early stages, later groundnut cake and rice bran were mixed in equal proportion to make required quantity. In addition to solid feed materials the grasses, crop residues etc were given at regular basis. A person was engaged to watch and ward, feeding, catching fishes etc. throughout the season.

Table 47: Mean weight (g) of different breeds of fishes reared in farm pond during project.

Fish Breed	Feeding zone	2007-08		2008-09		2009-10		2010-11		Weight range (g) Polled	Mean weight (g) Polled
		Weight range (g)	Mean weight (g)	Weight range (g)	Mean weight (g)	Weight range (g)	Mean weight (g)	Weight range (g)	Mean weight (g)		
Common Carp	Bottom	77-153	113.0	55-95	75	60-110	85	137-189	155.2	141-137	107
Catla	Surface	20- 67	40.2	48-89	69	54-92	73	59-92	76	45-84	64.5
Rohu	Middle	31- 60	44.8	102-124	112	114-136	125	132-193	153.96	95-128	108.9
Grass Carp	Top	10-27	17.3	30-44	37	40-50	45	25-32	29.65	26-38	32.2

Plate 9. Recording weights of different breeds of fishes rear in farm pond.

Plate 10. Different breeds of fishes were reared in the farm pond at DLAP, GKVK, UAS, Bengaluru.

Plate 11. Fish harvest in farm pond and growth measurement

In the year 2007-08 due to very low water level, we were compelled to harvest fishes before attaining maturity and their mean weights are presented in Table 47. During 2008-09 the fishes were harvested at 165 days after release and during 2009-10 the fishes were harvested before attaining physiological maturity due to the fact that less amount of stored water in the pond. The periodic observation on average length, breadth and weight of fishes were recorded. The mean weight of different breeds was ranged from 30-44 g in grass carp to 102-124 g in common carp.

The mortality rate of different fish breeds at harvest is presented in the Table 48. Among different breeds rohu (17 %) has more mortality rate followed by common carp (15%) however, it was lower in grass carp (8 %).

Table 48: Mortality rate of different fish species

Sl. No.	**Fish species**	**Mortality rate (%)**				
		2007-08	**2008-09**	**2009-10**	**2010-11**	Pooled
1	Catla	10	09	14	08	10
2	Rohu	17	19	22	18	19
3	Common Carp	15	14	18	21	17
4	Grass Carp	08	10	10	12	10

The mortality rate and suitability of each fish species in run-off water was worked out at harvest. The total cost of production of all the fish species was worked out and presented in Table 49. The fishes were sold at present market price of Rs. 70 per kg. The economic feasibility of fish culture was worked out by considering the total returns and cost of production and it was found that the net returns to the tune of Rs. 3957=00 in 2008-09, Rs.3117=00 during 2009-10 and Rs. 3107=00 during 2010-11

Table 49: Economics of fish culture

Item	2008-09			2009-10			2010-11		
	Quantity/ Number	**Cost (Rs/unit)**	**Total cost (Rs)**	**Quantity/ Number**	**Cost (Rs/unit)**	**Total cost (Rs)**	**Quantity/ Number**	**Cost (Rs/unit)**	**Total cost (Rs)**
Price of fish fingerlings									
Catla									
Rohu	210	0.6	126	210	0.6	126	210	0.6	126
Common Carp	160	0.5	80	140	0.5	70	160	0.5	80
Grass Carp	280	0.4	112	280	0.4	112	280	0.4	112
	70	1.0	70	70	1.0	70	70	1.0	70
Packingcharges									
			05			05			05
Sub Total	**720**		**393**	**700**		**383**	**700**		**393**
Feeding material									
Groundnut cake							100	12	1200
Rice bran							50	8	400
	100	12	1200	100	12	1200			
	50	8	400	50	8	400			
Sub Total	**150**		**1600**	**150**		**1600**	**150**		**1600**
Maintenance charges and application of feeding material, catching of fishes			**500**			**500**			500
Grand total			**2493**			**2483**			**2493**
Receipts realized by the sale of fishes (**Total receipts**)	86	75	6450	80	70	5600	80	70	5600
Net Returns			**3957**			3117			**3107**

PROJECT OBJECTIVE: III

To know the effect of accumulated Sesqui-Oxides on growth and yield of fishes in farm ponds and to develop methods to neutralize their effects.

Experiment 1: ***Studies on minimizing effects of accumulated sesqui-oxides on fishes in farm pond.***

Treatments: Organic/Chemical residues

(1) Cow dung (2) Grass/Drumstick leaves (3) Pundi (4) Lime

(5) Single super phosphate (6) Oil cake (7) Rice bran

Fish culture: (1) Grass carp (2) Catla (3) Rohu (4) Mrigal

Observations:

I. *Water*: Quantity of run off water collected, pH, Turbidity, Carbonates, Bi-carbonates, O.M. residues, Sesqui-oxides etc., of pond water.

II. *Crops*: Periodic bio-metric observations on yield and yield attributing characteristics, Consumptive use of water, WUE, Scheduling of irrigation, Soil moisture etc.,

III. *Fishes*: Periodic observations on length, breadth, weight and No. of fishes, Mortality and disease incidence, suitability of different fish cultures.

Water sample analysis for Sesqui-oxides:

The water samples were drawn from the farm ponds where runoff water collected from arable and non-arable lands.

The different chemical parameters of runoff water values were categorized into different groups as follows. Based on the experimental data the water quality has been assessed for suitability to fish and crop production activity.

Table 50: pH ratings of water samples

Category	Value
Acidic	below 6.0
Normal	6.0 to 8.4
Tending to alkaline	8.5 to 8.9
Alkaline	9.0 and above

Table 51: Categories of EC of water samples

Category	Value (dS/m)
Normal	< 1.0
Critical	1.0 to 3.0
Injurious	3.0 and above

Table 52: Categories of SAR, RSC and Na % and their suitability for fish and crop activity

Category	SAR	RSC	Na %
Excellent	<1.0	<1.0	<30
Good	1-2	1.0-1.25	30-60
Fair	2-4	1.25- 2.0	60-75
Poor	4-8	2.0- 2.5	75-80
Very poor	8-15	2.5-3.0	80-90
Unsuitable	>15	>3.0	>90

Before fish release:

The water samples collected from farm ponds were analyzed for physical and chemical properties before fish release. The results indicated that pH (7.24) and EC (0.115) were in safe range and chlorides (0.6 me/l), bi-carbonates (1.2 me/l) and sodium (0.08 me/l) are present at safe level (Table 53). Relative Sodium Carbonate (RSC) (0.09) and Sodium Adsorption Ratio (SAR) (0.11) were also at normal level indicating that water is good for fishing activity (Table 52).

60 days after release of fishes:

Water samples were collected from the same farm pond after 60 days of fish release and analyzed for chemical properties of water to test the suitability of water for fish activity. The results indicated that pH (7.36) and EC (0.035 dSm-1) were in safe range but decreased over before fish release. While, bicarbonates (0.6 me/l), calcium (0.22 me/l) and magnesium (0.06 me/l) concentrations were decreased as the duration of water storage increases. Similarly chlorides, bicarbonates and sodium were present at safe level. RSC (0.32) and SAR (0.11) were also at normal level indicated that the runoff water is good for irrigation as well as pisciculture.

120 days after fish release:

The data of chemical properties of runoff water samples indicated that pH (7.12) and EC were at safe level. The chlorides (0.4 me/l), carbonates (traces), bicarbonates (0.5 me/l), calcium (0.27me/l), magnesium (0.27 me/l) and sodium (0.06 me/l) concentration were present in safe level. While, RSC (-0.19) and SAR (0.1) are also at normal level indicating that runoff water is good for irrigation and Pisciculture.

At final fish harvest

The fishes were harvested at 165 days after release and water samples were analyzed for its chemical properties. The results revealed that the runoff water was in safe limit with respect to all the parameters. The water pH (7.23) and EC (0.453 dS/m) were in the safe limit indicated that the runoff water collected in the farm pond were not contaminated and no adverse effect on fish growth and development was observed. But, the bicarbonates (3.8me/l), sodium (0.42me/l) concentrations and relative sodium carbonate (2.57) were increased to greater extent as compared to all other observations. However, all these were in safe limit without affecting fish growth.

Water chemical analysis indicated that the runoff water collected from arable and non-arable lands could be used for fish as well as crop production activities without affecting growth and development of both the components.

Table 53: Sesqui-oxides content of runoff water before fish culture

Particulars	Before fish release	60 days after fish release	120 days after fish release	At harvest 165 days after release
Ph	7.24	7.36	7.12	7.23
EC (dsm^{-1})	0.115	0.035	0.094	0.453
Chloride (me/l)	0.6	0.4	0.4	0.8
Nitrates (me/l)	0.056	0.064	0.055	0.019
Sulphates (me/l)	0.112	0.644	0.022	0.171
Carbonates (me/l)	traces	Traces	Traces	Traces
Bicarbonates (me/l)	1.2	0.6	0.5	3.8
Calcium (me/l)	0.31	0.22	0.27	0.63
Mg (me/l)	0.31	0.06	0.27	0.6
Na (me/l)	0.08	0.04	0.06	0.42
RSC	0.09	0.32	0.19	2.57
SAR	0.11	0.11	0.1	0.59

Plate 12: Harvesting of fishes in the farm pond

Normal Rainfall and observed monthly rainfall (mm)

Month	Normal (1972-2006)	2007	2008	2009	2010	2011	2012	2013
Jan	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Feb	10	0.8	13.2	0.0	0.0	16.6	0.0	2.0
Mar	14.2	0.0	137.4	20.2	34.2	0.0	0.4	0.0
Apr	43.7	109.6	1.6	106.0	112.8	57.4	8.6	56.8
May	97.5	85.4	98.8	191.3	137.4	121.7	84.4	92.8
Jun	82.3	60.3	31	58.8	95.4	24.8	26.6	96.5
Jul	100.6	149.2	182.8	55.6	141.4	95.4	97.2	59.2
Aug	127.2	189.8	249.8	106.8	158.2	249.7	100.1	58.8
Sep	203.9	179.1	126.0	231.7	89.4	59.6	29.2	362.3
Oct	174.5	151.6	205.4	29.6	116.6	126.4	64.2	81.9
Nov	55.1	12.4	7.6	42.6	127.2	35.4	150.0	37
Dec	12.8	31.2	0.0	9.4	9.8	0.0	11.2	0.0
Total	**924.9**	**969.4**	**1053.6**	**842.0**	**1022.4**	**804.5**	**571.9**	**845.3**

Criteria for designing farm pond

- **The depth of pond should not exceeds 5 meters to avoid the seepage losses**
- **Naturally low lying areas should be identified for construction of farm pond to minimize the cost of excavation**
- **The soil of the selected site should be impermeable in nature to minimize the percolation loss**
- **Provide 1:1 side slope to avoid caving**
- **Construct the silt trap pit in the inlet region**
- **Provide proper inlet and out lets to farm pond**
- **The size of the pond depends on the volume of runoff water**
- **Volume of farm pond to be considered for 1 hectare area is 250 m^3 capacity**
- **Provide lining materials to control seepage loss**

Farm pond: Expenditure Abstract

Particulars	Cost in Rupees
Excavation of pond	10,000
300μ LDE (@Rs. 88/kg)	2,905
Cement: (18 bags)	5,150
Bricks: (1300)	3,500
Sand (1.5 t)	1,500
Gum	225
Labour charges	7,050
Total	30,330