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Water Management Technologies for Different Agro-Ecological Conditions

भाकृ अनुप
ICAR

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भारतीय जल प्रबंधन संस्थान

AICRP on Irrigation Water Management

ICAR-Indian Institute of Water Management
Bhubaneswar – 751 023 (Odisha)
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Preface

Irrigation water will continue to play central role in providing food security across the globe. The efficient use of irrigation water with higher productivity is crucial for the development of sustainable agriculture. Workable option is to develop water-use efficient easy-to-adopt technologies, which enhances productivity per drop of water.

We are privileged to present the Technology Information Bulletin of AICRP on Irrigation Water Management covering research findings of the All India Coordinated Research Project on Water Management centres. The network centers of AICRP on Water Management made considerable efforts to develop improved technologies through five well defined themes for last couple of decades.

The XII Plan of Government of India has given highest priority to water management next to Energy sector. All India Coordinated Research Project on Water Management has made spectacular progress in developing a variety of strategies and technologies for improving sustainable use, planning and management of available water resources.

We take this opportunity to express our sincere gratitude to Dr. S. Ayyappan, former Secretary (DARE) and Director General (ICAR) and Dr. Trilochan Mohapatra, Secretary (DARE) and Director General (ICAR) for the constant support and encouragement. We also express our sincere gratitude to Dr. A. K. Sikka, former Deputy Director General (NRM) and Dr. A.K.Singh, former Deputy Director General (NRM), ICAR for their guidance, cooperation and keen interest in conducting network research. We sincerely acknowledge the timely cooperation received from Dr. S.K.Chaudhari, Assistant Director General (S&WM), NRM Division, ICAR. We also express our sincere thanks to all the Chief Scientists and other scientists working in different centers for their hard work and timely cooperation to Impliment the project smoothly. The Chief Scientists of Individual centres have contributed to development of this bulletin and they deserve special appreciation. We hope that the bulletin will prove worthy to agricultural planners, policy makers, researchers and other stake holders who are directly and Indirectly related with agricultural water management of the country.

BHUBANESWAR **Authours**

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Agro-Ecological Region – VIII

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Agro-Ecological Region – X

AICRP on IWM Centres Addressing Problems of Major Canal Commands in Different Agro-Ecological Regions

AER	State	Centre	Command area	Soil Texture
2	Punjab	Bathinda	Bhakra	Loamy sand
2	Haryana	Hisar	Bhakra	Loamy sand
2	Rajasthan	SG'Nagar	IGNP	Silty clay loam
4	M.P.	Morena	Chambal	Sandy clay loam
5	Rajasthan	Kota	Chambal	Clay loam
6	Karnataka	Belvatagi	Malaprabha	Clay-vertisol
6	Maharashtra	Rahuri	Mula	Clay loam-vertisol
6	Maharashtra	Parbhani	Jayakwadi	Clay-vertisol
8	Tamil Nadu	B'sagar	LBP	Red sandy loam
8	Tamil Nadu	Madurai	P.V.C.	Red sandy loam
9	U.P.	Faizabad	Sharada Sahayak	Silty loam
9	Uttarakhand	Pantnagar	Sharda	Sandy loam
10	M.P.	Powarkheda	Tawa	Deep clay-vertisol
11	Chhatisgarh	Bilaspur	Hasdeo-Bango	Sandy loam
12	Odihsa	Chiplima	Hirakud	Sandy loam
13	Bihar	Pusa	Gandak	Sandy clay-loam
14	Uttarakhand	Almora	Hilly area	Podzolic-acidic
14	J&K	Jammu	Ravi-Tawi	Sandy loam
14	H.P.	Palampur	Hilly area	Podzolic- silty clay loam
15	Assam	Jorhat	Jamuna	Sandy clay loam
15	West Bengal	Gayeshpur	DVC	Sandy loam
17	Meghalaya	Shillong	Hilly area	Sandy loam-acidic
19	Kerala	Chalakudy	Chalakudy	Loamy sand
19	Gujarat	Navsari	Ukai- Kakrapar	Clay
19	Maharashtra	Dapoli	Hilly area	Laterite

Drip Fertigation Technology in Cotton-Vegetable Crop Sequence for Higher Returns (Sriganganagar)

Relevance

The water availability in the state of Rajasthan is only 1.16% of the total water availability in the country. The inadequate and uncertain rainfall, high evaporative demand and very low water holding capacity of sandy soils expose the vegetation to serious risks of drought. Acute scarcity of rainwater and vagaries of rainfall force the farmers to use precarious groundwater. The groundwater resources of the state are highly deficient both in quality and quantity. The groundwater is in general brackish. Thus, the crop production is mainly dependant on canal irrigation. The water availability in canal commands is also inadequate and uncertain. Thus, pressurized irrigation and fertigation is the only option to improve water and fertilizer use efficiency and to improve livelihood of the farmers.

Description of the technology

Optimum crop geometry, optimum irrigation schedule and optimum fertigation schedule has been developed for Bt cotton. The same drip layout was found suitable for subsequent vegetable crops (brinjal, tomato and chilli). The paired planting of 120 cm x 60 cm x 60 cm was found optimum for cotton as well as vegetables. The irrigation and fertigation schedule for vegetables have been optimized. To make the system more sustainable and profitable low tunnel technology in vegetables was adopted. Moreover, dry sowing of cotton and subsequent irrigation with drip has been standardized to cover more area under cotton as sowing time of cotton coincide with canal closure for annual canal maintenance. The irrigation schedule has been recommended 1.0 ETc for Bt cotton, brinjal and chilli and 0.8 ETc for tomato. The fertigation schedule has been recommended 80% RD+2% KNO_3 for Bt cotton in 6 splits at 15 days interval, 80% RD for brinjal in 12 splits at 10 days interval and 120% RD for chilli in 9 splits at 13 days interval.

Output and scalability

Cotton–vegetable crop sequence with drip fertigation is remunerative and most suitable for irrigated north western plain zone of Rajasthan. It increased cotton yield by 31% and vegetables yield by 31-55%, saved irrigation water in cotton by 25% and in vegetables by 30-45% and saved fertilizers by 20%. The technology has been adopted by the farmers of Sriganganagar and Hanumangarh districts of Rajasthan. This technology can also be popularized among farmers in other cotton growing districts of Rajasthan.

Drip fertigation in cotton–vegetable crop sequence

Managing Poor Quality Groundwater in Cyclic Mode with Canal Water and using Mulch for Cultivation of Potato (Bathinda)

Relevance

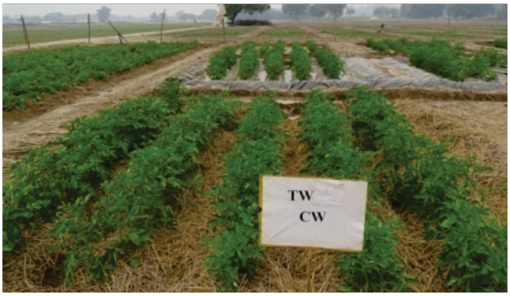
Potato cultivation is practiced on approximately 85000 ha area in the state of Punjab. In south-western region of Punjab, the underground water quality is brackish. Continuous use of such waters deteriorates the physical and chemical properties of soil. Conjunctive use of poor quality water with good quality water helps to ameliorate the harmful effect of poor quality water on soil thereby sustaining the tuber yield. Mulch is used to create congenial conditions for the growth which includes moisture conservation, soil temperature moderation, salinity and weed control. Black plastic elevates the soil temperature of surface layer facilitating early germination of potato tubers leading to earlier crop growth. Besides these benefits, straw mulch application adds organic matter to the soil.

Description of technology

An experiment was conducted to investigate the effect of different qualities of water and mulch application on tuber yield of potato and soil properties on loamy sand soil having low organic carbon, medium available phosphorus and high in available potash. The mulch treatments consists of no mulch, rice straw mulch @ 6 t/ha and plastic mulch (black,50 µ) and irrigation water quality comprises canal water (CW), tube well water of poor quality (TW) and alternate irrigation with CW/TW in a split plot design in permanent plots. The rice straw mulch and plastic mulch was applied immediately after planting of the crop. The residual sodium carbonate of the tubewell water and canal water was 6.4 meq/L and 0.5 meq/L and electrical conductivity was 2.2 and 0.45 dS/m, respectively.

Output and scalability

Under cyclic mode of CW/TW irrigation, straw and plastic mulch application produced 18.8% and 31.7% higher tuber yield compared with no mulch, respectively. The benefit cost ratio recorded with straw mulch(1.04) was higher than plastic mulch(0.97) due to low input cost of straw mulch irrespective of irrigation water quality. Alternate use of saline sodic water and good quality canal water (1:1) in potato is recommended to obtain 30.9% higher than marketable tuber yield. Application of rice straw mulch @ 6 t/ha (dry weight basis) along with cyclic use of CW/TW further improves the potato tuber yield and to maintain soil health on long term basis in south-west Punjab.



Mulch cultivation of Potato

Sodic Water Irrigation with Pressmud for Optimum Grape Yield (Bathinda)

Relevance

In Punjab, grape cultivation is generally practiced in south-western part of Punjab. This region is characterized by low rainfall, erratic and inadequate canal water supply and poor quality underground water. The continuous use of poor quality water affects the sustained production of grapes in the area. Application of pressmud (by-product of sugarcane industry) along with irrigation with poor quality underground water helps in improving the physico-chemical properties of soil and reduces the harmful effect on soil due to its acidic nature.

Description of technology

An experiment was carried out on sandy loam soil at research farm of PAU Regional Station, Bathinda to investigate long term effect of poor quality water on the performance of grapes [*Vitis vinifera* L. (cv. Perlette)], water productivity and soil properties with the application of different amendments. Alternating irrigation of canal and poor quality tubewell water (CW/TW) and irrigation with tubewell water along with sulphitation pressmud @ 6 kg/vine were compared with CW and TW water irrigation alone. The sulphitation pressmud was applied every year after pruning during the month of January. The electrical conductivity and residual sodium carbonate of tubewell water was 2.1 ds/m and 6.4 me /L, respectively.

Output and scalability

The treatments CW/TW and TW + sulphitation pressmud significantly increased the grape yield by 28.3 and 31.0% respectively as compared to TW alone. Application of sulphitation pressmud and cyclic use of canal and ground water helped in improving the soil health and decreasing the pH and SAR of the soil. Irrigation with tube well water caused detrimental effect on soil quality as it resulted in highest pH, EC, SAR values and lowest OC of the soil. Thus, in light textured soils of south-west Punjab, underground sodic water can either be used with the application of sulphitation pressmud @ 6 kg/vine on dry weight basis every year after pruning in the month of January or can be used alternately with canal water for higher productivity of grapes and minimal adverse effect on soil health.

Grape Cultivation under sodic water Irrigation

Reclaiming Sodic Waters through Gypsum Beds (Hissar)

Relevance

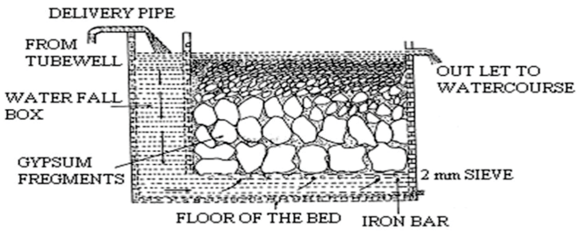
In the North-western arid and semiarid regions of India, good quality water for irrigation in scarce input inhibiting the full exploitation of other production inputs for achieving potential crop yields. About 40% of the groundwaters, predominant in the Haryana, Punjab, U.P. and Rajasthan are sodic in nature. To increase the irrigation potential of an area exploitation of such marginal ground water is essential. A relatively more economical and efficient method using gypsum clods through a chamber was developed in which sodic waters are reclaimed before entering the field without affecting soil and crops. There is no requirement of fresh water and the amount of gypsum needed is relatively less compared to its direct application in the field.

Description of Technology

Gypsum chamber/bed: It is a brick-cement-concrete chamber, the size of which depends primarily on tube well discharge and its sodicity. This chamber is connected to a waterfall chamber on one side and irrigation channel on the other. The partition wall between the waterfall box and gypsum bed is provided with a 10 cm slit at the bottom to allow the entry of water in the gypsum bed from below the iron bars. A net of iron bars covered with wire net (2 mm x 2 mm) is fitted at a height of 10 cm from the bottom of the bed to hold the gypsum fragments. Water from waterfall box enters into the bed from below the iron net, comes vertically up and then flows out in the irrigation channel after dissolving gypsum. The bed is filled with gypsum fragments and regularly replenished at about 20 to 25% depletion of bed due to gypsum dissolution. With a little modification, farmers can easily convert waterfall chambers of their tubewells into gypsum chamber. The cross section of composite gypsum bed is shown in figure below.

Output and Scalability

The technology results in 20-30% higher crop yields, especially when higher sodicity irrigation water is used. It is Cheaper, economically viable and practically feasible for the farmers. There is no possibility of non-uniform application of gypsum in the field as the sodic water is reclaimed in the chamber itself before reaching the field. It does not require micro level field leveling It saves in energy used for powdering and bagging. The gypsum clods can be stored in the open.



Cross section of composite gypsum bed

Drip Fertigation Technology for Higher Water use Efficiency and Quality of Sugarcane in North West Plain Zone of Rajasthan (Sriganganagar)

Relevance

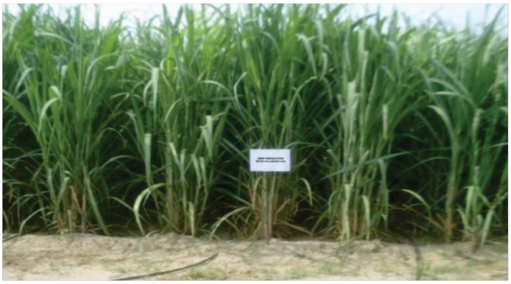
Sugarcane is an important commercial crop grown in irrigated north west plain zone of Rajasthan. It is a remunerative crop. Its water requirement is the highest (1500-1750 mm) among the crops grown in the region. There is only one sugar mill in Sriganganagar district of Rajasthan.The water availability is the major constraint in this zone. The introduction of drip irrigation in sugarcane is the only option for increasing production & quality of cane and save precious irrigation water as well as nutrients.

Description of the technology

Optimum crop geometry, optimum irrigation schedule and optimum fertigation schedule has been developed for sugarcane. The recommended row to row spacing for sugarcane is 75 cm. To make the system cost effective paired row planting was tested with single row planting. The paired planting of 90 cm x 60 cm was found optimum for sugarcane. The drip line was placed within the pair. Dripper to dripper distance was kept 30 cm and the discharge of each dripper was 2 lph. The irrigation schedule at 80% pan evaporation was found optimum for sugarcane. The month wise irrigation schedule in terms of time period was recommended. The fertigation schedule at 75% RD (150 kg N & 40 kg K_2O per hectare) in 9 equal splits at interval of 21 days was found optimum for sugarcane. The full dose (40 kg P_2O_5 /ha) of phosphorus was applied as basal at the time of sowing.

Output and scalability

Drip irrigation and fertigation in sugarcane increased cane yield by 26%, water saving by 21% and sugar recovery by 46% in comparison to conventional flood irrigation. The net income under drip system of irrigation was Rs. 2,06,197 as against Rs. 1,59,205 per hectare under flood irrigation. The benefit cost ratio of drip irrigation was 1.65 as against 1.55 in flood irrigation. The technology is being adopted by sugarcane growers in the region. The sugar mill is also encouraging the farmers to adopt drip irrigation and fertigation as this technology increases sugar recovery.



Drip irrigation and fertigation

Conventional flood irrigation

Cluster Bean-Wheat Cropping Sequence for Higher Water Productivity in South-West Region of Punjab (Bathinda)

Relevance

The south-western zone of Punjab is at the tail end of the canal irrigation system. Hence it is prone to the uncertainty and inadequacy of canal water. The irrational and discriminate use of water over last four decades has led to water scarcity due to monoculture of cotton and wheat in Punjab state. Therefore, cluster bean-wheat system which includes cereal and leguminous crop fulfills the basic rule of crop rotation for efficient utilization of water and nutrients in coarse textured soils ultimately leading to sustenance of soil health and higher monetary gains. Thus, it also accomplishes the need for crop diversification and intensification.

Description of technology

Nine crop sequences viz., wheat–*Bt* cotton, wheat-cluster bean, wheat-green gram, barley-*Bt* cotton, barley-cluster bean, barley-green gram, raya-*Bt* cotton, *raya*-cluster bean, *raya*-green gram were compared to find out the feasible cropping sequence for system productivity and water expense efficiency. Among these cropping sequences, cluster bean-wheat sequence was more cost-effective. Nearly 22.5 cm saving of water was observed under cluster bean than cotton. Also, 5.3 % yield benefit has also been measured in wheat grown in rotation with cluster bean than cotton. Since, after the harvest of cluster bean crop, it returns considerable amount of organic matter to the soil surface as mulch.

Output and scalability

It was found that the cotton equivalent yield of cluster bean-wheat (3035 kg/ha) was statistically at par with cotton-wheat (3276 kg/ha) system. The benefit cost ratio was higher in cluster bean-wheat (2.36) than cotton-wheat (1.37) due to lower input cost in cluster bean, which resulted in nearly Rs. 26000 per hectare increase over cotton-wheat rotation. Water productivity of cluster bean-wheat cropping system was 0.36 kg/m^3 which was the highest among other cropping sequences. Moreover, the organic carbon status of surface layer of soil in cluster bean based cropping sequences significantly improved as compared to cotton based cropping system. Cluster bean-wheat cropping system can replace the existing cotton-wheat cropping system, which will encourage crop diversification along with sustenance of soil and water resources and higher economic returns, water productivity and maintenance of soil health in semi-arid region of Punjab.

Clusterbean - wheat Sequence in canal command

Method and Scheduling of Irrigation in Turmeric (Morena)

Relevance

Turmeric (*Curcuma longa* L.) is an important condiment and a useful dye, with varied use in drug and cosmetic industries. India is one of the leading growers, with about 90,300ha area under this crop, producing 1,53,900 tonnes per annum. Turmeric is having wider adaptability and high yield potential.

Description of the technology

An experiment in split-plot design with four replications was conducted during 2012 and 2013 on sandy clay loam soil of Morena, Madhya Pradesh. Sixteen treatment combinations, comprising four method of irrigation viz. porous pipe, drip, furrow and check basin in main plots and four irrigation scheduling *viz*., 0.4, 0.6, 0.8 and 1.00 IW/CPE ratio in sub-plots. The recommended dose of fertilizer 150 kg N, 125 kg P_2O_5, 125 kg K_2O per ha with 20 t/ ha FYM were applied. Roma verity was sown with a seed rate 2500 kg/ha in third week of June and harvested in last week of December. The ridges and furrows are prepared and the rhizomes were planted in shallow pits on the top of the ridges. Spacing adopted 45 cm between the ridges and 20 cm between plants. There mulching was done first after planting and second and the third at internal of 45 days. The porous pipes were bury in the ridges at the time of ridges preparation. The drip line were placed both side of the ridges. Irrigation depth of 7 cm of was applied as per treatments in surface irrigation methods.

Output and scalability

Among, the irrigation methods, irrigation through porous pipe produced significantly higher rhizomes yield in both years and pooled over two years (19.98 t/ha) followed furrow irrigation method (19.13 t/ha) which was also significantly higher than drip irrigation (14.20 t/ha) and check basin method (10.82 t/ha). Turmeric crop required continuous wetted/moist soil for its better growth. Perhaps, this is the reason for higher productivity in porous pipes irrigation. Irrigation schedule of 0.8 IW/CPE ratio resulted significantly higher rhizomes yield (18.65 t/ ha) followed by 1.00 IW/CPE ratio (16.20 t /ha). The highest net returns (Rs. 3,27,804 per ha), additional returns (Rs. 1,84,708 per ha) and B:C ratio 5.60 were registered with irrigation through porous pipes. Further, the maximum net returns of Rs. 3,02,565 per ha, additional returns of Rs. 1,03,717 per ha and B:C ratio of 5.29 were realized with irrigation schedules of 0.8 IW/CPE ratio. The micro irrigation technology saves 70 – 90% water over surface irrigation. It increase the yield, improved the quality of produce, reduces the labour cost, weed population, and allows chemical/fertilizer to be used through this method. This technology is demonstrated through department of horticulture on progressive farmers fields and farmers are satisfy from this newly technology for further adoption. This is newly introduce crop in the area.

Application of irrigation through porus pipe and irrigation at 0.8 IW/CPE

Rhizome production with of irrigation through porus pipe at 0.8 IW/CPE

Irrigation Method, Scheduling and Fertility Levels on Soybean-Chickpea Cropping Sequence in Alluvial Soils (Morena)

Relevance

The demand for pulses and vegetable oils is increasing at a very high rate due to the increasing population, improvement in standard of living, industrialization of new demand for bio fuel. Oilseeds and pulses are energy-rich crops on demand higher nutrition for their optimum production. Low productivity of pulses and oilseeds is due to sowing of crop in rainfed conditions, limited soil moisture with inadequate and imbalance use of nutrition. In oilseed, inclusion of leguminous crops in sequence may help economize the fertilizer 20-40 kg N/ha. Fallow-mustard is a dominate practice in the region form long time which yield is decline due to emergence of new disease like white rust and stem rot. Therefore, soybean is better option to include with *rabi*, pulses like chickpea, lentil, pea, etc., to the increasing demand of vegetable oils and pulses and to maintained the soil health.

Description of the technology

The field experiment was conducted during 2011-12 and 2012-13 at research farm, Morena, Madhya Pradesh. The climate of the zone is semi-arid, sub-tropical with annual rainfall of 700 mm. The sandy loam soil of experimental field with available N, P, K was 134.1, 12.9 and 312 kg/ha, respectively. The experiment was laid out in split plot design with three replications. Keeping three scheduling of irrigation (0.4, 0.6 and 0.8 IW/CPE) and two method of irrigation (check basin and sprinkler method) in main plots and four fertility levels *viz*. recommend dose of fertilizer (30N :60P_2O_5 :20K_2O kg and 10 t FYM ha^{-1} for both crops), 125% RDF, 75% RDF + 25% FYM and 50% RDF + 50% FYM ha^{-1} in sub plots. The crop variety JS 93-05 of soybean and JG-16 chickpea were sown at a seed rate of 80 kg ha^{-1}. The recommended packages of practices were adopted during crop growth period.

Output and Scalability

The irrigation scheduling method of irrigation and fertility levels showed significantly effect on seed yield of soybean and chickpea in both the year and pooled over two years. The maximum seed yield of soybean and chickpea were record with 0.6 IW/CPE ratio 2.39 t and 2.77 t/ha, sprinkler irrigation method 1.95 t and 2.57 t /ha and fertility levels 125% RDF 1.93 t and 2.67 t/ha, respectively. The maximum net returns of soybean and chickpea were realized with 0.6 IW/CPE ratio Rs.66,898 and 84,877 per ha, sprinkler irrigation method Rs. 51,536 and 77,595 per ha and 125% RDF Rs. 52,236 and 80,875 per ha,respectively.The additional returns and B:C ratio also recorded higher as mentioned in above treatments.

Soybean-Chickpea Cropping Sequence

Improving Irrigated Productivity of Blackgram - Rajma Cropping System in Sandy Loam Soil of Chambal Command Area (Morena)

Relevance:

The depletion of soil fertility by the intensive cereal-cereal base production system and absence of irrigation are considered to be a major cause of the yield decline. Pearlmillet-wheat cereal based cropping system in the region has also resulted second generation problems for reducing crop productivity and soil health. To over cane these problems, a cropping system using legumes (blackgram-rajma) under different irrigation and fertilizer levels can be evolved.

Description of the technology

An experiment was conducted in Morena where mean annual rainfall is 700 mm. The soil of the experimental field was sandy loam with low available nitrogen and medium available P and K.The experiment was laid out in split plot design with four replications.Twelve treatment combination comprising three irrigation schedule *viz.* 0.4, 0.6 and 0.8 IW/CPE ratio in main plots and four fertility levels *viz.* recommend dose of fertilizer (Blackgram–20N :60P_2O_5 :20K_2O kg and 5 t FYM /ha and Rajma 100N :60P_2O_5 :40K_2O kg and 10 t FYM /ha), 125% RDF, 75% RDF + 25% FYM and 50% RDF+50% FYM /ha in subplots.The Pant-35 and Rekha variety of blackgram and rajma were used for sowing, respectively. Irrigation was applied at a depth of 70 mm.

Output and Scalability

The application of fertilizer at the rate of 75% RDF and 25% FYM /ha registered the highest seed yield (1355 kg/ha) pooled over two years. Under this treatment maximum net return of Rs. 50,005 per ha, additional returns of Rs 9,718 per ha and B:C ratio of 5.89 were noticed. The irrigation and fertility levels significantly marked the seed yield of rajma. However, maximum seed yield (1362 kg /ha), net returns (Rs.85,974 per ha), additional returns (Rs.27,452 per ha and B:C ratio 4.30 were records under 0.6 IW/CPE ratio.The highest seed yield (1294 kg/ha), net returns (Rs.78,611 per ha), addition returns (Rs.17,952 per ha) and B:C ratio 3.97 were also realised with 125% RDF.The technology is demonstrated in ORP area and progressive farmers of this region.

Crop stand of 125% RDF under Blackgram

Crop stand of irrigation schedules 0.6 IW/CPE and fertility levels 125%

Irrigation Timing and Tillage Impact on Wheat after Harvest of Clusterbean (Morena)

Relevance

Clusterbean – wheat sequence has proved to be profitable in north India. Clusterbean (*Kharif*) takes 125 to 170 days duration for maturity depending upon quantity and intensity of rainfall. Harvesting of clusterbean in these regions generally gets delayed from last week of November to whole month of December. After harvesting of clusterbean crop, sowing of wheat is delayed due to 4 to 6 tillage operations performed after pre-irrigation for seed bed preparation. Management of irrigation timing and conservation tillage is the only way to mitigate the adverse effects of late sowing on productivity of wheat crop grown under clusterbean – wheat sequence. Keeping these points in view, a study was conducted to investigate the effect of irrigation timing and tillage practices on wheat under clusterbean - wheat crop sequence in semi-arid climatic conditions.

Description of the technology

The treatment consisted of irrigation timing, *viz*. dry sowing of wheat crop just after harvest of clusterbean and irrigation for germination (DS) and pre sowing irrigation after harvest of clusterbean (PIS) in main plot and tillage practices before sowing in sub plots such as conventional tillage (CT), minimum tillage (MT) and zero tillage (ZT). The climate of this zone is Semi-arid sub-tropical with annual rainfall of 700mm. The recommended dose of fertilizers for this zone was 100 kg N, 60 kg P_2O_5, 40 kg K_2O and 20 kg $ZnSO_4$ per ha for wheat. Wheat variety 'GW-366' @ 120 kg/ha was sown in all the treatments after harvest of clusterbean. The recommended critical stages for irrigation of wheat crop were crown root initiation, tillering, flowering, milking and grain development.

Output and scalability

Sowing of clusterbean by DS method as compared to PIS and ZT as compared to CT significantly influenced the growth parameters, yield, net profit, benefit cost (B:C) ratio, productivity of water as compared to PIS. However non-significant difference in growth parameters and yield were observed between MT and CT. The increase in grain and stover yields by 6.8 % and 6.1 % was observed with DS as compared to PIS system. Maximum cost of production was observed with CT as compared to MT and ZT. Total water-used in case of clusterbean by PIS method was significantly higher as compared with DS method, whereas reverse trend was observed in water use-efficiency. Similarly, total water use by wheat was significantly higher in CT (33.52 cm) as compared to ZT (30.90 cm), whereas maximum water use-efficiency in ZT was 152.17 kg grain/ha-cm followed by MT (140.42 kg grain/ha-cm) and CT (137.59 kg grain/ha-cm).It is concluded that under late conditions dry sowing of wheat just after harvest of clusterbean crop without any tillage to be promising options on sandy loam soil and semi-arid climatic conditions of India.

Conventional tillage sowing by single box seed drill

Minimum tillage sowing by seed cum fertilizer drill

Sowing of crop by zero till seed drill

Broad Bed Furrow Technology for Increasing Water Productivity of Soybean in Rajasthan (Kota)

Relevance

Soybean is an important oilseed crop of South Eastern Rajasthan. Most of the farmers of south eastern Rajasthan depends on monsoon to grow soybean. Low productivity of soybean is due to erratic and unequal distribution of rainfall. The crop water requirement of the soybean is 450-700 mm and generally requires 3 to 4 Irrigation during *Kharif* Season. *In-situ* rain water management can be carried out through land configuration techniques (BBF) to increase productivity and water Productivity of soybean.

Description of technology

The broad bed furrow (BBF) machine was developed basically to cope up with the problem of moisture stress in the soybean fields. The soil moisture is managed by maximizing the use of rainfall through increasing infiltration and moisture retention and reducing runoff and soil erosion. Thus, by this machine, the performance of high yielding improved varieties of soybean is optimized as the deep furrows created under BBF provides effective drainage during excess rains, while serves as *in-situ* moisture conservation during dry spells, thus mitigating the detrimental effects of both extreme situations. Three rows of soybean having 30 cm spacing between rows were sown by BBF planter, which ultimately increase over all water productivity.

Output and scalability

By adopting BBF technique, water availability and water utilization by crop increased to greater extent and 30% saving of irrigation water was observed, it can be utilized to irrigate another crop or expansion of soybean area. The cost of cultivation of BBF technology is low by saving of labour, water, inputs etc. and it can generate additional income of about Rs. 10000 to 12000 per ha as compared to normal sowing of soybean and also minimize the risk of crop failure due to heavy rainfall. The technology has give yield information due to BBF been adopted by farmers of South Eastern Rajasthan.

BBF (3 rows) Soybean

Enhancing Productivity of Wheat through Zero Tillage in Canal Command (Kota)

Relevance

Rice-wheat cropping system is a dominant cropping system on fertile and irrigated vertisols of humid south eastern plain zone of Rajasthan. In this region, conventional crop establishment practice in rice involves manual transplanting of rice in puddle soil, where as wheat is seeded in well- prepared fine seedbed. These practices involve excessive tillage and hence, result not only in high-energy consumption but also in deterioration of soil structure. Rice stubbles create a problem to complete tillage operation with in short period. Under this situation, zero tillage offers the benefit of saving of fuel, time, labour, retained surface residue, improve organic carbon, nutrients, reduced soil water, protect the soil from the sun, rain, wind and allows soil micro-organisms, fauna, reduces the breakdown of the soil structure. It is, therefore, necessary to manage the inflow of organic sources of nutrient optimally through residue management under zero tillage condition and their integration with fertilizers

Description of technology

Due to shortage of time between harvesting of rice and sowing of wheat under rice-wheat cropping system, zero tillage with proper irrigation management can help to mitigate the adverse effect of conventional farming practices by increasing soil organic carbon, increased soil moisture availability and sustainability of production system in a long run. Growing of two cereal crops in a year involves heavy removal of plant nutrients, which diminishes the soil fertility. However, wheat grown under zero tilled condition requires 25 % more of recommended dose of inorganic fertilization as compared to conventionally tilled field under rice-wheat cropping system the zero tillage machines was developed basically to cope up with the problem of low irrigation water and delay availability by canal for pre sowing irrigation in wheat crop.

Output and scalability

The technology is suitable in rice-wheat cropping system where duration between harvesting of rice and sowing of wheat is quite less. After initial investment on purchasing of zero tilled machine, technology is very beneficial for the farmers of the command area. Due to adoption of this technology 6 cm irrigation water was saved with the addition of 2 to 3 t/ha organic matter to the soil.There was no significant yield increase due to zero tillage. However, net return of Rs. 5000 to 10,000 can be achieved as compared to conventional system.

Zero Tillage Method

Mini Sprinkler Irrigation for Higher Productivity of Wheat in Chambal Command Area of South – East Rajasthan (Kota)

Relevance

Chambal command area of South-Eastern Rajasthan is predominantly a wheat growing area; farmers mainly follow Soybean–Wheat cropping system. Paddy is another major kharif crop, while Mustard and coriander are other major rabi crops. Farmers of the area irrigate their fields by traditional methods, and are reluctant to adopt the pressurized irrigation methods, as there is enough availability of irrigation water in the canal system. However, sprinkler irrigation is need of the hour for enhancing water productivity, in heavy clay soils, traditional hand move system with high discharge rate have lesser adoptability in comparison to low discharging mini sprinklers and need to be popularized.

Description of the Technology

Sprinklers are suited best for sandy soil with high infiltration rates although they are adaptable to most soil types. The average application rate of the sprinklers (in mm/hour) should be lower than the basic infiltration rate of the soil so that surface ponding and runoff can be avoided. Compared to "large" sprinklers, "Mini" sprinklers have a relatively low discharge rate, radius of throw and can operate at low pressures and flow conditions. Mini sprinklers having discharge of 600–800 litre per hour, can be laid out at a spacing of 8 m x 8m, and is suitable for most of the field and vegetable crops. Doption of Mini sprinkler irrigation technology is suitable for most of the medium height crops like wheat, coriander, gram, green gram, black gram etc. and vegetables. The initial installation cost is high; it comes around rupees 125000 to 150000 / hectare.

Output and scalability

The adoptions mini-sprinklers in wheat crop revealed that, maximum and significantly higher wheat yield (57.52 q/ha) was observed when irrigation was applied at IW/CPE ratio = 1.0, with 25% of recommended dose (120 kg/ha) of Nitrogen as basal and remaining 75% in equal splits with irrigation as fertigation. This also resulted in mean maximum water use efficiency (18.89 kg/ha-mm).This technology not only resulted in increased crop production, saving of irrigation water but also saved labour required for irrigation and applying fertilizer. Adoption of Mini sprinkler irrigation technology has a great potential in clay loam soils of Chambal command in south eastern part of Rajasthan.

Cultivation of Wheat with Mini-Sprinkler Irrigation

Wheat Based Intercropping System in Water Scares Area of Chambal Command (Kota)

Relevance

In Kota region, most of the area (about 47.2 %) is under Chambal command, but there is a considerable non-command area also. The non-command area and the tail end of canal system usually face the problem of water scarcity. In the area of soybean-wheat cropping system, wheat based intercropping with low water requiring crops is a solution for getting higher productivity and net remunerations.

Description of technology

The most common advantage of intercropping was the production of greater yield on a given piece of land by making more efficient use of available resources. The utilization of limited agriculture land through multiple cropping to increase productivity per unit area of available land. Sowing of wheat based intercropping system, by seed drill machine under limited irrigation water condition and in this system taken only low water requiring crops i.e. durum wheat, chickpea, mustard, fenugreek and field pea. Two irrigations ware given only in wheat crop and moisture reach in the root zone of intercrop, ultimately increase water use efficiency of the system.

Output and scalability

The technology is suitable for sowing of low water requiring wheat based intercrops in the low irrigation water availability as well as tail end reach area of canal. In wheat based intercropping system, sowing of wheat + gram (6:4) intercrop and irrigation schedule at IW/CP 0.6 gave maximum wheat equivalent yield and saved irrigation water. Adoption of the technology is increased area 10 to 25% under tail end reach in *rabi* season. The cost of cultivation per ha area of intercropping system is low and it can generate additional income of Rs. 10000 to 15000 per ha compared to sowing of sole wheat. By the wheat + gram intercropping system, maximum benefit cost ratio of 3.3 can be achieved over sole wheat and also minimized the risk of crop failure. The technology has been adopted by farmers of South Eastern Rajasthan.

Wheat + Gram (6:4)

Wheat + Mustard (6:4)

Alternatively Alternate Furrow (AAF) Irrigation in Maize and Cotton in Malaprabha Command (Belvatgi)

Relevance

Maize and cotton are the major crops in Malaprabha command area during kharif / rabi season. Farmers irrigate for both the crops at every furrows in vertisols of Malprabha command area. Instead of irrigating for every furrow the alternatively alternate furrow is the new proven technology, which saves about 40% of irrigation water. Use of less water in vertisols prevents soil salinity.

Description of technology

Maize/cotton planting is done on flat beds during June/July after rainy season starts or common pre sowing irrigation at spacing 60 X 20 cm for maize and 120 X 60 cm for cotton. During 1st irrigation schedule irrigate at 0.6 IW/CPE ratio level only for odd numbers of furrows like 1, 3, 5 etc. Afterwords for 2^{nd} irrigation schedule at 0.6 IW/CPE ratio irrigate every even number of furrows 2, 4, 6 etc. Hence, by adopting this proven technology AAF irrigation we can save up to 40% of irrigation water.

Output and scalability

This proven technology is very much popular in Malaprabha command and farmers are adopting for saving of irrigation water. The AAF technology can be adopted in any region of the country Where Maize and Cotton is growing in *vertisols.* This AAF technology saves water, time and labour. This avoids over irrigation in command area and soil salinity.

AAF method of irrigation in maize crop

AAF method of irrigation in cotton crop

Border Strip Irrigation With 80% Cutoff Length in Wheat and Chickpea (Belvatgi)

Relevance

Wheat and chickpea are major crops in Malprabha command area during Rabi season. Boarder strip method of irrigation for wheat and chickpea is proven technology and popular. Farmers irrigate the whole length of boarders strip at every schedule of irrigation. Irrigation with 80% cutoff length in boarder strip irrigation will prevent over irrigation and soil salinity in *vertisols* of Malaprabha command area.

Description of technology

Narrow spaced crops like wheat and chickpea planting is done on flat beds during rabi season after rainy or common pre sowing irrigation. Formation of boarder strip width about 2 to 5m and length is about 100 to 150m will be done after sowing. For every schedule, instead of irrigating whole length boarder will only irrigate boarder strip at every 80% and stop water for remaining 20% will cover recession flow of water. This technology will save about 20% of water in border strip irrigation. This technology avoid over irrigation and saves water in *vertisols.*

Output and scalability

This proven technology has become very much popular in Malaprabha command and farmers are adopting it for saving of water. The 80% cutoff length of border strip irrigation technology in narrow spaced crops *viz*., wheat and chickpea crops can be adopted in vertisols of any region of the country. This proven technology will saves water, time and labour. This avoids over irrigation in command area and soil salinity.

Border strip with 80 % length cutoff method of irrigation in chickpea crop

Border strip with 80 % length cutoff method of irrigation in wheat crop

Water and Nutrient Management in Bt-Cotton in Vertisols of Malaprabha Command Area (Belvatgi)

Relevance

India has the largest area under cotton and ranks second in cotton production. However, the productivity of cotton in India (555 kg/lint/ha) is below the world average (790 kg lint/ha). Introduction of Bt-cotton hybrids has resulted in substantial increase in yields owing to effective bollworm control and the consequent economic benefits and drastic reduction in the use of chemical insecticides leading to environmental benefits. There is rapid increase in the Bt cotton area in Malaprabha Command. The water and fertilizer are the key inputs for improving cotton productivity, .Hence, the study was undertaken to find out optimum water and nutrient requirement for Bt-cotton.

Description of technology

Experiment was laid out in split plot with irrigation levels (I_1 = 1.0 IW/CPE, I_2 = 0.8 IW/CPE and I_3 = 0.6 IW/CPE) as main plots and RDF levels (F_1 = 100% RDF, F_2 = 125% RDF, F_3 =150% RDF and F_4 = 175% RDF) as sub plots. The recommended dose of 120:60:60 NPK kg/ha was applied in the form of urea, single super phosphate and muriate of potash. The fertilizer 120:60:60 N:P:K kg/ha for F_1 (100% RDF) and for remaining fertilizer levels was applied as per the treatment. N, P and K were applied in the form of urea, single super phosphate and muriate of potash. Bt cotton hybrid (H xH) was sown by hand dibbling method with a plant spacing of 90 X 60 cm. The whole amount of P and K and 50% N were applied at sowing. Remaining 50% N was applied in three equal splits at 50, 80 and 110 days interval after sowing. Plant protection measures were taken for thrips, mites and jassids as per recommendations.

Output and scalability

Irrigation at 0.8 IW/CPE ratio with application of 175% RDF cotton can increase uptake of plant nutrients N,P and K and thereby increase seed cotton yield significantly. However, considering WUE and B:C ratio 150% RDF is better. Further 125% RDF is more economical and beneficial for farmers to get economically good yield. Irrigation at different levels i.e. 0.6 IW/CPE, 0.8 IW/CPE ratios and 1.0 IW/CPE ratio not produced any significant difference in the Bt cotton yield. To save the irrigation water scheduling of irrigation at 0.6 IW/CPE ratio (4-5 irrigations) is recommended and to save the fertilizer 125% RDF(150:75:75 N:P_2O_5: K_2O kg/ha) is recommended to Bt-cotton (HxH) for higher economic yield in Vertisols of Malaprabha Command Area.

100% RDF + FYM 10t/ha and 4-5 Irrigations (0.6 IW/CPE)

125% RDF + FYM 10t/ha and 4-5 Irrigations (0.6 IW/CPE)

Paired Row Planting for Sugarcane with Intercropping (Rahuri)

Relevance

Sugarcane being the major crop in the irrigated tract of western Maharashtra and parts of Marathwada, was grown with same old practices of cultivation viz. 90 x 30 cm ridges and furrows being planted with three eye bud sets with high density planting as well as surface irrigation with unlimited water. As a feedback from some of the farmer and sugar factories regarding reduction in sugarcane yields, sugar recoveries, illness of soil and loweconomic returns an experiment was conducted to change in the layouts, spacing, methods of planting and planting of intercrops for getting higher yields, maximum water saving and additional income from the intercrops to compensate the expenditure on cost of cultivation.

Description of the technology

The experiment was carried out with different planting techniques consisting of single row planting (150x30 cm, 180 x30 cm, 270 x 30 cm) and paired row planting (75-150 x 30 cm, 90-180x30 cm, 90-270 x 30 cm). The intercropping of cucumber and watermelon was done with sugarcane based cropping. The recommendation given was in deep clay soils of semiarid climatic conditions of Maharashtra, planting of *suru* sugarcane at a distance of 90–180x30 cm in paired row planting and cucumber, cabbage, potato, gram, soybean , watermelon, onion as intercrops are recommended under drip irrigation for getting higher yield (185.67 t/ha), higher monetory returns (Rs. 2,44,063 ha) and maximum saving of water (51%) with high water productivity (1.7 t/ha cm). The recommendation was passed in the JOINT AGRESCO and was then recommended for transfer of technology to the Government of Maharashtra and sugar factories in the state.

Output and scalability

The impact of the recommendation was so large that the sugarcane farmers are growing sugarcane on paired row planting at a distance of 90-180x30 cm with different intercrops like cucumber, cabbage, potato, gram, soybean , watermelon, onion etc. The wide row spacing gave more number of tillers, aeration, more space for the crop to grow luxuriously and intercrops were very easily harvested till the main crop comes to the stage of earthing up. The intercrops were not needed to be looked after separately since irrigation, fertilization and management was done for the main crop. So, without having any additional efforts and expenditure, the farmers could earn about Rs. 25,000 to 30,000 per ha from intercrops. This income could meet the whole expenditure of the main crop i.e. upto Rs. 30,000 to 40,000 per ha. The yields of main crop sugarcane were not in any case hampered by the intercrop but over and above a saving of 25% N could be achieved by intercropping crops like gram and soybean. There is also a additional benefit of residue management which could be done through soybean, gram, cabbage, watermelon, onion leaves and straw which helped in increasing the biomass in rhizosphere thereby increasing the microbial population to boost the yields of main crop of sugarcane by 10 to 15% and also improve soil health.

sugarcane + Cucumber under drip irrigation system

Sugarcane + Watermelon under drip irrigation system

Drip Irrigation in Alternate Brinjal-Chilli Crop Sequences in Medium Deep Soil (Rahuri)

Relevance

The sugarcane being conventional crop of the area has very low productivity requiring more water and very low price for sugarcane. Sugarcane was grown on surface irrigation from many years because of which the soils are getting saline and saline sodic which leads to low productivity of sugarcane the by declining the economical status of the farmers. The conventional technology of growing sugarcane can be altered by changing the cropping sequences such as Brinjal-chilli both being vegetable cash crops which fetch higher market value during summer season which also equalizes the returns of sugarcane with saving of water to the tune of 20% . The reutilization of idle drip of previous sugarcane crop can be used efficiently.

Description of the technology

Experiment with different irrigation methods and cropping sequences were conducted to study the economic feasibility of alternate cropping sequences under different irrigation methods and the recommendation was passed in the JOINT AGRESCO. It was recommended that "For Western Maharashtra Brinjal-chilli crop sequence on drip irrigation is recommended for medium deep soil (60 to 90 cm) as an alternate crop sequence for sugarcane crop considering higher yield, water use efficiency and monetary returns". Brinjal and chilli crops sown in paired row planting with 90-180x60cm and 90-180x45cm, respectively in cropping sequence. Sowing of brinjal done in the month of May and harvested in October while chilli was sown in the same plot in the month of December and harvested in the month of May. The cost of intervention is Rs. 1 lakhs per ha.

Output and scalability

The conventional technology of growing sugarcane has been altered by changing the cropping sequences such as Brinjal-chilli both being vegetable cash crops which fetch higher market value during summer season which equalizes the returns of sugarcane with saving of water to the tune of 20% . The output of the technology is in terms of saving of water i.e. the amount of saved water is being utilized for irrigating more area. As the income is more the economic status of the farmers has raised. Hence, many farmers from irrigated tract are adopting this technology.

Drip Irrigation in Alternate Brinjal-Chilli Crop

Mini Portable Sprinkler Irrigation System for the Coastal Sandy Soils (Madurai)

Relevance

Under the constraints of sandy soil and underground saline water, normally the farmers of the coastal areas start their agricultural activity during receding monsoon to avoid total crop loss due to heavy rains during mid of the rainfall season. The success of the crop is fully dependent on the extend of rainfall during North East Monsoon season. In the month of Jan-Feb, irrigation becomes difficult by conventional methods in many areas and further non availability of electricity in the coastal areas forced the farmers to go for oil engines to pump water from shallow wells/ farm ponds with less water.

Description of Technology

Mini portable irrigation system is low cost simple irrigation system with one single head sprinkler system operates at 1.5 hp pump. This pump can create a pressure head up to 4 kg/cm cover an area of 0.06 - 0.07 ha in one hour with an irrigation depth of 10 to 12 mm. Since the sprinkler head is being fixed on an iron platform with30 m long flexible hose pipe, one unit can be used to cover 0.4 ha of crop and covers one ha in 5 to 6 hours. The system can be used for irrigating crops like brinjal, tomato, cluster bean, bhendi, annual moringa, curry leaf, etc. with poor quality saline water. Hence introduction of this technology for coastal sandy soils by utilizing the good quality water from the shallow low output wells/farm ponds will help to raise successful crops with high returns. Further, helps to reduce the saline water entry into aquifer due to over irrigation and saves irrigation water pumping with high output motors up to 50%.

Output and scalability

Field demonstrations have been organized in more than 10 locations under participatory mode involving farmers by providing the mini portable sprinkler irrigation systems with the funding from MoWR under FPARP the coastal district of Ramanathapuram in Tamil Nadu. The water was lifted and irrigated to the groundnut crop during stress period coinciding with the critical stage of peg formation and pod development stage. By providing life saving irrigation farmers could able to get highest groundnut yield of 2.40 t/ha and mean groundnut yield of 1.80 t /ha. The mean groundnut yield under conventional method was 0.70 t/ha. The yield increase over conventional method was 80 %.

Mini Portable Sprinkler Irrigation System

Sub-Surface Drip Fertigation in Sugarcane Cultivation in Tamil Nadu (Madurai)

Relevance

Sugarcane is one of the most important commercial crops grown in an area of around 3.0 lakh hectare in Tamil Nadu with an average productivity of 105 Mt ha. Efficient use of irrigation water and fertilizer becomes an important means to increase cane productivity the drip fertigation helps to supply the required quantity of irrigation water and nutrient to the root zone of the crop and thus increases use efficiency and results in higher crop and water productivity.

Description of Technology

Sub-surface drip system has to be designed and laid out based on the water source and pumping capacity of the electrical motor. Lay the drip laterals with 16 mm size to a depth of 25 to 30 cm just below the setts and the drippers must face upwards. A spacing of 180 cm is provided lateral to lateral. Use "Inline" laterals with an emitter spacing of 60 cm with 4 lph drippers. Thin wall laterals can be used for cost reduction. Necessary filters and fertigation units for system maintenance and injection of plant nutrients also provided. The irrigation is to be given to the crop on alternate days for light soils and once in two days for heavy textured soils at 100% pan evaporation. To ensure uniform and high germination it is better to irrigate the crop daily up to 15 days from planting of the setts. For fertigation, the entire recommended dose of fertilizer to the cane crop can be applied in the form of single super phosphate or DAP as basal and preferably in three splits (planting, 30 and 60 DAP). Recommended N and P can be applied in the form of urea and white potash through fertigation starting from 15 DAP up to 210 DAP at weekly interval.

Output and scalability

The sugarcane under drip fertigation system significantly increased sugarcane yield. The mean cane yield under drip fertigation system was 135 t/ha, which is 29% higher yield than the conventional method of sugarcane planting. It is also possible to save the water for the sugarcane crop to the tune of 24% by adopting sub-surface drip fertigation method.

Cultivation of Sugarcane with Sub-Surface Drip Fertigation

Alternate Wetting and Drying Irrigation in Transplanted Rice in Tamil Nadu (Bhavanisagar)

Relevance of the technology

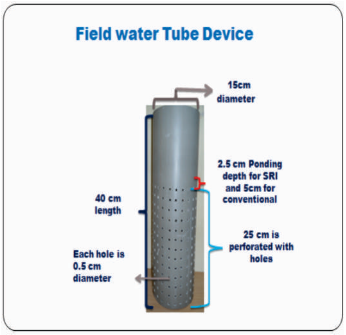
Alternate Wetting and Drying (AWD) may be a well known terminology with regard to rice irrigation. But the concept of intermittent irrigation is changed completely based on the depletion levels below the surface. IRRI has evaluated the AWD technique of irrigation and found AWD threshold of 15 cm as the suitable depletion level for sustained productivity. Therefore, a study was conducted to evaluate the field under AWD with water tube in transplanted low land rice condition to assess its efficiency and suitability.

Description of the technology

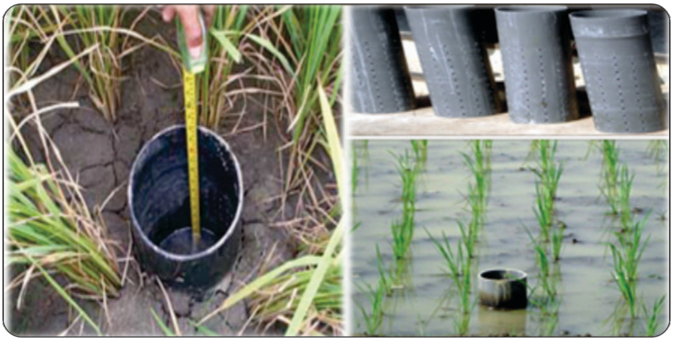
A practical way to implement AWD technique is to monitor the depth of ponded water on the field using a 'Field Water Tube' made of 40-cm long and 15 cm dia perforated plastic pipe inserted in soil to a depth of 25 cm. Take care not to penetrate through the bottom of the plow pan. Remove the soil from the inside so that the bottom of the tube is visible. Check that the water table inside the tube is the same as outside the tube. The tube can be placed in a flat part of the field close to a bund, so it is easy to monitor the ponded water depth. The different irrigation levels viz., Irrigation after 10 cm, 15cm, 20cm drop of ponded water (from ground level) from (seven days after) transplanting to 10 days prior to harvest.

Output and scalability

This technology is suitable to increase the water productivity and production of rice in sandy loam soil. The cost of intervention of technology is Rs. 37,510.00 per hectare. Adoption of technology, irrigation after 15 cm drop in ponded water in field water tubes (DPW) upto maximum tillering stage (30- 35DAT) (from seven days after transplanting) and after that 10 cm DPW up to 10 days prior to harvest increased the production of rice about 12.7% and the technology generate an additional income of Rs.7,276.00 per hectare over conventional rice cultivation. The highest water use efficiency of 6.47 kg/ha.mm and net return of Rs.48,355 per hectare with a benefit cost ratio 2.27 can be achieved from this technology. This technology has been developed for the benefit of rice growing farmers of western zone of Tamil Nadu.



Field water Tube Device



Cultivation of Rice with Alternate Irrigation

Single Economical Drip Layout for Major Annual Commercial Crops (Bhavanisagar)

Relevance of the technology

Research studies have been conducted in many annual commercial crops with drip fertigation and the results revealed that there is yield increase, fertilizer saving and water saving. But the layout of the drip system (lateral spacing, dripper spacing, dripper discharge, arrangement of drippers) are different for different crops. Hence the farmers are facing much problem and they have to invest more for changing the layout for other crops. Hence single economical drip irrigation layout suitable for many annual commercial crops will be of much useful to the farmers to go in for any commercial crop without change in the drip layout system. The life of such system will also be more if it is laid permanently.

Description of the technology

This technology consists of a economical drip irrigation layout for optimal water and fertilizer requirement for various commercial crops like sugarcane, banana, turmeric, tomato and tapioca. Drip irrigation layout of 1.50 m lateral spacing with 4 lph drippers at 60 cm spacing along the lateral with drip fertigation 100% of recommended N & P is most suitable for sugarcane, banana, turmeric, tapioca, tomato and other annual crops without altering the layout for several years. In all the crops, paired row geometry is adopted.

Output and scalability

1.50 m lateral spacing for banana, turmeric, sugarcane and tapioca gave higher yields. Higher water use efficiency is achieved in the 1.50 m lateral spacing with 100% recommended N & K.The increase in cost of layout for 1.50 m lateral spacing when compared to 1.60, 1.65 and 1.80 m were only 4, 8 and 16% respectively.

Triangular method of planting – Banana

Paired row method – Sugarcane

Paired row method – Tapioca

Raised bed method - Turmeric

Irrigation and Fertigation Schedule in Sub-Surface Drip Irrigation for SSI in Tamil Nadu (Bhavanisagar)

Relevance

The Sustainable Sugarcane Initiative (SSI) is a practical approach to sugarcane production which is based on the principles of 'more output with less input'. SSI improves the productivity of water, land and labour. Sub Surface Drip Irrigation (SSDI) is becoming popular now a days because most favorable moisture and nutrient environment can be maintained in the root zone in SSDI. Because of long standing crop, SSDI is being increasingly adopted to Sugarcane. Though benefits of SSI under SSDI are realized by farmers, development of optimal irrigation and fertigation schedule for SSI under SSDI is essential for Western Agro climatic zone of Tamil Nadu for adoption.

Description of the technology

Optimum irrigation and fertigation schedule gives minimum loss of water and fertilizer. Subsurface drip irrigation is laid with 150 cm lateral spacing and sugarcane seedlings raised in protrays is planted 60 cm spacing along the laterals. Irrigation is given to sugarcane crops based on pan evaporation and fertigation is given based on recommended dose of Nitrogen and potassium.

Output and scalability:

Adoption of SSDI with 100% pan evaporation + 100% recommended dose of N and K through fertigation increased the sugarcane yield in SSI for Western Zone of Tamil Nadu particularly in areas where plenty of water is available. The highest net return of Rs. 2,30,000 per hectare with a benefit cost ratio of 2.8 can be achieved from this technology.In water scarce areas, subsurface drip irrigation with 60% PE+100% RD of N and K through fertigation can be practiced for lower water use and higher WUE. Water saving can be achieved upto 40% with a net return of Rs. 1,50,000 and benefit cost ratio of 2.1. This technology has been developed for the benefit of sugarcane growing farmers of western zone of Tamil Nadu.

Cultivation of Sugarcane with Sub-Surface Drip Irrigation and Fertigation

Irrigation and Fertigation Schedule in Turmeric under Different Lateral Spacing (Bhavanisagar)

Relevance

Turmeric is one of the important crops in the western zone of Tamil Nadu. In the common drip layout, 150 cm lateral spacing is recommended for turmeric such that one lateral covers four rows of crop. The lateral spacing of 90 cm for turmeric which covers two rows, though high cost and water application, are adopted by some farmers. Farmers who adopted 150 cm spacing raised the problem of excess water usage for wetting the four rows i.e. over irrigation in the two rows near to lateral and problem of rhizome rot in these two rows. Moreover farmers also have the opinion that more of fertilizers is leached away from root zone in 150 cm spacing in turmeric crop. Hence this study optimizes the irrigation and fertigation schedule for turmeric through drip irrigation for sandy loam soils of western zone, besides fixing correct lateral spacing to avoid fertilizer and water loss.

Description of the technology

This technology consists of optimal irrigation and ferigation schedule for turmeric under 90 cm and 150 cm lateral spacing. 150 cm lateral spacing covers 4 rows of plants at 35 cm between rows in a bed of 1.2 m and 15 cm between plants. 90 cm lateral spacing covers 2 rows of plants (paired row) at 40 cm between rows in a bed of 60 cm and 15 cm between plants. Irrigation is given to sugarcane crops based on pan evaporation and fertigation is given based on recommended dose of Nitrogen and potassium.

Output and scalability

Adoption of drip irrigation at 40% of pan evaporation with lateral spacing of 90 cm for lower water use and higher WUE in areas where water is scare. In areas where water is plenty, drip irrigation at 80% of pan evaporation with lateral spacing of 90 cm and 100% recommended dose of N and K through fertigation can be adopted for higher yield and economics. Higher yield and economics can also be obtained if farmers can go for 120% of pan evaporation with lateral spacing of 150 cm and 100% recommended dose of N and K through fertigation. The highest net return of Rs. 4,00,000 per hectare with a benefit cost ratio of 5.5 can be achieved from this technology.

Turmeric Cultivation with Different Lateral Spacing

Raised and Sunken Bed Technology for Higher Productivity Under Poor Availability of Irrigation Water (Faizabad)

Relevance

In eastern Uttar Pradesh, rice-wheat is a major crop rotation and farmers are not able to harvest its potential yield particularly in the areas of canal command where sufficient irrigation water is not available. Farmers of these regions mainly depend on rain water. Modified land configuration like raised and sunken beds with diversified cropping system has potential to reduce the risk and stabilize the farm income considerably.

Description of technology

This technology comprises of alternate raised and sunken beds for cultivation of rain based up and low land crops. The top soil of raised beds constructed at 100 cm intervals remain in unsaturated condition and allow the cultivation of pigeonpea crop in paired row, 50 cm part. The direct sown rice crop can be grown in 100 cm wide sunken beds at 20 cm row spacing simultaneously in adjacent sunken beds where soil remain almost saturated.

Output and scalability

This technology is suitable for cultivation of pigeonpea and rice crops in medium lands of eastern Uttar Pradesh. The cost of intervention of technology per unit area is Rs. 26,500per hectare. Adoption of technology increased the kharif paddy and pigeonpea yield 25.50% in terms of pigeonpea equivalent yield in comparison to pigeonpea flat bed system. The technology generates an additional income of Rs. 18,240 per hectare/year over pigeonpea flat bed system alone. The highest net return of Rs. 60,262 per hectare/year with a benefit cost of 3.3 can be achieved from this technology. The technology has been developed and demonstrated in the farmers fields and is getting popular among the farmers in canal command.

Raised and sunken bed technology for higher productivity

Integrated Farming Technology Through Multi use of Water for Higher Land and Water Productivity in Canal Command (Faizabad)

Relevance

Uttar Pradesh has 32.04% (5.386 m/ha) cultivable land under canal irrigation out of which 30.72% (1.760 m/ha) falls under the jurisdiction of eastern Uttar Pradesh. The land and water productivity has quite low in of eastern Uttar Pradesh as compared to Western Uttar Pradesh and India. Conventional cropping system (rice-wheat) consumes large quantity of agricultural resources particularly water and the output is not in accordance to the input and hence the land and water productivity is quite low. Integrated farming technology through multi use of water particularly at head section of the canal command will stabilize the farm income by improving the land and water productivity.

Description of technology

Integrated farming technology through multiple use of water, particularly at head section of canal command comprises of diversified cropping system with pisiculture and duckery. The rain water is collected in the pond developed under MANREGA and its level is maintained through canal water. The gram, pea, lentil and wheat along with rai as inter crop are grown in the surrounding of the pond during rabi using canal and pond water and rice is grown in all the fields during kharif crop season using rain and canal water. If required, irrigation can also be provided through shallow tubewells. The pond water is also used for fish production and duckery simultaneously.

Output and scalability

This technology is suitable for cultivation of rice based diversified cropping system along with pisiculture and duckery, particularly at head section of canal command in eastern Uttar Pradesh. The cost of intervention of technology is Rs. 50,850 per hectare/year. Adoption of technology increased the productivity of land which enhance the gross return to the tune of Rs. 172982 ha/year. The technology generate an additional income of Rs.44,744 per hectare/year in comparison to conventional rice-wheat cropping system. The highest net return of Rs. 1,22,132 ha/year with a benefit cost of 3.4 can be achieved from this technology. The technology has been developed and demonstrated successfully to the farmers in their fields and is getting popul.

Integrated farming technology with pisiculture and duckery

Alternate Wetting and Drying Technology with Integrated Nutrient Management for High Productivity of Scented Rice (Faizabad)

Relevance

Rice-wheat is one of the major cropping systems followed in Uttar Pradesh and it occupies about 33.31% (5.6 m/ha) area. Farmers of this region are still not able to harvest the potential yield of rice crop. Water is a scare resource and flood irrigation in rice production requires huge amount of irrigation water which is energy and cost intensive. Soil health is also decreasing day by day due to regular application of chemical fertilizers. Proper irrigation scheduling with integrated nutrient management has potential to reduce the risk and sustain the production and soil health and also increase the farm productivity.

Description of technology

The technology comprises of irrigation and nutrient management in scented rice production. 7cm water is applied in each irrigation at 3 days after disappearance of ponded water (DADPW) before panicle initiation (PI) and at 1 DADPW from PI to milking stage of scented rice in checks of 10mx10m under alternate wetting and drying technology and 25% of nitrogen is applied through bio-compost along with 75% recommended dose of fertilizers through chemical fertilizers to sustain the soil health and increase the productivity of rice.

Output and scalability

This technology is suitable to sustain soil health and increase the production and quality of scented rice. The cost of intervention of technology is Rs. 22,400 per hectare. Adoption of technology increased the production of scented rice about 15.73% and the technology generate an additional income of Rs. 9,640 per hectare over conventional rice cultivation. The highest net return of Rs. 47,800 per hectare with a benefit cost ratio of 3.13 can be achieved from this technology. This technology has been developed for the benefit of rice growing farmers of eastern Uttar Pradesh.

Scented rice grown under different moisture regimes and integrated nutrient management

Relay Cropping of Mentha (Japanese Mint) in Wheat to Enhance Income and Water Productivity (Pantnagar)

Relevance

Mentha (Japanese mint) is a remunerative cash crop (Feb-June) of the Northern states of the country (Punjab, Haryana, Bihar, Uttar Pradesh and *tarai* belt of Uttarakhand). The region is pre-dominated by rice-wheat cropping system. Between rice harvests till next rice transplanting, there is a gap of about 7 months. Taking only wheat or mentha alone during this period leaves about 90 days fallow period. Relay cropping of mentha during late ontogeny of wheat was helpful to improve the crop and water productivity.

Description of technology

Wheat is sown during November in skipped-row planting pattern i.e. after every two rows of wheat (20 cm apart), one row is skipped. During February, furrows are opened manually on skipped rows and mentha suckers (4-5 cm length) are planted and covered with loose soil. Irrigation is provided within 2-3 days of mentha planting. During initial phase of mentha, irrigation is applied as per wheat crop. However, from mid March onward to sustain growth of mentha, 2 additional light irrigations are required. After harvest of wheat, mentha should be irrigated at an interval of 6-8 days. Nitrogen at 100 kg/ha is applied in 2-3 splits after irrigation. Only one harvesting of mentha is feasible from this system. In sandy loam soil, around 5 irrigations to wheat crop and around 7-8 irrigations to mentha crop are required.

Output and scalability

This technology is suitable for *tarai* and Northern plain areas. Relay cropping of in wheat in 2:1 row pattern, gave 36.0 and 63% higher mint oil equivalent yield and net return, respectively over sole mint crop. It also provided 17.1% higher irrigation WUE than sole mint crop. It is more suitable option for small and marginal farmers. In northern states sizeable area is under wheat crop, which can be put under this technology. The technology has been refined and is already in public domain especially in *Tarai* belt and adjoining areas in Uttar Pradesh.

Mentha planted in standing wheat

Mentha after wheat harvest

Direct Seeded Rice (moist soil) for Higher Yield and Water Productivity in Heavy Soils (Pantnagar)

Relevance

In Indo-gangetic plains, rice-wheat is the major cropping sequence. The ill effects of transplanted are numerous and well known. Alternatively, rice can be grown as direct seeded crop under moist soil conditions. Soils with high clay contents have the potential to retain appreciable amount of water and maintain a good moisture supply to the rice crop.

Description of the technology

Field with good water holding capacity (around 25% moisture at field capacity) is prepared and pre-sowing irrigation is provided. Nutrients are applied at 120:60:40:25 kg N: P_2O_5:K_2O:$ZnSO_4$ per ha. Nitrogen is applied in 4 splits and remaining nutrients as basal. To combat Fe deficiency, 0.5% $FeSO_4$ is applied as foliar spray. With the help of seed drill, rice seeds at 30 kg/ha are sown. Rice population is corrected 20-25 days after sowing by gap filling using seedlings from the same field. To control weeds, pendimethalin at 1.0 lit/ha is applied after sowing. Bispyribac-Na at 20 ml/ha is applied 18-20 days after sowing to control second flush of weeds. Irrigation is provided at 5-6 days interval. Use of organic input (FYM 5 t/ha or vermicompost 2.5 t/ha) may be helpful in correcting the nutrient deficiency and improving the water holding capacity of the soil.

Output and scalability

The technology is suitable for growing rice in relatively heavy soils having good water holding capacity. DSR in heavy soil provided comparable yields to transplanted rice, besides saving 20% irrigation water compared to transplanted rice. The weed control and plant population were also good in heavy soil owing to good water holding capacity. In DSR, the B:C ratio was 1.21 against 1.03 in case of transplanted rice. The cost of production was Rs. 38831 per ha for DSR compared to Rs. 45022 per ha for transplanted rice. This technology is becoming popular among the farmers of the region. Thus DSR can successfully only be adopted in soils having good water holding capacity.

DSR in silty clay loam soil irrigated at 5-6 days interval

Transplanted rice in silty clay loam soil irrigated at 3 DADSW

Sprinkler Irrigation in Vegetable Pea for Quality Produce and High Water Productivity (Pantnagar)

Relevance

Vegetable pea is a remunerative cash crop. In *tarai* belt of the state, generally soils are heavy in texture with shallow water table. In low lying areas, such issues are still more prominent. It is a very sensitive crop to excess moisture and can tolerate only limited irrigation depth (2-3 cm). Flood irrigation (6-7 cm) often leads to heavy damage to the crop by creating aeration problem in the root zone. During winter months, the moisture loss rate (winter months) from soil remains very slow. Sprinkler irrigation is a viable option as it can provide desired irrigation depth and also modifies the micro climate.

Description of technology

Vegetable pea is sown in well prepared land after rice harvest during October/November after applying pre-sowing irrigation, if required. Field is not bunded. Crop is then irrigated by sprinkler irrigation using irrigation depth of 2-3 cm. During the entire crop season (75-80 days), 2-3 irrigations are required at early vegetative, flowering and pod development stages. Crop is fertilized at 30:60:30 kg $N:P_2O_5:K_2O$ kg/ha as basal application. An area having good drainage facility should be selected for this crop.

Output and scalability

The mean green pod yield of sprinkler irrigated crop was 7236 kg/ha compared to 6982 kg/ha in flood. Sprinkler method provided an additional net income of Rs.2570 per ha over flood method with a B:C ratio of 3.01. Sprinkler irrigated crop also produced better quality pods, with more uniform maturity.The technology has spread over more than 20,000 ha area In flood irrigated crop the vegetative growth use to restart after irrigation.

Flood irrigated vegetable pea, less uniform pod maturity

Sprinkler irrigated crop, more uniform pod maturity

Drip Irrigation under Mulch for Higher Productivity of Summer Cowpea (Faizabad)

Relevance

The cropping intensity of Uttar Pradesh is about 153% which is quite low in comparison to progressive states of India. Cultivation of summer crops, particularly vegetables have great potential to increase the farm income and has minimum risk. Drip irrigation with mulch is very effective and efficient technology to minimize the water losses and increase the farm income particularly in deficit irrigation region of Uttar Pradesh.

Description of technology

This technology is very effective for summer cultivation and has been tested for cowpea crop. Irrigation was applied through drip @ 80% of PE every third day under rice straw mulch @ 5 ton/ha in summer cowpea crop which is planted at a spacing of 30x15cm on broad base, 45cm wide raised beds. 30 cm wide channel was provided both side of the bed for drainage if required in case of heavy summer rain.

Output and scalability

The technology saved about 60% irrigation water in cultivation of summer cowpea as compared to conventional surface irrigation (1.0 IW/CPE). The cost of intervention of technology is Rs. 22,700 per hectare and adoption of technology increased the production of cowpea 41.83%. The technology generate an additional benefit of Rs. 19,270 per hectare over conventional system of irrigation. The highest net return of Rs.56,890 per hectare with benefit cost ratio of 3.51 can be achieved from this technology.This technology has been developed for deficit irrigation areas where water is most scare resource for agriculture.

Cowpea crop grown on beds under drip irrigation with rice straw mulch

Straw Mulch to Save Water and Augment Spring Maize Productivity (Pantnagar)

Relevance

Sizeable area is under spring maize in foot hills of the state. Maize cultivation for green cobs during the spring season (Feb-May) is a remunerative proposition for the farmers in the north-Indian plains. It is a cash crop and largely grown to cater tourists demand. Spring maize growing season coincides with the high evapo-transpiration (ET) demand period (March-May) and necessitates frequent irrigations. Use of rice straw mulch (mostly unused) in these areas can be a suitable option to save water and to improve the green cobs yield. Use of straw mulch adds to soil fertility and may also be helpful in preventing the burning of straw.

Description of technology

Maize planting is done on flat beds during mid February after applying pre-sowing irrigation at spacing of 60x20cm. Atrazine at 1.0 kg/ha as pre-emergence is applied just before the straw mulch application for controlling the weeds Fine rice straw @ 6.0 t /ha is applied uniformly after the sowing of the crop. Straw material should be fine and chopped and its thickness should be optimum (3-4 cm). If required, 1-2 t /ha of mulch material may be applied at 60-70 days after sowing to enhance the efficiency of applied water. The cost of mulching material and application is Rs. 2000 .

Output and scalability

Use of mulch recorded 42% higher green cob yield over the flat planting without mulch (6790 kg/ha).Flat planting along with straw mulch fetched Rs.24677 per ha, additional net returns than non mulched maize (Rs. 56790 per ha). Water saving through straw mulch application was equivalent to 1-2 irrigations.This technology especially use of fine straw mulch is being advocated to the farmers of the *tarai* and *bhabhar* area of Uttarakhand. This approach can be adopted in any region of the country where maize is grown during high ET demand period.

Maize without mulch

Maize with fine rice straw mulch

System of Rice Intensification – A Water Saving Technique for Bhabhar and Hilly Areas (Pantnagar)

Relevance

Transplanted rice is a high water requiring crop, consumes approximately 3000-5000 liters water to produce 1 kg rice. In lower and foot hill areas, transplanted rice is grown in light texture soils which necessitate frequent irrigations. However, due to high infiltration rate the water disappears very fast resulting into poor water and crop productivity. Further in these areas, rice is transplanted at closer spacing (10x10 cm), which makes the cultivation more labor and energy intensive. The system of rice intensification (SRI) has potential to work well even under limited water supply condition and can improve the productivity besides saving of water.

Description of technology

In SRI system, 15 days old seedlings uprooted along with the soil are transplanted at 25x25 spacing. Proper geometry is maintained using a marked rope. Single seedling/hill is transplanted at shallow depth (2-3 cm). For water management, after the root establishment, alternate wetting and drying pattern (light irrigation at 3-4 days interval during rainless period) is followed up to flowering stage and thereafter field is maintained close to saturation. Conoweeder is used after applying light irrigation, first at 12-15 days after transplanting and second 10-12 days thereafter. Along with inorganic, 5 t FYM/ha should be applied.

Output and scalability

The technology is suitable for growing rice in lower hills and *bhabhar* area of Uttarakhand and similar other areas. SRI produced 30% and 21% higher grain yield in lower hills and *bhabhar* area, respectively over the conventional transplanting. SRI method had mean B: C ratio of 1.75 against 1.19 in case of conventional transplanting.In the area, farmers have shifted the plant spacing from close to wider, which resulted in 30% reduction in the drudgery. Water saving to the tune of 15-20% can be realized. The technology has been refined and demonstrated in the farmers field and is already in public domain. It is more suitable for the small and marginal farmers.

Rice as SRI

Rice with conventional practice

Zero Tillage in Wheat (Powerkheda)

Relevance

In Hoshangabad district of Tawa Command area, the negative economic returns from soybean has resulted in crop diversification to a great extent i.e. nearly 1.0 lakh ha area has been noted under paddy cultivation during Kharif 2015. After paddy, the field preparation for Rabi wheat is quite difficult. Under above situation the practice of zero tillage is a feasible practice to reduce cost of cultivation and to avoid yield losses in wheat due to late sowing.

Description of technology

After paddy harvesting the sowing of wheat should be done with zero-till-seed cum fertilizer drill machine. At the time of sowing care should be taken that the soil moisture should be sufficient for germination and the field is weed free. In case of weed infestation spray of glyphosate @ 3.5 l/ha 2 days before sowing should be done. Presently, the sowing machine is available as "happy seed drill", which can be successfully operated in the fields where harvesting of paddy is done by combine - harvestor which leaves huge straw in the field.

Output and Scalability

Sowing with "zero-tillage seed cum fertilizer drill" avoids problems in field preparation and save nearly Rs.4000 per hectare. At the same time, timely sowing of wheat with this practice will ensure better seed yield. Besides above the adoption of this technology, the burning of paddy straw can be checked and the straw will add to soil organic matter. This recommendation may prove beneficial for whole paddy - wheat areas of the state as well as country.

Zero tillage at farmer's field

Zero tillage in experiment

Broad Bed Furrow (BBF) Planting of Soybean (Powerkheda)

Relevance

Kharif soybean has been subjected to poor germination and poor crop vigour due to heavy rains in deep black soils of whole Central Narmada Valley (M.P.) sowing of soybean in broad bed furrow has proven to be a feasible measure to overcome this problem.

Description of technology

In the traditional seed drill (Tractor driven), the outer tines on both the sides are replaced by Ditchers (furrow opener). Thus, only 6 or 8 times (depending on original size of seed drill) adjusted at 30 cm row spacing are used for sowing. The ditchers are adjusted to open furrow of 9" which ensure proper drainage. The field should be well pulverized before sowing. Thus, the soybean bed of 180 or 240 cm and furrow of 30 cm is obtained in the operation. The sowing is done along the slope.

Output and scalability

The technology is suitable for whole soybean area, particularly having heavy soils and high rainfall. The experimental results revealed 12% higher seed yield of soybean under 180/30 cm BBF as compared to the yield under flat bed (traditional). The attachment i.e. ditcher cost is nearly Rs.5000/- at once only which can be used for many years. In terms of feasibility the broad-bed-furrow is much easier than the ridge-furrow system. The BBF method can be used for sowing of other Kharif crops also.

Broad bed furrow planting at farmer's field Broad bed furrow planting 180/30 cm in soybean

Drip Irrigation in Sugarcane (Powerkheda)

Relevance

Sugarcane is the most important and remunerative cash crop of Madhya Pradesh; occupying nearly 1.04 lakh ha area but the productivity is considerably lower i.e. nearly 45 t /ha. The crop is mostly irrigated by surface irrigation system (flooding or ridge furrow methods) and is subjected to moisture stress during hot summer (May-June), which is one of the most important factor for reduced cane yield. Under this situation drip irrigation is the best measure to fulfill the irrigation need and enhance water productivity with sugarcane even under limited water availability.

Description of technology

Drip irrigation at 0.75 PE in normal planting (the sugarcane planted with row spacing of 90 cm) gives maximum cane yield. However, in normal planting as well as paired planting (120 X 60 cm) the drip irrigation yields higher than surface irrigation. The lateral pipes should be provided inside drippers at 60 cm spacing. In case of paired row planting only one lateral on 60 cm cane spacing is provided between two rows.

Output and scalability

Sugarcane yields obtained under drip irrigation in normal planting were maximum (157.8 t /ha) and 15.77% higher over surface irrigation (136.3 t/ ha). Besides yield increment, 27.9% water saving was also observed in drip irrigation. In case of paired row planting (120 X 60 cm) the yield increment of 15.19% and water saving by 58.3% was recorded. The initial installation of drip system cost about 1.0 per ha.

Zero tillage at farmer's field

Zero tillage in experiment

Drip Irrigation in Potato (Powerkheda)

Relevance

Potato is the most important rabi vegetable crop of Madhya Pradesh. In the cropping system research it has proved more remunerative than wheat in deep black soils of Hoshangabad. However, the average tuber yields are low, which can be enhanced by using drip irrigation and planting in ridge furrow method.

Description of Technology

Ridge sowing of potato with 60 X 20 cm planting geometry should be done. The drip irrigation laterals are provided on each row and irrigated at 0.8 PE. The crop should be planted in November first week with the fertilizer dose of 120:80:100 kg $N:P_2O_5:K_2O$ per hectare respectively, alongwith 20 kg $ZnSO_4$ per ha.

Output and scalability

The tuber yield 21.9 t/ha with drip irrigation at 0.8 PE was found to be 11.60% higher over the yield (196 t/ha) with surface irrigation at 60 mm CPE. The water use efficiency of 592.1 kg/ha-cm was also higher with this treatment as compared to surface irrigation (434.1 kg/ha-cm). Thus, the recommendation of drip irrigation in potato will help in increasing water productivity in potato.

Drip irrigation in potato at 0.8 PE

Surface irrigation in potato at 60 mm CPE

Crop Diversification in Wheat Based Cropping System for Efficient use of Soil Water (Powerkheda)

Relevance

Monocropping of soybean since last four decades has resulted in severe pest and disease problems in this crop and ultimately very poor yields (0.4-0.5 t/ha) or even crop failure has been recorded. In the low land areas of Hoshangabad (nearly 1.0 lakh ha) with full irrigation facility farmers has adopted rice crop but the remaining upland farming situation areas of about 1.60 lakh ha still need a suitable kharif crop. Under this situation sorghum can be a good option for crop diversification in the area.

Description of technology

In place of soybean, improved sorghum variety of 115-120 days maturity should be planted with the onset of monsoon. Crop planting on broad-bed-furrow of 180/30 cm with the row spacing of 45 cm has been recommended. Each bed of 180 cm has four rows of sorghum. At either ends of the seed-drill one tine is replaced by ditcher (furrow opener) so as to get the furrow of about 9" depth. The fertilizer schedule comprised of 80:60:40 kg N:P:K per hectare, respectively.

Output and scalability

The mean sorghum equivalent yield of sorghum (3333 kg/ha) was substantially higher than that of soybean and sesame. Therefore, improved sorghum varieties with recommended package of practice can be adopted as a suitable alternate of kharif soybean in Tawa Command area.

Cultivation of Sorghum in Tawa Command Area

Alternate use of Shallow Waterlogged Area in Hasdeo Bango through Buch (*Acorus calamus*) Cultivation (Bilaspur)

Relevance

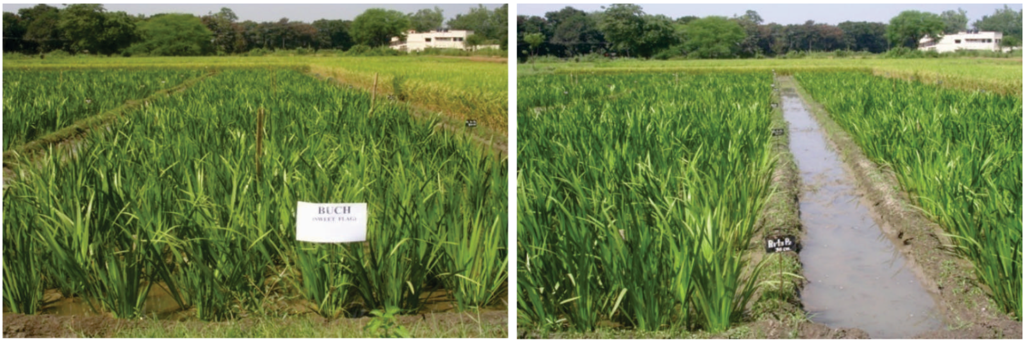
Bilaspur division of Chhattisgarh state has Hasdeo Bango, Kharung and Maniyari irrigation commands, where more than 15% area is water logged for prolong period. In such water logged area it is difficult to grow crops except long duration and tall traditional paddy, which is usually not economical under such conditions.Buch (*Acorus calamus*) is one of alternative and remunerative medicinal crop that can be raised easily under that condition. The rhizomes of *Acorus calamus*,which is commonly known as sweet flag has various medicinal properties.

Description of technology

The rhizomes of buch are planted at 30 x 20 cm spacing in puddled soil. Crop is fertilized with N:P:K in ratio of 100:60:40 kg/ha, where 50% N is given through FYM. Provision of irrigation one day after disappearance of pounded water produces the rhizome yield of 8.9 t/ha. These technologies ensure 13% saving of irrigation water with enhancing 14% of the yield over traditional system of buch cultivation.

Output & Scalability

The technology is suitable for prolonged water logged area, as buch is 9 months crop. The cost of cultivation was Rs. 74250 per ha, whereas benefit was Rs.108875 per ha over existing technology. One of the contract farmer Mr. Raghvendra Singh of Village–Risda, Block Masturi, Distt. Bilaspur, was benefited with the technology. Day by day this technology is gaining popularity among the farmers of the region and the diversification of rice with buch is changing the socio economics of the farmers, who possess prolonged water logged areas.



Manual (hand) irrigation

Drip Irrigation Scheduling of Sugarcane (Bilaspur)

Relevance

After formation of Chhattisgarh state local government promoted sugar factory as well as sugarcane crop based power plant in co-operative sector. Where adequate water is available, sugarcane is one of the remunerative cash crop. The productivity of sugarcane can be increased and farmers who have limited water can also be benefited by raising sugarcane under drip environment.

Description of technology

Sugarcane was planted in the last week of December in paired row planting 60 cm (120 cm L x 60 cm R x 30 cm LR). Nutrients were applied at 300:90:60 kg N:P:K per ha. Nitrogen was applied in 3splits and remaining nutrients as basal. Irrigation was provided at 80% PE (Potential evaporation) through drip. Crop was harvested in January and ratoon crop was also taken which was harvested in month of January next year.

Output and scalability

Sugarcane cultivation under drip system produced average yield of 121 t /ha with higher WEE (158 kg/ha-cm). The benefit cost ratio of main crop was 1.78, where as for ratoon crop it was 1.24. Sugarcane by planting at 60 cm paired row spacing and with 80% PE ensures 28% more yield with 35% saving of irrigation water over traditional practices. Some farmers of the state, who raised the sugarcane under drip, applied the technology and increased the yield and at the same time saved the water. In Chhattisgarh state 28,130 ha area covered under sugarcane.

Sugarcane Cultivation under Drip System

Increasing Land and Water Productivity in Chronically Waterlogged Areas though Land Configuration and Multiple Use of Water (Chipilima)

Relevance

Lowlands comprise of about 86,600 ha of the CCA of Hirakud command. Out of this, 29,846 ha of land are susceptible to water logging. Around 30% of the low lands at different locations in the Hirakud command have been permanently waterlogged and become uncultivable. The area under this type of land is increasing every year. Waterlogging has already emerged as a major threat to the water productivity in lowlands. Proper land configuration, crop diversion and multiple use of water in lowlands can be adopted to reclaim these areas.

Description of technology

Land configuration is carried out through digging of a small pond and trenches, and using the soil for development of elevated field plots with drainage channels at one side. The designed land configuration is:elevated plots (43%), bunds (41%), pond (4%), trenches (9%) and drainage channels (3%). The reclaimed plots, treated with rice mill waste, are used to grow waterlog resistant lowland varieties of rice. The trenches and the pond, connected to the drainage channels, are used for pisciculture. The pond and trench bunds are used to grow vegetables.

Output and scalability

After few years of experimentation it was established that cultivation of rice in the developed plots, aquatic crops like water chestnut in trenches and fish in pond was feasible with rice equivalent yield of 5.74 t/ha per year at a B:C ratio of 2.07. Through the process, better performing rice cultivars for elevated plots were also identified, which were, in order of their increasing productivity, Mahanadi, Kanchan, Sabitri, Ramachandi, Sarala, CR 661236, CR 780-1937, CR 662-2210 and Swarna respectively. Hence, the technology is suitable for reclaiming waterlogged areas of the Hirakud command as well as in the other commands.



Modified Water Regime for Efficient Weed Control in SRI (Chipilima)

Relevance

Transplanted rice is very popular in the irrigated zone of Odisha which comes under Hirakud command area. For better yield and all other advantages of system of rice intensification like less use of inputs, labour, plant protection etc. It is gaining popularity. Due to controlled water condition without stagnation the major problem faced by the farmers was reported to be used menaces which could be easily and effectively controlled by slight modification of water regime with use of weedicide helping to get potential yield of any rice variety under irrigated condition.

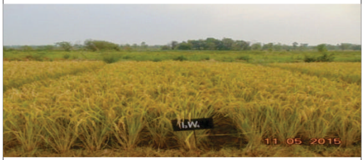
Description of Technology

System of rice intensification technology was followed exactly by raising seedlings on paddled raised beds separated by channels of 30 cm wide & 15 cm depth. Seed rate of 2 kg/acre was used in 3 seed beds of 30 m length & 2 m width. Seeds soaked overnight were broadcasted on the beds of were covered with layer of FYM. 15 days old seedlings were uprooted after giving irrigation in the channels by metal foils so that the soils along with root mass were taken in a tray with little water. Care was taken not to damage root system & not to give any stress to plant. These were planted in the main field marked with marker at 25cm x 25cm spacing with single seedling per hill. Alternate wetting & drying pattern was followed for irrigation. Only at the time of weeding either by mandwaweeder or weedicide application irrigation of 2″ was given the day before weeding operation. Fertilizer dose was reduced to 50% of recommended dose along with 5t of FYM.

Output and Scalability

The technology of application of 2″ water the day before weeding was very effective in controlling the weeds in this zone where either mandwaweeder operation upto 20 DAT followed by post emergence application of Chloromuron ethyl + metsulphurun ethyl @ 8g/acre gave best weed control and yield which was at par with application of pre & post emergence herbicide taking Pretilachor @ 800 ml/acre as pre emergence herbicide. This produced 12 % higher yield over only mandwaweeder operation at saturated soil moisture condition which is the general recommended practice. But the highest B:C ratio of 2:06 was achieved with application of both pre & post emergence herbicide against 1.96 B:C ratio achieved with mandwaweeder & post emergence herbicide combination and the conventional practice of only mandwaweeder operation at saturation gave a B:C ratio of 1.67. In the context of problem in availability of labour, timeliness in operation and increased cost of cultivation this refinement in the system of rice intensification will help the farmers a lot to improve yield & acceptability of SRI overcoming the weed problem.

Steps of System Rice Intensification in Field



SRI with Application of Herbicides

Increasing Water Use Efficiency in Wheat by Mini Sprinkler Irrigation and LEWA (Pusa)

Relevance

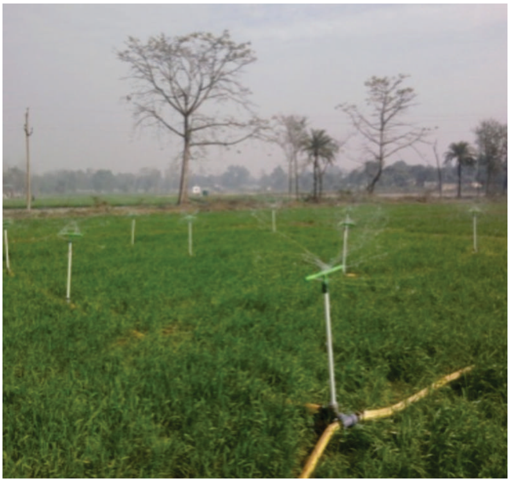
During rabi season shortage of irrigation water is evident and with increasing cost of diesel, surface irrigation system has become costlier. Alternatively pressurized irrigation system although, have high installation cost prove more economical even in crops like wheat in the long run. The Low Energy Water Application (LEWA) system which involves much less installation and running cost could be more useful in saving water.

Description of the technology

The treatments consisted of three levels of irrigation methods (main plot) i.e. surface irrigation (T_1), LEWA (T_2) and mini-sprinkler (T_3) and three levels of moisture regimes (sub-plot) i.e. IW/CPE ratio of 0.6 (I_1), 0.8 (I_2) and 1.0 (I_3). The experimental plot was laid out in split plot design with four replications.

Output and scalability

Higher grain yield of wheat was recorded with mini-sprinkler and LEWA system of irrigation as compared to surface method of irrigation. The maximum grain yield of wheat was recorded with irrigation applied at IW/CPE ratio of 1.0 and decreased with decreasing IW/CPE ratio from 1.0 to 0.6 ratios. Water use efficiency achieved in wheat crop was 20.31, 18.73, and 15.12 kg/ha-mm for mini–sprinkler, LEWA and surface irrigation method, respectively. An increase of 34.33 and 23.88% was observed in WUE in case of mini-sprinkler and LEWA, respectively as compared to surface irrigation. These technology should be adopted in Bihar under changing climatic condition.



Mini-sprinkler method

LEWA method

Establishment Methods and Irrigation Management for Improving Wheat *(Triticum aestivum L.)* Productivity in Bihar (Pusa)

Relevance

In India wheat is the second most important food crop after rice. The productivity of wheat in Bihar is much below the national level as well as world average productivity. Proper establishment method with matching agronomic practices particularly irrigation levels could pave the way for increasing economic wheat productivity.

Description of the technology

A field experiment was conducted in split plot design with four establishment methods (Conventional tillage, Zero tillage, Bed planting and SWI methods) in main plots and four irrigation levels (3 irrigation at 20, 50 and 80 DAS; 4 irrigations at 20, 40, 70 and 90 DAS; 5 irrigations at 20, 40, 60, 80 and 100 DAS and irrigation at 1.0 IW/CPE ratio in sub-plots replicated thrice.

Output and scalability

Significantly higher grain yield, water use efficiency and net return were recorded with Bed planting method of establishment as compared to Conventional method, Zero tillage and SWI. The maximum grain yield was recorded with irrigation level receiving 5 irrigations at 20, 40, 60, 80 and 100 DAS which was significantly superior over irrigation level receiving 3 irrigations at 20, 50 and 80 DAS and irrigation level receiving 3-4 irrigations based on IW/CPE ratio of 1.0 but there was parity with irrigation level receiving 4 irrigations at 20, 40, 70 and 90 DAS. Higher water use efficiency was recorded with irrigation level receiving 3 irrigations at 20, 50 and 80 DAS as compared to all other irrigation levels. The maximum net return was recorded with irrigation level receiving 5 irrigations at 20, 40, 60, 80 and 100 DAS as compared to all other irrigation levels.

Conventional tillage

Bed planting

Harvested Rainwater Use Through Poly-lined Tank for Crop Diversifications in North West Himalayas (Palampur)

Relevance

In North -West Himalayas, 70-80 % of the cultivated area is rainfed and mostly, subsistence type of agriculture is being practiced. The selection of farming systems, its integration, success or failure mainly depends on the source of assured irrigation supply throughout the year. It is generally being done through rain/run-off water harvesting in farm ponds during monsoon periods and its utilization thereafter depending upon its period of storage as per seepage rates. The selection of cropping sequences for efficient utilization of harvested rain-water is one of the challenges in hills for sustaining livelihood in hills. Generally, the size of the tank will depend mainly on catchment area, rainfall- run-off generation, type of cropping sequence followed, area to be irrigated and crop water requirement.

Description of the technology

The poly-lined tank technology and recommended the use of UV resistant blue coloured sheet (200-250 GSM thickness) for seepage control by lining all the sides of pond followed by brick/stone lining for extra safety was standardized. The rain water may be harvested and stored in small dug-out / embankment type farm ponds on individual farmer basis (100-200 m^3) or larger (6000 m^3 or more) reservoirs on community basis during rainy days and its utilization thereafter especially for growing of vegetables under deficit water supplies.

Output and scalability

On an average, 7134 mm of total stored water in poly-lined tank can be applied to 400 sq meter area out of which, 5269 mm (2/3), 1399 and 466 mm may be applied in vegetable, rice and maize/soybean based cropping systems, respectively. The marketable yields and returns however, are the highest under vegetable based cropping systems in comparison to cereal based cropping systems. The average values of water use efficiency (WUE) are 7.88 kg/ha-mm under vegetable based cropping systems, 6.65 kg/ha-mm under soybean-wheat cropping system, 5.94 kg/ha-mm under rice (SRI)-wheat cropping system, 4.77 kg/ha-mm under maize-wheat cropping system and 2.17 kg/ha-mm under rice (CTR) -wheat cropping systems. The technology suggests that the harvested rain-water should be used exclusively for vegetable based cropping system rather than for its utilization as life saving irrigation under cereal based cropping system.

Plate : Poly-lined tanks for rain-water harvesting in hills

Low Cost Covering Material for Protecting LDPE/ Silpaulin Pond Lining in Hills (Almora)

Relevance

It is well proven fact that LDPE/Silpaulin lined tanks are very useful and economical for storing water. But polythene lining damage due to various factors and alone polythene lined tank life is only one to five years.Different type of materials and their combination has been tried to protect pond lining, reduce cost of covering material and provide full protection to lining. Out of different material locally made block technology was found very effective not only to protect the film but to help in creating conducive environment for fish farming. The expected life of block covered tanks will be more than 40 years.

Description of Technology

Blocks made by using local material (sand collected from river / *gadhera or nala* /rivulets and sandy soils having more than 80% sand, stone) with 1:7 ratio of cement and sand. The blocks made by 1:7 cement and sand mixture and in between local stones were used. Covering material cost ranged from Rs 90 to 150 / m^3. This is estimated that covering cost comes around Rs 9000 to 10,000 of 100 m^3 capacity tank. The covering cost comes around Rs 90 to 100 per cubic meter water storage. Cost is varied because of farmers sometimes make blocks lower ratio of cement and sand than recommended 1:7 cement : sand ratio.

Output and scalability

The covering material protects lining of tank and it enhances life of tank more than 40 years. If one makes 100 m^3 LDPE lined tank and it gets damaged every five years and if farmers repair after five years then it will cost around 3.0 lakh for LDPE and 5.5 lakh of silpaulin tank. This technology can be adopted in all the areas where poly lined tanks are made for water storage. It can be adopted in hilly as well as plain areas. Farmers are accepting technology and around ten tanks are already constructed at farmer's field. There is an increase in demand by the farmers to construct such type of tanks in their field.

Algal formation, in block covered tanks

Locally made blocks

Block Covering LPDE Film

Block Covered Silpaulin tank at farmers field

Laser Land Leveling for Improved Rice-Wheat Productivity in Irrigated Canal Command (Jammu)

Relevance

Rice- wheat system is the important cropping sequence providing food security at regional scale. Stagnating yields and declining input use efficiency coupled with diminishing water availability for agriculture is the major concern even in command areas of Jammu region. Land leveling with tractors has smoothen farmers' field to great extent but there are depressions and elevated points which effect production on elevated portions due to lack of water availability and in depressions due to water stagnations. Precise leveling can be attained with laser land leveler which can save water, increases use efficiency of inputs and can improve farm income through improved productivity.

Description of the technology

Precision land leveling involves topographical alterations in such a way as to create a constant slope of 0 to 0.2% in the fields. Cutting or filling to create the desired slope/level of the field is achieved using large horsepower tractors and soil movers that are equipped with global postioning systems (GPS) and or laser-guided instrumentation so as to move the soil in either direction. The improved yield levels in laser levelled plots were achieved due to increase in use efficiencies of applied nutrients and water in terms of application, distribution and storage.

Output and Scalability

The technology is most suited for irrigated canal commands where rice-wheat is prevalent and one of the most water intensive cropping sequence.This intervention involves expenditure of Rs. 8800/ha and the adoption of this technology can increase yield of rice -wheat sequence by 1 t/ha. The technology can generate additional benefit of Rs. 18000/ha/yr compared to traditionally leveled plots. The highest net returns of Rs.1,12,000/ha/yr with a benefit cost ratio of 2:1 can be achieved from the system. The technology has been adopted by farmers of village Sultanpur and Haripur Sania of Kathua district, Jammu and Kashmir. The technology has been developed and demonstrated in the farmers field and is ready for use.

Rice-Wheat Sequence in Laser levelled Plots

Multiple use of Water through "Raised and Sunken Bed Technique" for Waterlogged Areas of Low Land Eco Systems of Jammu (Jammu)

Relevance

Due to high rainfall in monsoon and delivery of excess water through canal irrigation systems, many low-lying agriculture farms in Jammu and Kashmir remain saturated to over saturate through dry as well as wet seasons and farmers can hardly grow any other crop than rice. The farmers land affected in Jammu region is approx. 20,000 ha out precious one lakh hectares of irrigated belt and more than double the area of Jammu are waterlogged prone/ water congested in Kashmir region.

Description of the technology

Raised and sunken bed technology farm is developed by converting (4ha)water-congested area of the university into technology farm. The developed physical model comprises (06) numbers of raised and sunken beds having average size of 86.0 m x 9.0 m for raised beds and 86.0 m x 9.0 m x 1.5 m for sunken beds.One farm pond of average size: 90.0 m x 30.0 m x 2.0 m has been developed.Water in sunken beds remains full to the capacity throughout the year.The water quality harvested has pH 7.8, EC 0.18, DO (ppm) 8.3, Temp. $16-18^{0}$ and has been found suitable for the fishery.The trials on (06) numbers of raised and sunken beds for planting technique of cash crops like common vegetable, floriculture, exotic vegetable, strawberry and fish culture has been started *w.e.f Rabi* 2015-16 in collaboration with concerned divisions of the university.The cost involved in development of the physical model is @ Rs.80,000 per ha achieved mechanically and for making the land arable with continuous availability of water. The market price of such land is approx. Rs.2.0 crore.The input output for cash crops like common vegetable, floriculture, exotic vegetable, strawberry and fish culture is successful.

Output and scalability

Regarding scalability of the outcome as the major portion of such water congested areas are along Indo-Pak border fencing which is on the lowest contour and after every monsoon water gets stagnant and the farmers can hardly grow any crop other than rice. The demonstration of the physical model is being given to line department officer and farmers through training programme and the central department like NIH also conducted the farmer awareness programme on the physical model.

Overall view of the physical model Strawberry, vegetable and floriculture

Modified Drip System for Small Terraces / Kitchen Gardens of Hills (Almora)

Relevance

The large scale drip systems along with dug out ponds are not feasible in the hilly region everywhere. The small and fragmented land holdings are main problem in adopting the technology. The wild animal damages force to farmers to limit their cultivation especially vegetable in 200 to 1000 m^2 area nearby their homes. Farmers are mostful applying irrigation manually through buckets which is more laborious and uneconomical. Thus, a drip system has been developed with roof top water harvesting or connected to a water sources (water tape/ water springs) and used by gravity (keeping on terrace risers, roof top).

Description of Technology

A plastic tank of 500/1000 litre capacity with terrace risers / roof top used by gravity to give appropriate head to run the drip system. The sprinkler as well as drip system can be run with the 2 meter terrace risers which give pressure 2.90 m head including 0.9 m height of 500 litre plastic tank. The drip system can also be run with tank placed on soil surface with 0.9 m head without any extra terrace riser head. The clogging problem of drippers is major problem. As suggested by a farmer drippers replaced by hole in 16 mm lateral pipes. These holes delivered the water to the plants and work dripper under low pressure and sprinkler under high pressure condition.

Output and scalability

It is very economical and can be easily adopted by the farmers. It required Rs. 8625 to install for 200 m^2 area including drip irrigation. It is estimated that if farmer apply irrigation manually, its labour cost comes around Rs. 4224. Hence cost incurred on drip system can be recovered after two to three crop seasons.

Modified Drip / Sprinkler System for irrigating experiments

Fertigation Technology for Enhancing the Crop and Water Productivity in Vegetable Crops in Hills (Palampur)

Relevance

Intensification of agricultural production to meet growing market demand requires the simultaneous application of irrigation water and fertilizers. Fertigation as an attractive technology in modern irrigated agriculture which allows the landscape to absorb up to 90% of the applied nutrients, while granular or dry fertilizer application typically result in absorption rates of 10% to 40%. Drip irrigation along with fertilizer reduces the wastage of water and chemical fertilizers, subsequently optimizes the nutrient use by applying them at critical stages and proper place and time, which finally increases the water and nutrient use efficiency.

Description of the technology

The total fertilizer quantity of water soluble fertilizers calculated is divided into 10 equal parts and each part is applied through irrigation water at 8-10 days intervals. In venturi system, 1/10 part of total water soluble fertilizer quantity is generally dissolved in 4 litre of water and is applied in 6-8 minutes. In fertilizer tank system, 1/10 part of total water soluble fertilizer quantity is dissolved in 20-40 litre water and is applied in 5-7 minutes. The commercially available water soluble fertilizers used for fertigation are, 19:19:19, 18:18:18, 12:61:0, 17:44:0, 0:0:50, Urea, 13:0:45 etc.

Output and scalability

Based on experimentations, the following fertigation schedules have been standardized using commonly available water soluble fertilizers such as 19:19:19, 0:0:50 and urea and superiority of fertigation over conventional fertilizers and fertilizer application methods have been obtained.For Cauliflower, the increase in yield compared to conventional fertilizer was 21.3 % while it was 21.4% and 15.1% in case of Broccoli and Capsicum, respectively. The fertigation frequency was about 8 – 10 days for each crop.

Drip based fertigation in vegetables for higher yield and nutrient efficiency

Substitution of Sprouted Seeding with System of Rice Intensification (SRI) for Efficient Utilization of Kuhl Irrigation (Palampur)

Relevance

In Kangra district of Himachal Pradesh, rice is cultivated where assured irrigation through kuhl (gravity stream) is available. Generally, farmers grow the rice by sprouted seed method during first week of June where perennial kuhls are available. However, conventionally transplanted rice is grown in the areas with seasonal kuhls mostly flowing during monsoons. Sprouted seed method is successful but involves use of 5-8 times more seed rate than recommended.In Conventionally transplanted rice, during seasonal variations in rains, required ponding depth of 5-6 cm is sometimes difficult to maintain. Approaches such as SRI may serve the important needs of resource-poor farmers in areas with poor soils, but are likely to have little potential for improving rice production in intensive irrigated systems on more favourable soils, where high yields can be achieved through implementation of more cost-efficient management practices.

Description of the technology

The (SRI) system have advantages like lower seed requirement, less pest attack, shorter crop duration, higher water use efficiency and the ability to withstand higher degree of moisture stress than traditional method of rice cultivation. SRI hence can be replaced with sprouted seeding in Hilly areas for efficient utilization of kuhl irrigation.

Output and scalability

With the planting method of sprouted seeding, the grain yield, total water use, water use efficiency and B:C ratio obtained was 4.99 t/ha, 2163 mm, 2.34 kg/ha-mm and 1.35 along with 13 tillers. While in case of conventional transplantation with 14 tillers it was 4.04 t/ha, 1828 mm, 2025 kg/ha-mm and 1.13, respectively. On the other hand, for SRI the statistics obtained were 4.87 t/ha, 2034 mm, 2.57 kg/ha-mm and 1.68, respectively with 18 tillers.

System of Rice Intensification on farmers' fields in Kangra District (HP)

Integration of Roof Rainwater Harvesting and Drip Irrigation to Increase Productivity of Banana, Arecanut and Assam Lemon (Jorhat)

Relevance

Assam receives high rainfall during *kharif* where as *rabi* is practically dry. This offers possibility of rain water harvesting and subsequent use for crop productivity. Harvesting rainwater involves cost, therefore, this water has to be used through drip irrigation to increase productivity of high value crops only. In Assam fruits cultivation is mostly done in homestead. Since roof is the best catchment for rainwater harvesting,roof water harvesting and subsequent use through drip irrigation in high value fruit crop is a good proposition.

Description of the technology

Rain water is harvested from roof of Assam type building through gutters and stored in excavated pond. The ponds are dug and the dug up earth is placed in the sides to create a bund so that effective depth of pond becomes 2.75 m.The 0.75 m of water depth is designed as dead storage for fish rearing. Side slope of the pond is kept as 1:1. Pond lining is done with black low-density polyethylene (LDPE) film of 0.25 mm thickness (as per IS: 2508-1984). The size of the pond is to be based on roof catchment available. The roof catchment to command area ratio (C:C ratio) for Banana and Arecanut is 7.37 and for Assam lemon it is 14.73. For drip irrigation 12 mm laterals are used. For Banana and Arecanut one 2 lph dripper per plant and for Assam Lemon 2 numbers of 2 lph dripper is to be used. Irrigation rate is 80% of Pan Evaporation (PE) for Assam lemon and Banana and 100% of PE for Arecanut. Irrigation frequency is daily for Assam Lemon and 3 days interval for Banana and Arecanut during 2nd week of November to 1st week of April or onset of pre-monsoon rains whichever is earlier. Fish rearing can be done throughout the year.

Output and scalability

The technology is suitable for *"Bari"* system of Assam where fruit tree are grown. The cost of the intervention is Rs 1,11,000 only . Breakeven point is 3-4 years. Adoption of the technology increased the fruit production of Banana, Arecanut and Assam Lemon by 25, 110 and 142 % respectively. The benefit cost ratio of the technology is 3.98 for Banana, 2.10 for Arecanut and 2.33 for Assam Lemon. A minimum cash flow of Rs.45/ square m of pond surface area/yr can be achieved . The technology has been tested through farmers participatory action research and is available in public domain.

Integration of roof rain water harvesting and micro irrigation in Arecanut in Golaghat district of Assam

Drip Irrigation and Fertigation in Assam Lemon Cultivation (Jorhat)

Relevance

Irrigation requirement of citrus trees is generally higher than most of the other sub tropical fruits because of their evergreen nature and active growth and development throughout the year. Assam Lemon is major citrus fruit of Assam and is grown in an area of 13000 ha. Local wisdom associated with good productivity of the fruit is to locate the plants near water body where frequent watering is possible. Due to the promotional effort under Horticulture Mission, this important crop has evolved into a commercial crop. Since the fruit crop requires small and frequent irrigation, for a commercial plantation, drip irrigation has the potential of providing optimum irrigation solution.

Description of the technology

Assam Lemon plants are planted at 3m x3m spacing and drip irrigation laterals of 12 mm diameter are to be aligned with the base of the plant. Two numbers of 2 lph drippers are to be fitted at a distance 30 cm from the trunk on either side of the plant. Irrigation frequency should be everyday during 1st week of November to 2nd week of April or initiation of pre-monsoon shower whichever is earlier . maximum operating hours for the drip irrigation system is one hour per day. The same set up is used for fertigation.Fertigation dose should be 480 g N, 210 g of P and 386 g of K per plant per year.The source of fertilizer may be Urea (N), DAP or MAP (N & P) and MoP (K).Water soluble fertilizer may also be used. Fertigation is to be done through 60 equal splits during 1st week of November to 2nd week of April. The cost of the intervention is Rs 30000 per ha only.

Output and scalability

Adoption of the technology increased the Assam Lemon fruit production by 153% compared to traditional practice. The technology can generate additional benefit of Rs.70016 ha/yr when only drip irrigation system is adopted.The highest net return of Rs. 168000 ha/yr with a benefit cost ratio of Rs. 3.17 can be achieved. A additional investment of Rs 6000 is required to make the system capable of fertigation.Fertigation further increased the Assam Lemon fruit production by additional 35% compared to soil application of fertilizer. This also brings in additional benefit of Rs 25000 ha/yr with a benefit cost ratio of 4.17 and 20% saving in fertilizer. The technology has been extended by Horticulture Department of Assam Government under its promotional schemes. The technology has been perfected through farmer's participatory action research and demonstrated in KVK and is already available in public domain.

Drip fertigated plot

Without Drip fertigatation

Refinement of Manual Low Lift Pump for Flower and Vegetable Production in Shallow Water Table Areas of Assam (Jorhat)

Relevance

Some area of Brahmaputra valley and Indo Gangetic belt have ground water table at shallow depth. For those areas ground water may be a good source of irrigation. Line departments have been encouraging shallow tube well irrigation coupled with 5 HP CI engine pump set in these areas. But such pumps are not very attractive for small and marginal farmers which occupy 85.3% holding in sate like Assam. Rising fuel prices has also made these pumps unsustainable. An improved manual pump with low lift was refined developed for such shallow water table areas in India.

Description of the technology

The pump section consists of a sheet metal or cast iron pump box, a bamboo frame with two treadles for foot operation, and a bamboo or PVC strainer. The pump box has two cylinders welded together with a single suction inlet at the bottom and two plungers. The diameter of the cylinders varies for different water outputs and water-level depths. Pump with cylinder size 300 mm x 88.9 mm and 100 mm stroke length is most common. The cylinders are joined together at the base by a junction box, which connects through check valves to the suction pipe. The pump is a foot-operated device that uses a bamboo, or a PVC or flexible pipe for suction to pump water from shallow aquifers or surface water bodies. It can also be attached to a flexible hose, and used for lifting water at shallow depths from any source such as pond, tank, canal, or catchment basin or from tubewells up to a maximum height of 7 m. It performs best at a pumping head of 3.0-3.5 m delivering 1.0-1.2 l/s through a crank speed of 50 RPM which is even comfortable for women worker. Best result in terms of yield and profit may be obtained when the pumps are used to irrigate flowers and vegetables only. Each pump can command a minimum area of 0.25 ha per crop cycle for vegetable and flowers. Suitable for drawing water from bamboo, plastic or GI tube well of 38 mm bore.

View of manual low cost pump in field operation

Output and scalability

The technology is suitable for shallow water table area up to a depth of 5 m . Command area for each pump is 0.25 ha per crop cycle for vegetable and flower crop. Initial investment required is only about Rs 3000.00. Initial investment is recovered in the first year itself. Ideal for small farm with hort-floriculture based cropping system. Benefit cost ratio for growing Cauliflower, Cabbage,Knolkhol ,Bottle gourd, Potato, Palak, Pumpkin, Brinjal, Tomato, Sugarcane, Tuberose, Ridgegourd, Cucumber and Maize are 3.16, 2.64, 2.96, 3.27, 4.21, 4.09, 3.39, 3.24, 3.56, 6.82, 8.50, 4.86, 4.01 and 2.59 respectively.

Gravity Drip Irrigation and Nitrogen Management in Gladiolus for Higher Water Productivity (Gayeshpur)

Relevance

Gladiolus is one of the most popular remunerative ornamental bulbous plants grown commercially in the sandy loam soils of lower Indo-Gangetic plain for its attractive colour, elegance, appearance and keeping quality. The productivity and quality of crop are declining considerably due to poor irrigation water management and imbalanced plant nutrition use. Controlled water supply through drip irrigation system in synchrony of crop physiological demand and complementary use of organic manures and inorganic chemical fertilizers remains the best alternative choice of growers for sustainable production, considerable water saving and high profitability owing to quality of produce.

Description of technology

Medium sized corms of the gladiolus variety cv. American beauty was planted in well prepared land with crop geometry of 30 cm row to row and 25 cm plant to plant spacing during first week of November and harvested in third week of January next year. Crop was drip-irrigated at 0.8 pan evaporation replenishment once in every 3-4 days during the 80-85 days growing period. Recommended fertilization rate was 100:60:60 kg N:P_2O_5:K_2O kg/ha. Full P and K and ½ N as organic manure (vermicompost) were applied as basal and remaining ½ N as urea was top dressed in two equal splits at 30 and 60 days after planting. The other cultural operations are routinely adopted.

Output and scalability

Gravity drip irrigation scheduling at 0.8 evaporation replenishment (112 mm water) in conjunction with 50% inorganic N plus 50% organic N through vermicompost along with 60:60 kg P_2O_5:K_2O kg/ha produced 34% higher spike yield (9.86 t/ha) compared with the surface irrigation and conventional soil fertilization. The B:C ratio obtained under drip irrigation with integrated N management is 2.78 as against 2.11 in case of surface irrigation and soil fertilization, besides exhibiting 97% higher water use efficiency and 66% water saving. In limited water supply condition, drip irrigation at 0.6 evaporation replenishment (84 mm water) with 1: 1 proportion of inorganic and organic N recorded competitive yield of 8.60 t/ha with B:C ratio of 2.49.


Drip irrigation with integrated nitrogen management on gladiolus

Drip and Nitrogen Fertigation and Mulching on Broccoli in Indo-Gangetic Plain (Gayeshpur)

Relevance

Broccoli, the newly emerging crop in the lower Indo-Gangetic plain of West Bengal, is gaining popularity due to its higher nutritional and medicinal values, palatability, short duration, high productivity and good marketability. It requires high amount of water and fertilizer nitrogen for optimum yield and quality produce. The low-cost gravity fed drip-nitrogen fertigation is the better option for getting higher crop and water productivity and profitability.

Description of technology

Broccoli cv. green magic seeds are sown on 14-15 October in the nursery bed at 5 cm depth with 10 cm row spacing. Thirty-day old seedlings are transplanted in 13-15 November in crop geometry of 45 cm row to row and plant to plant spacing. A pre-planting irrigation of 20 mm depth is applied. Crop is harvested on 20-25 January next year. The recommended dose of $N:P_2O_5:K_2O$ is 100:60:40 kg/ha, respectively. All P and K are applied manually as basal one week before planting. The fertilizer nitrogen is dissolved in 10 L of water and the stock nitrogen fertilizer solution is dissolved in a 500 L capacity over head tank placed at a height of 3.5 m above to facilitate water movement on gravitational force and applied along with the irrigation water. The drip irrigation is operated at 3-day interval. Nitrogen is applied through drip in eight equal splits at weekly intervals, commencing from 16-18 November. Black polythene (BP) film of 25 µ thickness having small holes of 60 mm diameter at a distance of 45 cm is spread over the prepared field and seedlings were transplanted in the holes.

Output and scalability

Maximum curd yield (17.8 t/ha), water use efficiency (27.03 kg/ha-mm), net return (Rs. 142800/ha) and B:C ratio (4.05) is obtained with drip irrigation scheduling at 0.8 crop evapotranspiration (95 mm water) accompanied with N-fertigation and BP mulch. Under limited water supply, drip irrigation at 0.6 ETc (71 mm water) with N-fertigation and BP mulch is much competitive giving higher curd yield (16.4 t/ha), net return (Rs. 128900/ha) and B:C ratio (3.66). The yield augmentation in drip N-fertigation and BP-mulch integration is around 20-30% over surface irrigation and conventional soil N-fertilization, which recorded minimum yield (13.7 t/ha), net return (Rs. 109900/ha) and B:C ratio (2.97). Drip irrigation can save 27-38% of water compared to the surface irrigation, which can be utilized to bring about 37-62% additional area under drip irrigated crop. Thus under scarce to limited water supply condition, gravity drip irrigation at 0.6 or, 0.8 crop evapotranspiration along with N-fertigation and BP mulching is advantageous in promoting higher yield, water economy and profitability to the broccoli growers.

Drip irrigation, nitrogen fertigation and Black polythene mulch on broccoli

Deficit Irrigation and Phosphorus Fertilization in Broad Bean (Gayeshpur)

Relevance

Broad bean is a less privileged minor grain legume crop. It has immense potential for human nutrition besides improvement in soil fertility. It has unique ability to adapt as a contingent crop in crop diversification programme substituting high water consuming summer paddy in lowland situation. In the lower Gangetic plain of eastern India, the poor farmers raise the crop using the residual soil moisture after *kharif* paddy harvest, but the productivity is considerably low due to improper irrigation and phosphorus fertilizer management practices. The strategy of judicious irrigation-fertilizer phosphorus management can sustain the crop productivity, better water saving and economic returns under different water supply condition.

Description of technology

The land is well prepared by 2-3 ploughing followed by ridging. Healthy disease free local cultivar is sown at 5-7 cm soil depth on the ridges during the last week of October with crop geometry of 60 cm row to row and 15 cm plant to plant spacing. Well decomposed FYM @ 10 t /ha and N:P_2O_5:K_2O @ 20:90:40 kg /ha, respectively are applied as basal just before sowing. Depending on the water available situation, four and two number of irrigation each at 50 mm water depth at 22-24 and 43-45 days interval, respectively are applied including a common irrigation of 20 mm water depth just after sowing for proper seed germination and plant establishment. The crop is harvested in the second week of March next year. The crop duration is 135-137 days.

Output and scalability

Broad bean is very responsive to both irrigation regime and phosphorus fertilization for yield augmentation. Maximum seed yield of 5.69 t/ha is displayed with four irrigation (200 mm water) at 22-24 days interval along with phosphorus fertilization @90kg P_2O_5/ha. The crop also accomplishes the maximum economic values in terms of higher net return (Rs.28870/ha) and B:C ratio (1.73) in this moderate water supply condition. When the water availability is the limiting factor or, the farmer is facing the water scarcity, crop is irrigated twice (100 mm water) at 43-45 days interval supplemented with higher dose of phosphorus application @90 kg P_2O_5/ha. This approach is found to be the best alternative option with competitive seed yield (5.13 t/ha), higher net return (Rs. 25590/ha) and B:C ratio (1.66).This technology is most suitable and remunerative to the small and marginal farmers of the lower Gangetic alluvial plain.

Irrigation and phosphorus management on broad bean

Micro Rain Water Harvesting Structures (Jalkund) Suitable for Hilly Condition (Shillong)

Relevance

Medium to heavy rainfall in hilly areas mostly gets wasted as run off. With this technology rain water can be efficiently collected during peak monsoon period and can be recycled/utilized for multiple purposes during the winter season when there is a scarcity for water

Description of technology

- Select a site preferably on the hilltop/upland. Avoid stony areas.
- Dig a pit of 5 m x 4 m x 1.5 m dimension. Keep gentle slope while digging.
- The inner walls including bottom of the *kund* is to be plastered with mixture of clay and cow dung in the ratio of 5:1.
- Start laying of agri – film/silpaulin from one end of the sheet and make sure it does not have any folds left with. Any pinhole in LDPE agri – film should be sealed with plastic adhesive. The agri film/Silpaulin sheet is laid down in the *kund* in such a way that it touches the bottom and walls loosely and uniformly and stretches out to a width of about 50 cm all around the length and width of the *kund.*
- Dig 25 x 25 cm trench all around the *kund* and about 25 cm outer edge of agri–film/silpaulin is buried in the soil all around.
- A Jalkund of 7 m x 6 m x 1.25m would able to harvest about 52 m^3 water.
- The *Jalkunds* should also be fenced with locally available materials (bamboos, tree branches etc) to protect it from any animals and children.
- The stored water should be covered with thatch (5-8 cm thick) made of locally available bamboo and grasses to avoid the evaporation loss of water particularly during off season (November to March).

Output and Scalability

The farmers have accepted and adopted this technology in a large scale as a means to collect and store rain water during the monsoon period. Farmers have been able to use the stored water for different purposes, such as for irrigating winter vegetables, strawberry cultivation, piggery, dairy and also for irrigating their poly houses.

Jalkund at Mawpun village

Jalkund at Umeit village

Micro Irrigation for High Value Crops (Strawberry and Cauliflower) under Mulched Condition (Shillong)

Relevance

Mulching helps to conserve the soil moisture and increases its availability to the crop while application of water through drip irrigation enables the crop to efficiently use the water without any wastage as water is applied only around the root zone.

Description of technology

Drip irrigation at 1.0 PE along with Black polythene mulch or paddy straw mulch for higher productivity and water use efficiency in strawberry and cauliflower.

Output and Scalability

The soil moisture content in the hilly areas during the *rabi* season usually remains low. Hence the land remains fallow throughout the off season. However with the use of drip irrigation along with mulch materials farmers are able to grow winter season crops, which are of high value and thereby earning a secondary income. Farmers of this region are using straw mulching as a means to conserve the soil moisture, reduce weed competition and improve the yield. Strawberry was cultivated on an area of 30 ha in Ri Bhoi and East Khasi Hills districts of Meghalaya which yielded about 20,124 kg/ha. While B:C ratio obtained was 2.93:1.

Strawberry under paddy straw and Black Plastic mulches

Resource Conservation Practices (Zero tillage + Intercropping) in Maize-toria Cropping System in Hilly Terraces (Shillong)

Relevance

Zero tillage reduces the time required for land preparation and thereby reduces the labor cost. Further, maintains soil health in appropriate condition by reducing soil manipulation. Intercropping helps to conserve the soil profile moisture, reduces weed competition as well as improves the soil organic carbon content and improves the soil health.

Description of technology

Maize+groundnut (Paired row) and maize+soybean (Paired row) intercropping systems under zero tillage is to be followed along with residue incorporation under terrace land situation. The succeeding toria is to be grown under zero tillage. The technology results in 35–40% increase in yield and 20-25% increase in water use efficiency (WUE).

Output and Scalability

The technology is suitable for high rainfall and hilly areas of North - Eastern region. Zero tillage resulted in 15.2% higher maize equivalent yield (MEY) (6959 kg/ha) as compared to conventional tillage (6042 kg/ha). Among the intercropping system, the MEY was 4778 kg/ha while Maize + Groundnut (Paired Row) was 6214 kg/ha. Yield achieved for Toria (1150 kg/ha) after Maize + Groundnut was higher by 31.43% as compared to yield (875 kg/ha) after sole maize. The WUE of sole maize was observed to be 3.45 kg/ha-mm and for Maize + Groundnut was 4.53 kg/ha-mm. The B:C ratio obtained was 1.13:1.

Maize + Groundnut (Farmers field)

Toria after Maize (Farmers field)

"Konkan Jalkund" for Small Scale Horticulture Crops on Hill Slopes (Dapoli)

Relevance

The technology of micro rainwater harvesting known as 'Konkan Jalkund' technique, for harvesting and storing rainwater has been generated which is boon for horticultural plantation in Konkan region that have undulating land and hill slopes where harvesting of rainwater becomes difficult. The horticultural crops suffer water stress in the hill slopes during October to June.

Description of the technology

On hill slopes and tops with shallow soil depth and rocky terrain, for new mango/cashew plantation, rainwater storage pits of 4 x 1 x 1m be excavated for a block of 10 newly planted grafts. Thus, in an area of 1 ha of new mango plantation, 10 such storage pits would be required. If the soil is having good depth, pits of 2 x 1 x 2m size can be excavated. The sharp edges of the exposed stones all along the walls and bottom of the pit should be removed and surfaces smoothened and sufficient quantity of anti-termite powder e.g. Folidol, Lindane etc. should be dusted on the walls and bottom of the pit. About 5 to 10 cm thick pre-lining cushioning bed of rice straw bundles be put along the walls and bottom of the pit to avoid puncture of the lining film. For this purpose, while excavating the pit sufficient extra portion should be cut along all the three dimensions so as to accommodate the rice straw cushioning bed. Finally, the storage pit should be lined with 200 GSM grade Silpaulin lining plastic film. The size of the film should be 7 x 4m for 4 x 1 x 1m size and 7 x 6m for 2 x 1 x 2m size pit. Due care should be taken while spreading silpaulin in the pit so as to avoid wrinkles/folds. The extended portion of the line silpaulin film on the land surface all along the length and width of the pit should be buried in a trench and covered with soil on all the four sides so as to avoid entry of turbulent runoff water into the pit.

Output and scalability

This technology is suitable for growing newly planted mango and cashew grafts on hill slopes where water availability is inadequate and scares. The cost involved in adoption of Konkan Jalkund technique is Rs.34400 ha of new mango plantation.

Konkan Jallkund Technique

KAU Micro-Sprinkler (Chalakudy)

Relevance

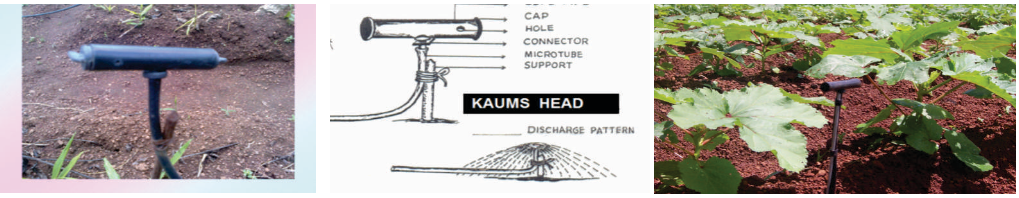
Evaporation loss and distortion by wind are the drawbacks of sprinkler irrigation. Even though water saving and application efficiency are not as high as drip irrigation, Sprinkler irrigation creates a cool atmosphere in the field. It improves the microclimate of the plant. Wastage of water by wetting outside root zone area is more in sprinkler irrigation, if the field is not in a multi-tier cropping system.Higher water saving and water use efficiency are the important advantages of drip irrigation. Micro sprinkler is a system which provides advantages of both sprinkler and drip system, almost in between the two system. But clogging and maintenance are the major problems with commercially available micro sprinkler. Hence a micro sprinkler was designed at ARS of KAU which has minimum clogging problem and easy to maintained by the farmer.

Description of the technology

Major part of KAUMS is its sprinkler head. LDPE pipes of 8 or 12 mm diameter is used for this sprinkler head. Length of LDPE pipe is 5 or 8 cm respectively according to the diameter. Holes of 1mm diameter have been made on both ends (1cm from end) of this pipe in opposite directions. Both ends are plugged with caps and a hole of 4.4 mm diameter has been made at the center. By inserting one pin connector through this hole, sprinkler head is ready.The sprinkler head could be connected to lateral pipe through a 6mm micro tube. This is then placed in the crop basin using a support. Pressure required for operating this micro sprinkler is between 1 to 2 kg/cm^2. Discharge rate is 40 – 45 l/hr and wetting diameter varies from 2 to 3 m.

Output and scalability

KAUMS is a farmer friendly micro-sprinkler which provides clog free operation. Farmer can make the KAUMS by himself, if he get a simple training .It is cost effective, installation is simple and resembles drip system. Maintenance is also easy. By adjusting the height of support wetting diameter can be adjusted as per requirement of the plant. Yield of vegetables increased up to 40 % by the use of this micro-sprinkler. Water saving varies from 30 to 50% compared to conventional irrigation. As in the drip and sprinkler system, fertilizer could be applied through micro-sprinkler system. Effective life period of KAUMS is 8 -10 years. Many farmers are using the KAU micro-sprinkler all over the district and nearby districts.



KAU Micro-Sprinkler System

Organic Fertigation Unit (Chalakudy)

Relevance

To maximize crop production and to ensure food security for the growing population, hi-tech farming techniques could be used. Drip fertigation is an inevitable component of hi-tech precision farming. At present, water soluble chemical fertilizers alone are applied through fertigation. A mechanism to apply organic manures also along with irrigation water can save application cost, time, labour and help production of organic crop produce. However, the filtration of organic manure solutions is quite difficult because of the presence of finer debris which can clog the irrigation channels and impair organic fertigation. Hence, a good filtration is needed for it. In this context, a mechanism was designed to filter out the debris from organic manure solutions so as to prepare them for a smooth run in fertigation.

Description of the technology

The organic fertigation unit developed consists of three major parts - a settling tank for keeping manure solutions, a filtering unit and a tank meant for collecting the filtrate. The first part was a settlement tank and it was placed at a height so that a person of average height standing at ground level could easily pour the organic solution to the tank . This tank has two valves in opposite directions placed at two different vertical levels. One valve is placed at ¼th height of tank from its bottom and other valve at the bottom of the tank. Once the solid particles are settled, the supernatant passes to the filtering unit through first valve and the second valve could be used for removal of settled portion of organic solution.

Second tank contains the filtering unit. Top portion of this tank is placed just below the outlet valve of the first tank so as to collect the supernatant. The filtering mechanism consisted of three successive filters made up of two different materials. Third part of the unit is a plastic tank of same capacity of the second tank. The filtrate from the filtering tank was collected in this tank and from here it was pumped through micro irrigation system having a screen filter. In this particular stage only power is required. Up to this stage the flow was maintained by gravitational force. The clear filtrate obtained doesn't encounter any problem of clogging. The rate of discharge of cow dung filtrate through different micro irrigation system was found comparable to that of pure water.

Output and scalability

An organic fertigation unit suitable for small scale cultivation, especiallyvegetables has been developed and tested at the centre. Production of organic vegetables are possible using the technology. Present technology is helpful for incorporating organic cultivation with precision farming techniques. Technology will be transferred to farmers after to formalities of patenting the technology.

Organic Fertigation Unit

Development of Economic Layout for Drip Irrigation in Heavy Black Soil of South Gujarat (Navsari)

Relevance

South Gujarat is the horticulture belt of Gujarat state. Apart from fruits, considerable areas are under vegetable and sugarcane crops also. Accordingly, about 140 MIS technologies covering 40 different crops across the state have been developed and recommended for the use of farmers. It is observed that for most of the crops, the water saving over surface method is 20 to 57%. The yield increase varied from 13 to 60%.

Description of the technology

Navsari centre has developed drip irrigation technologies for different crops and optimized lateral spacing, dripper spacing and discharge rate for economized the system cost. The design of layout is given in table.

Developed technology for farmers of Ukai- Kakrapar Command

SN	Crop	System details			Yield increase (%)	Water saving (%)	Fertilizer saving (%)
		Lateral spacing (cm)	Dripper spacing (cm)	Dripper discharge (lph)			
1	Sugarcane	180	60	4	23	38	50
2	Banana(G-9)	240	60	4	-	37	20 NPK
3	Castor(GCH-4)	180	120	8	32	38	60 N
4	Smooth gourd	200	100	4	13	57	Drip+ trash mulch
5	Maize(Sweet corn)	180	100	8	66	20	-
6	Onion	80	80	4/8	36	39	-

Output and scalability

The drip methods of irrigation facilitate application of nutrient in rhizosphere and at higher frequency, which enhances efficiency of applied nutrient considerably. Because of this, fertilizer dose through drip can be reduced by 20 to 40% in different crops. The drip technologies developed by this unit have become popular among the farmers owing to effective transfer of technology programme. This is evident from the increase in area under drip irrigation in horticultural crop from 13345 ha in 2003 to 1,04,937 ha during the year 2015. Apart from this, based on the survey conducted by this unit, the farmers' opinion about the increase in yield and saving in water as well as fertilizer also.

Drip in Sugarcane

Drip in Banana

Drip in Maize

Drip in Onion

Drip Irrigation and Organic Mulching Technology for Crop Production (Navsari)

Relevance

Organic or plastic mulches have been found to reduce the irrigation requirement, conserve soil moisture, restrict upward movement of soluble salts, induces early maturity and control weeds. Because of these advantages, mulching plays vital role in irrigation management.

Description of the technology

The mulch material tested are grasses, crop residues, black plastic sheet of different thickness *etc*. In order to popularise mulching black plastic mulching demonstrations on farmers' fields in about 20 ha area under banana crop have been laid through Precision Farming Development Centre. Further, use of black plastic mulch in drip irrigated brinjal also enabled to use the saline water (EC 6 dS/m) without deteriorating soil health and crop yield.

Drip + mulch effect on yield and WUE of different crops

Crop	Yield (t/ha)		Water applied (mm)		WUE (kg/ha-mm)		% increase in WUE over surface
	Drip + mulch	Surface	Drip + mulch	Surface	Drip + mulch	Surface	
Banana	84	56	1154	1653	73	34	115
Bitter gourd	25.4	21.6	479	802	53	27	96
Brinjal	46	34	570	960	80	35	128
Chillies	12.5	7.9	928	1250	13.5	6.3	114
Okra	13.0	8.5	351	462	37	18	106
Tomato	43	27	380	880	112	30	273
Rose	7.50*	4.9*	1276	1540	592	318	86

Output and scalability

Mulching in surface method resulted in saving of 40 to 70% water along with increase in yield by 18 to 49%. With drip method, mulching not only improved the yield, saved water (17 to 57 %) and fertilizer (20-40%), as well as induces an early maturity in crop like banana about 30-35 days. Similarly, drip with plastic mulching also enables to use poor quality water without adversely affecting the soil health.

Drip + BPM in castor

Drip + BPM in banana

Crop Diversification through Cultivation of Spider Lily Flower in Canal Command (Navsari)

Relevance

Spider lily is the common name for a number of different plant species within the family Amaryllidaceae which is a tropical American plants of the genus *Hymenocallis,* having narrow leaves and umbels of white flowers propagated through bulbs. Spider lily an important perennial flower crop is recently popular in South Gujarat canal command covering 2000 ha area. This flower crop has best suitability in AES III of South Gujarat heavy rainfall zone. Market of this flower is developed by the growers in nearby metropolitan cities. The buds before it opened up are harvested early in the morning and 50 bud bunches are prepared with the help of rubber bands and packed in empty fertilizer bags. Generally, the crop is irrigated by surface method though is observ that farmers are over irrigating and keeping field almost submerged.

Description of technology

After three years experimentation, surface and drip irrigation schedules were developed by Navsari centre and recommended for the farmers of AES III of South Gujarat heavy rainfall zone growing spider lily in canal command area are advised to apply 20 irrigations (IW/CPE = 1.0) each of 6 cm depth at an interval of 13-15 days during winter (Nov. to Feb.) and 7 – 10 days during summer (March to June) and for drip irrigation farmers are advised to plant spider lily in paired row (30 x 60 x 120 cm).

The system details are: Lateral spacing: 1.80 m, Dripper spacing: 0.90 m, Dripper discharge: 8 lph, Operating pressure: 1.2 kg/cm^2, Operating frequency: Alternate day and operate their system during winter: 75 – 100 minutes and summer : 100 – 150 minutes.

Output and scalability

The drip treatment mean yield (54.34 lakh buds/ha) was conspicuously higher in comparison to local practice (43.29 lakh buds/ha). In terms of water saving, under local practice almost three times more water is required than drip as well as surface method of irrigation.This disproves the farmers' taboo that spider lily requires water just like transplanted paddy. With respect to net profit, the treatment receiving surface irrigation scheduled at 1.0 IW/CPE ratio ranked first by realizing net return of Rs.1,76,401 per ha and it was followed by drip irrigation @0.6 PEF (Rs.1,67,644 per ha), 0.8 PEF (Rs.1,67,960/ha) and 1.0 PEF (Rs.1,67,350/ha).

Experimental filed

Flower buds ready for harvest

Opened flower

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