Review Article

''Improved Irrigation Practices for Higher Agricultural Productivity-A Review''

ABSTRACT

The present and future challenges of agriculture sector due to continuous population increase can be met only by technological innovations. Water is one of important natural resource, since time immemorial, also acted as catalyst during Green Revolution and helped India achieve self-sufficient status in food grain production. Fresh water is only 2.6% of the total water resources of the world has to be utilized efficiently. Inspite of coverage under irrigation in India and phenomenal growth in production from irrigated area, about 40% of irrigation water is lost during conveyance and application and the water use efficiency remains very low. Prevalent irrigation methods used in agriculture are primarily based on gravity based flow. Surface Irrigation methods *viz*., Land configuration, Laser levelling and Cablegation can increase production and can save 33% of water.Likewise sprinkler and drip Irrigation practices can also increase both productivity and water saving by 70-90%. The modern methods of irrigation (sprinkler, drip and micro-sprinkler) are becoming increasingly popular with application efficiencies as high as 90 to 95% when compared to 50 to 60% in conventional irrigation methods. At present, the area under micro-irrigation is only 7.97 Mha which is dismal compared to large rain fed area in India. The potential for micro-irrigation is estimated as 69.5 Mha and cereal crop tops in the list with 29.6 mha. Several studies on other irrigation practices like Pre-irrigation, hydrogel can also play an important role in increasing the yield levels by 36% and water saving by 27%.

***Key words**:* Laser leveling, Cablegation, Sprinkler,Microand Drip Irrigation

1. Introduction

Irrigation is defined as the application of controlled amounts of water to plants at needed intervals, in a proper way and sufficient quantity to meet the requirement of plants for enhancement of productivity. Irrigation helps to grow agricultural crops, maintain landscapes, and vegetate disturbed soils in dry areas and during periods of less than average rainfall.Developing infrastructure for the water resources and their management have been the common policy agenda in many developing economies, particularly in the arid and semi-arid tropical countries like India (Amede, 2015; Awulachew andAyana, 2011).A study by the International Water Management Institute (IWMI) has shown that around 50 per cent of the increase in demand for water by the year 2025 can be met by increasing the effectiveness of irrigation.

Efficient utilization of available water resources is crucial for a country like, India, which shares 17% of the global population with only 2.4% of land and 4% of the water resources. Further, per capita availability in terms of average utilizable water resources, which was 5247 m^3 in 1951 (presently 1453 m^3) is expected to dwindle down to 1170 m^3 by 2050 (CWC, 2015). Agricultural sector alone consumes 80% of the ground water (Harsha, 2017). The declining trend of groundwater level in all parts of the country also indicates that the assured supply of good quality water will become a concern for country's development (Manivannan et al. 2017).The overall efficiency of the flood irrigation system range between 25-40% (Amarasinghe, 2007). Overall, micro irrigation shows superiority over other traditional irrigation methods in term of water use efficiency, energy saving, yield increase and net return per unit volume of groundwater (Kumar and Palanisami, 2010; Chandrakanth et al. 2013). To meet the food security, income and nutritional needs of the projected population in 2050, the food production in India will have to be almost doubled. The groundwater table can be improved with construction of various artificial conservation practices and improve crop productivity (Paul and Panigarhi, 2016). All these emphasize the need for water conservation and improvement in water-use efficiency to achieve More Crops per Drop(Awulachew et al., 2007).

The paper is organized as follows. Firstly, the paper presents status of irrigation in India followed by challenges of irrigation systems in India. The paper also highlights various schemes of irrigation and availability of surface and ground water. Lastly, we discuss various options to overcome these challenges, government initiations for efficient water management in agriculture followed by conclusion(Carter and Danert, 2006).Irrigation uses 65% of all water diverted for various uses worldwide. The large amount of water required for food productionare primarily dictated by the linkage between biomass production and yield(Battilani et al.,2012).Nevertheless, increased water demand for other usesin our society coupled with water scarcity is producing unprecedentedpressure for reducing the share offreshwater used in irrigation. Until recently society responded to increased demands for water by developing new supplies(Pereira et al., 2012,Tadesse et al.,2016). That is no longer possible in many cases todayas the economic and environment costs of new water source development exceedsthe perceived benefits. The alternative to new developments is conservation of existing resources, for which a new conservation ethic is needed in all sectors of society. Agriculture as aprimary user ofdiverted water istherefore under close scrutiny (Carter and Danert, 2006).High water demands and perceived wasteful practices make agriculture particularly vulnerabletocriticism.Water for agricultural use is the first to be considered as anewsource of supply for other uses, particularly in situations of water scarcity. In fact reallocation of water from agriculture to other sectors has already begun in many areas and is expected to increase in the future(Molden et al., 2010)

At the same time that agriculture is being asked to give up water, the world's increasing population demandsthat agriculture increase food production (Knox et al., 2012).The water use efficiency in Indian agriculture is only about 30-40% which is one of the lowest in the world. Thus judicious use of irrigation water needs more attention to enhance total production under irrigated agriculture.It can be achieved by introducing the advance method of irrigation like microirrigation coupled with other improved management practices. Crop plant needs water for processes like photosynthesis, nutrient uptake, dissipation of heat and other metabolic processes and about 400-500 liter of water is necessary for the production of a Kilo of plant dry matter.

2. Status of Irrigation in India

Irrigation is main consumer of fresh water and more than 90 per cent of groundwater draft in India. Growing population coupled with food security has put extra pressure on water resources. Country has reached a situation where the demand of water from various sector of economy is rapidly increasing while the supply of fresh water constant. Additionally, water overuse harms the environment by increased salinity, nutrient pollution, and the degradation and loss of flood plains and wetlands. Owing to poor water resource management system and climate change India faces a persistent water shortage. Spatial and temporal variation of precipitation has been boundless varying maximum in Cherrapunji (>11000mm) to lowest western Rajasthan (Net irrigated area (%) of India has increased from nearly 18 to 48% in recent times due to government interventions at various levels. Although government has given much emphasis on improving canal system in various five year plans but it has declined over years. People have identified groundwater irrigation as much reliable and independent source of irrigation. Groundwater irrigation has taken quantum jump since 1965.

Table 1. Source wise created utilized and ultimate irrigation potential

	At the time of independence Created&Utilized	Irrigation potential (million hectares) Upto2007-12		
		Created	Utilized	Ultimate
Major&medium(Surfacewater)	9.7	47.97	34.95	58.5
Minor(Surfacewater)	6.4	NA	NA	17.3
Minor(Surface&groundwater)	12.9	65.56	52.5	81.4
Total(Major,mediumandminor)	22.6	113.53	87.86	139.9

***Source*:CWC (2015); DES,GoI (2017)**

Table2. NetIrrigatedareafromvarioussourcesandtheirrelativecontribution

Source	2009-10		2014-15	
	NIA(Mha)	Contribution(%)	NIA(Mha)	Contribution(%)
Canal	16.697	26.40	16.18	23.66
Tank	1.638	2.59	1.72	2.52
Wells	39.042	61.72	42.96	62.82
Others	5.880	9.30	7.52	11.00
Total	63.257	100	68.38	100

Source:DES,MoA&FW,GoI(2018)

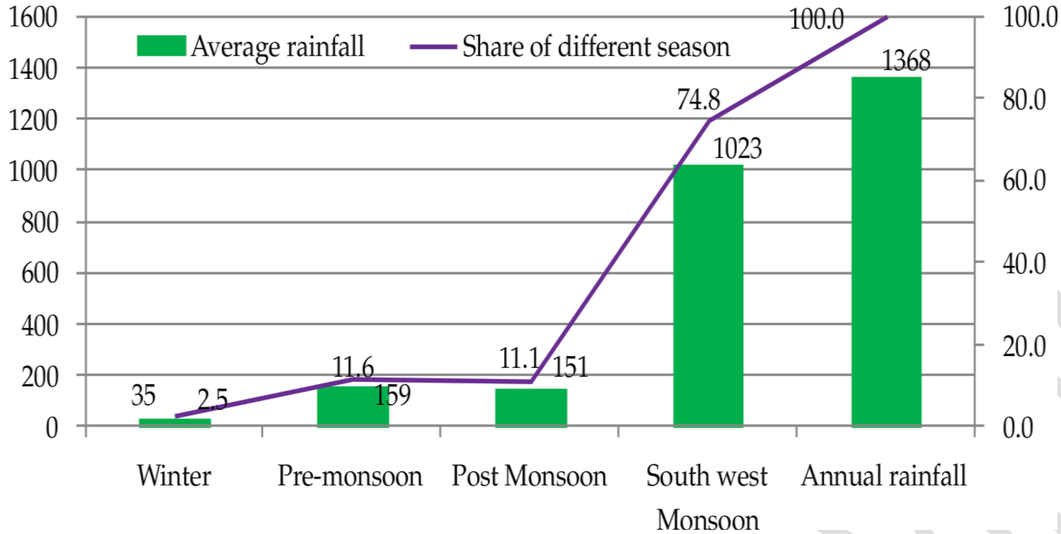

Fig. 1. Seasonal variation of rainfall in India

Improved Irrigation Practices: Following methods are generally adopted for irrigating crop fields.

- Uncontrolled flooding
- Check basin method
- Border strip method
- Ring basin method
- Furrow method

(a)Uncontrolled Flooding- Uncontrolled flooding generally results in excess irrigation at the inlet region of the field and insufficient irrigation at the outlet end. Application efficiency is reduced because of either deep percolation flowing away of water from the field. The application efficiency would also depend on the depth of flooding, the rate of intake of water into the soil, the size of the stream, and topography of the field. When water is applied to the cropland without any preparation of land and without any border to guide or restrict the flow of water on the field, the method is called uncontrolled flooding. In this method of flooding, water is brought to field ditches and then admitted at one end of the field thus letting it flood the entire field without any control. This method is suitable when water is available in large quantities, the land surface is irregular, and the crop being grown is unaffected because of excess water. The advantage of uncontrolled flooding is the low initial cost of land preparation. This is offset by the disadvantage of greater loss of water due to deep percolation and surface runoff.

(b) Border Strip Method- Border strip irrigation or border irrigation is a controlled surface flooding method of applying irrigation water. In this method, the farm is divided into a number of strips which can be 3-20 meters wide and 100-400 meters long. These strips are separated by low borders. The strips are level between borders but slope along the length according to natural slope. The slope should be between 0.2 and 0.4 per cent. But, slopes as flat as 0.1 per cent and as steep as 8 per cent can also be used. In case of steep slope, care should be taken to prevent erosion of soil. Clay loam and clayey soils require much flatter slopes around 0.2% of the border strips because of less infiltration rate. Medium soils may have slopes ranging from 0.2 to 0.4%. Sandy soils can have slopes ranging from 0.25 to 0.6%.The border strip method is suited to soils of moderately low to moderately high intake rates and low erodible. This method is suitable for all types of crops except those which require prolonged flooding which, in this case, is difficult to maintain because of the slope. This method, however, requires preparation of land involving high initial cost. Water from the supply ditch is diverted to these strips along which it flows slowly towards the downstream end and in the process it wets and irrigates the soil. When the water supply is stopped, it recedes from the upstream end to the downstream end.

Table 3. Effect of Land Slopes in Border Strip Irrigation Method in Wheat

Slopes(%)	GrainYield(Kg/ha)	Straw yield (Kg/ha)
0.15	3253	5810
0.30	3412	5421
0.45	3242	5633
SEm	94.33	161.37

Source: AICRP on Irrigation Water Management

- This method is based on the application of Border Strip irrigation method in wheat. The slope of 0.30% resulted in highest yield of 3412kg/ha and saved 20% of Irrigation water, when irrigation was applied to border step of 50 m length and 5.4 m width at 80%cutoff of Border length .
- This method not only improved the yield but also saved water which can be directed to other unirrigated area to cover more area under irrigation.

(c) Check Method- This method is based on rapid application of irrigation water to a level or nearly level area completely enclosed by dikes. The entire field is divided into a number of almost leveledplots surrounded by levees. Water is admitted from the farmer’s watercourse to these plots turn by turn. This method is suitable for a wide range of soils ranging from very permeable to heavy soils. The farmer has very good control over the distribution of water in different areas of his farm. Loss of water through deep infiltration and surface runoff can be decrease and adequate irrigation of the entire farm can be achieved. Thus, application efficiency is higher for this method. However, this method requires constant attendance and work . Besides, there is some loss of cultivable area which is occupied by the levees.

(d) Basin Method- This method is frequently used to irrigate orchards. Generally, one basin is made for one tree. However, where conditions are favorable, two or more trees can be included in one basin.

(e) Furrow Method- In the surface irrigation methods discussed above, the entire land surface is flooded during each irrigation. An alternative to flooding the entire land surface is to construct small channels along the primary direction of the movement of water and letting the water flow through these channels which are termed ‘furrows’, ‘creases’ or ‘corrugation’. Furrows are small channels having a continuous and almost uniform slope in the direction of irrigation. Water infiltrates through the wetted perimeter of the furrows and moves vertically and then laterally to saturate the soil. Furrows are used to irrigate crops planted in rows. Furrow lengths may vary from 10 meters to as much as 500 meters, although, 100 meters to 200 meters are the desirable lengths and more common. Very long furrows may result in excessive deep percolation losses and soil erosion near the upstream end of the field. Preferable slope for furrows ranges between 0.5 and 3.0 per cent. Many different classes of soil have been satisfactorily irrigated with furrow slope ranging from 3 to 6 per cent. In case of steep slopes, care should be taken to control erosion. Spacing of furrows for row crops (such as corn, potatoes, sugarbeet, etc.) is decided by the required spacing of the plant rows. The furrow stream should be small enough to prevent the flowing water from coming in direct contact with the plant. Furrows of depth 20 to 30 cm are satisfactory for soils of low permeability. For other soils, furrows may be kept 8 to 12 cm deep. Water is distributed to furrows from earthen ditches through small openings made in earthen banks. Alternatively, a smalldiameter pipe of light weight plastic or rubber can be used to siphon water from the ditch to the furrows without disturbing the banks of the earthen ditch. Furrows necessitate the wetting of only about half to one-fifth of the field surface. This reduces the evaporation loss considerably. Besides, puddling of heavy soils is also lessened and it is possible to start cultivation soon after irrigation. Furrows provide better onfarm water management capabilities for most of the surface irrigation conditions, and variable and severe topographical conditions. For example, with the change in supply conditions, number of simultaneously supplied furrows can be easily changed. In this manner, very high irrigation efficiency can be achieved.

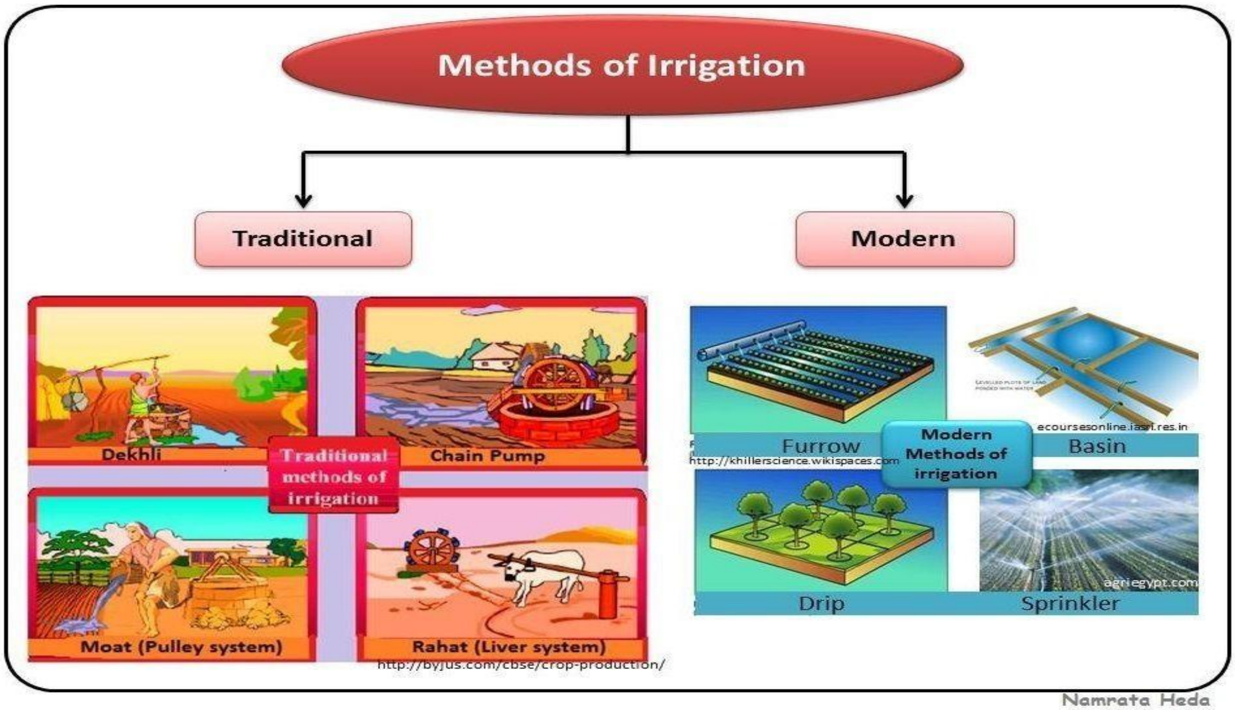

Fig.2. Different methods of Irrigation

(f). Drip Irrigation

- Most commonly used method of irrigation.
- Pipes are laid in rows near the crops or plants. These plastic pipes have holes in them.
- Water seeps from these holes drop by drop, hence the name drip irrigation. Extremely efficient method of irrigation as it reduces water wastage.
- Drip system allows water to slowly drip into the roots of the plants, either onto the soil's surface or directly onto the root zone.

(f.1)Subsurface Drip Irrigation

- Water is conveyed under pressure through a pipe system and applied to the roots below soil surface.
- No surface crusting or evaporation loss, thus highly efficient irrigation method.
- Fields can still be worked when irrigation systems are installed and application of fertiliser can optimise plant growth.
- It is most commonly used in cash crop like sugarcane.

(f.2)Low Cost Drip Irrigation

- Low-cost plastic pipes laid on the ground and irrigate crops.
- Small holes in the pipes allow a water to drip out.

- A water tank on a higher level distributes water by gravity.

No waste of water (e.g. evaporation, wind), specific irrigation at the root zone

Table 4. Distribution of micro irrigation area among states and penetration to gross sown area

State	Drip (%)	Sprinkler (%)	Total (%)	Penetration## (%)
Andhra Pradesh	24.1	7.9	15.5	20.6
Gujarat	13.3	11.8	12.5	10.0
Haryana	0.6	10.3	5.8	9.1
Karnataka	12.2	12.9	12.5	10.5
Madhya Pradesh	6.1	4.2	5.1	2.2
Maharashtra	22.8	8.3	15.1	6.6
Rajasthan	4.8	29.4	17.9	7.6
Tamil Nadu	8.6	1.7	4.9	8.4
Telangana	3.4	1.1	2.2	4.2
Others	4.0	12.5	8.6	1.2
Total area (mha)#	100 (4.7)	100 (5.6)	100 (10.3)	198.4
Potential area (mha)*	27.0	42.5	69.5	
% achievement to Potential estimated	17.4	13.2	14.8	

Source: Ministry of Agriculture (2017); '#': figures in parenthesis refer to country area in million hectares; '*':estimated by Task force on Micro Irrigation, 2004; '##': per cent micro irrigation area to its gross sown area.

Table5. Irrigationefficienciesunderdifferentmethodsofirrigation

Irrigation efficiencies	**Method of irrigation**		
	Surface	**Sprinkler**	**Drip**
Conveyance efficiency (%)	40-50 (canal) 60-70 (well)	100	100
Application efficiency (%)	60-70	70-80	90
Surface water moisture	30-40	30-40	20-25

evaporation (%)			
Overall efficiency (%)	30-35	50-60	80-90

***Source*: Saleth (2009); Narayanmoorthy (2006); Kumar and Palanisami (2010)**

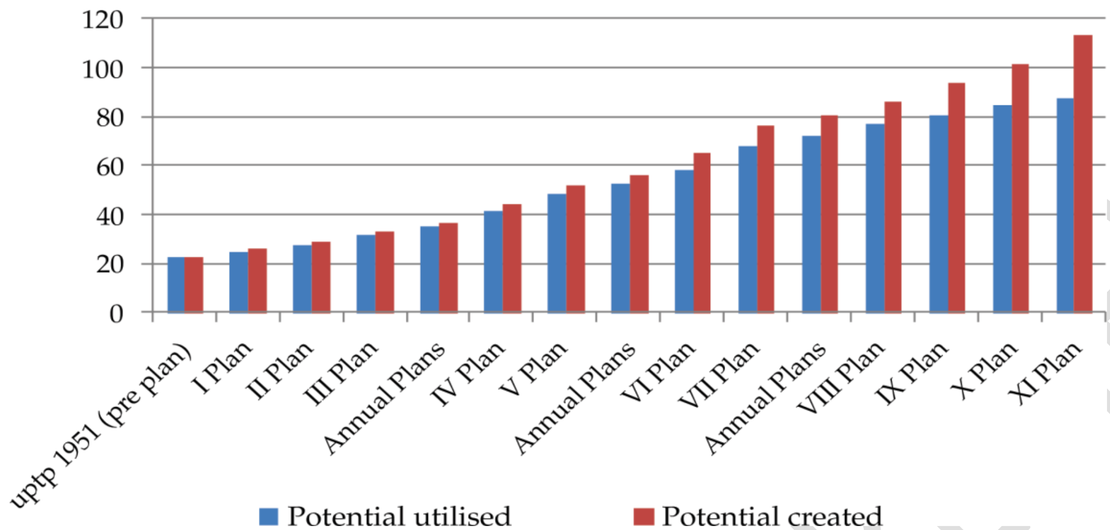

Fig. 3. Increasing gap between created and utilized irrigation potential (CWC, 2015)

Surface Irrigation Configurations Choosing a particular surface irrigation system for the specific needs of the individual irrigator depends on the proper evaluation and consideration of the following factors:

1. Costs of the system
2. Field sizes and shapes
3. Field slope and slope variability
4. Soil intake and water holding characteristics
5. the quality and availability (timing of deliveries, amount, and duration of delivery) of the water supply
6. Climate
7. Cropping patterns
8. Historical practices and preferences

Why land configuration

- About 12.9 mha of the country is rainfed but lowland, but the Productivity is quite low than it’s potential. The region received high rainfall during Kharif but root zone of the most agriculture field can remain saturated or over saturated and farmers can grow any other crop than rice.
- And in our Jammu region also 15-20,000 ha Area is affected due to this topography.
- Water in the sunken bed formed as a result of raised-sunken bed technique can act as a source of irrigation for the crops raised on sunken beds.
- There by leads to increase overall productivity and land use efficiency.

Ravendaret al. (2005) at Indian Institute of water management ICAR Bhubaneshwar (IIWM) conducted an experiment on effect of land configuration for improved water management and productivity reported that with the application of modified land practices like land configuration there is a increase of rice equivalent yield 32.42(t/ha) in Rice in rabi, rice in kharif, Brinjal ,okra which was followed by increase in monetary returns efficiency , Land utilization efficiency, water expense efficiency and increase duration in days is 300.21 Rs/ha/day, 78.08%annum, 111.37 kg/ha-cm and 285 days simultaneously as compared to rice alone (original land) i.e., REY (7.77 t/ha), MRE (55.03 % annum), WEE (2260 kg/ha-cm) and duration in days is 226. Based on these studies, it can be suggested to use modified land practices as compared to traditional land practices which could leads to improve both productivity , Monetary expenses and water saving.

Rajaket al. 2010 conducted an experiment on Influence of improved irrigation practices on growth and yield of cotton reported that with the drip irrigation system thereis an increase in plant growth parameters as compared to surface irrigation practices Plant height 73.9(cm) as against 69.02(cm) ,No of ball/plant 13.7 as against 11.92,increase in cotton yield 1.55(t/ha) as against 1.28 wid the water saving of 14.8% in drip irrigation system .Based on these studies , it can be suggested to use drip irrigation system as it helps in water saving of 14,8% and increase of yield 21,82% over surface irrigation.

Table 6. Effect of drip irrigation on plant parameters and yield of sweet corn

Effect of Drip Irrigation on Plant Parameters andYield of Sweet Corn

	Treatments	**Plant Height (cm)**	**Fresh cob length (cm)**	**Fresh cob girth (cm)**	**Fresh cob weight (g)**	**Green cob yield (t ha^{-1})**	**Green fodder yield (t ha^{-1})**
T_1	DI at 125 % PE with drip tape system	238.10	21.29	18.37	432.17	19.74	22.58
T_2	DI at 100 % PE with drip tape system	219.28	19.59	16.87	387.31	17.21	20.97
T_3	DI at 75 % PE with drip tape system	192.29	17.56	15.41	345.09	15.34	18.97
T_4	DI at 125 % PE with conventional inline drip system	241.40	22.20	18.81	446.63	19.88	22.93
T_5	DI at 100 % PE with conventional inline drip system	225.95	20.16	16.89	397.77	17.68	21.52
T_6	DI at 75% PE with conventional inline drip system	198.16	17.73	15.50	350.88	15.59	19.18
T_7	Surface irrigation at 0.8 IW/CPE	184.09	16.13	14.66	305.17	13.56	17.30
	SEd	8.74	0.80	0.69	15.90	0.74	0.87
	CD(P=0.05)	19.03	1.74	1.49	34.64	1.61	1.90

Archana *et al.* 2016 *Bangladesh Journal of Agronomy.*

Archanaet al.(2016) conducted an experiment effect of drip irrigation on plant parameters, water saving and yield of sweet corn as compared to Surface method reported that drip irrigation both with drip inline and drip tape had given significantly superior results in plant parameters , water saving and yield of sweet corn as compared to surface method .This is due to the efficient utilization of water with the help of emitters in drip irrigation system which drops water near the root zone of the crop and simultaneously there is reduction in the water losses which ultimately results in efficient water utilization.

(g). Sprinkler System

- This system mimics the phenomenon of rain.
- Water is carried by pipes to central locations on the farm. Sprinklers placed here distribute the water across the fields.
- This is the most efficient method to irrigate the uneven land. Sprinkler system also provides the best coverage regardless of the size of the farm.
- This method is better than surface irrigation as less water is wasted and water is distributed more evenly.

Pipes fitted with sprinklers are laid over or along the field. The sprinklers have rotating heads, which spray water over the crops.

Saini et al.(2006) during an experiment on total water requirement for different crop sequences reported drip irrigation is the most efficient irrigation system in crop sequence Cauliflower-hybrid chilly which yield 4365(q/ha) with water saving of 58.74% as compared to conventional irrigation crop sequence Cauliflower-hybrid Chilly which yield 340.3(q/ha) .Based on these studies we can irrigate additional area with drip *i.e*., 1.420 (ha) in cauliflower- hybrid chilly crop sequence fb 1.005(ha) in Sunflower-Maize-Potato fb 1.120 in Sunflower-Cotton.

Hemlataet al. 2018 conducted an experiment on effect of crop establishment and irrigation methods on Growth, yield attributes , yield and economics of Summer rice(Mean data of 2 years) and the results revealed that Drip irrigation had given significantly superior results when compared to traditional practice and sprinkler irrigation practice. As the crop is summer rice as the temperature is at peak at that time so the water application with the help of sprinkler in the form of shower that evaporated very rapidly hence resulted in reduced yield . Based on this study we can conclude that drip irrigation is the most efficient method even in hot summers it performed significantly superior results

Land leveling

Levelling, smoothing and shaping the field surface is as important to the surface system as the design of laterals, manifolds, risers and outlets is for sprinkler or trickle irrigation systems

- It ensures that the depths and discharge variations over the field are relatively uniform thus water distributions in the root zone is also uniform
- These field operations are required nearly every cropping season, particularly where substantial cultivation following harvest disrupts the field surface
- The preparation of the field surface for conveyance and distribution of irrigation water is as important to efficient surface irrigation as any other single management practice the farmer employs

Laser or Precision land leveling

- Land leveling-Precision land leveling is not as critical to furrow irrigation as it is to basin and border irrigation, an irrigator cannot expect to achieve high uniformities and efficiencies without it
- Precision land levelling will reduce the furrow to furrow variations in advance times and will improve both uniformity and efficiency
- Land leveling for furrow systems is also much less intrusive in field slopes can run in both field directions ,thereby reducing the volume of soil that has to be moved

Naresh and his co-workers has conducted an experiment on Water productivity and profitability of Maize and wheat rotation under various tillage and establishment techniques reported that with the application of precision land levelling with raised ,narrow and flat beds performed better as the results indicated that with the lowest amount of application of water 311(mm/ha) in Maize and 280 (mm/ha) in wheat, there is an increase in crop yield 4.41(t/ha) in Maize and 5.23(t/ha) in Wheat and increase in water productivity 1.42(kg yield/m^3 water) in Maize and 1.87 (kg yield/m^3 water) and simultaneously increase in net profit 24,545(Rs/ha) in Maize and 24,006 (Rs/ha) in wheat as compared to the traditional land levelling having a crop yield of 3.81 (t/ha) in Maize and 4.44(t/ha) in wheat with the highest amount of application of water 376(mm/ha) in Maize and 366 (mm/ha) in Wheat wid reduced water productivity 1.00(kg yield/m^3 water) in Maize and 1.21 (kg yield/m^3 water) wid lowest Net Returns.

Nareshet al. 2014 laid an experiment on Rice-Wheat yield and its components as affected by Laser Land Levelling and Traditional techniques reported that Laser land levelling out-performed better as compared to the traditional and unlevelled(control) technique with resulting increase in grain yield 5.73 (t/ha) in Rice and 4.47(t/ha) wheat with the lowest depth of water application 810mm in Rice and 340 mm in wheat, highest WUE and water saving upto 29.4% in Rice and 32.65 % in Wheat as compared to the control / Traditional levelled field which recorded lowest crop yield i.e.,4.25 (t/ha) in rice and 4.47(t/ha) in wheat with the highest amount of application of water i.e.,1260mm in Rice and 501 mm in rice with lowest WUE and no water saving. Based on these studies, it can be suggested to use precision Laser land practices as it helps in maintaining the uniformity coefficient of field and helps in uniform distribution of water over the entire field which results in water saving along wid increase in crop yield due to the uniform uptake of nutrient by the roots of the crop plants .

(h). **Cablegation**

- A method of controlling the water supply to irrigated furrows whereby a single, gated, pipeline is used for conveying as well as delivering individual streams of water
- It supplies water through a multi-outlet pipeline, pipe being used laid on a precise gradient and discharge is controlled by a moving plug inside the pipeline
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Jayasudhavanet al. 2001 during an experiment n Uniformity of moisture distribution in different treatments under cablegation and continuous flow reported that an uniformity coefficient upt0 98% can be achieved at the pipe slope of 1.5% when the orientation of outlet pipe at 60 degree having 9 no. of outlets when compared to the the continuous flow which can achieve only 72% of uniformity coefficient.

Singh *et al*.,2018 during an experiment effect of hydrogel on improved water use in Indian Mustard reported that Hydrogel is an water absorbing hydrophilic compounds which can retain water inside it for a long time and results revealed that with the application of 5.0 (kg/ha) of hydrogel had given significantly superior results in plant parameters (Plant height,Dry matter accumulation, Siliqualength,seed/siliqua, 1000 seed weight,seed yield ,CUW, WUE) and Net returns followed by 2.5 kg/ha of hydrogel as compared to the control(No hydrogel).

Singh *et al*., 2013 conducted an experiment on Growth parameters, Yield, water use, water use efficiency and economics of wheat as affected by the time of Pre-irrigation and tillage practices(Pooled data of 2 years) and the results revealed that Pre-irrigation before harvesting of Pigeonpea had given significantly superior results in growth parameters ,yield, water use.WUE and economics of wheat when compared to Pre irrigation after harvesting of pigeonpea.

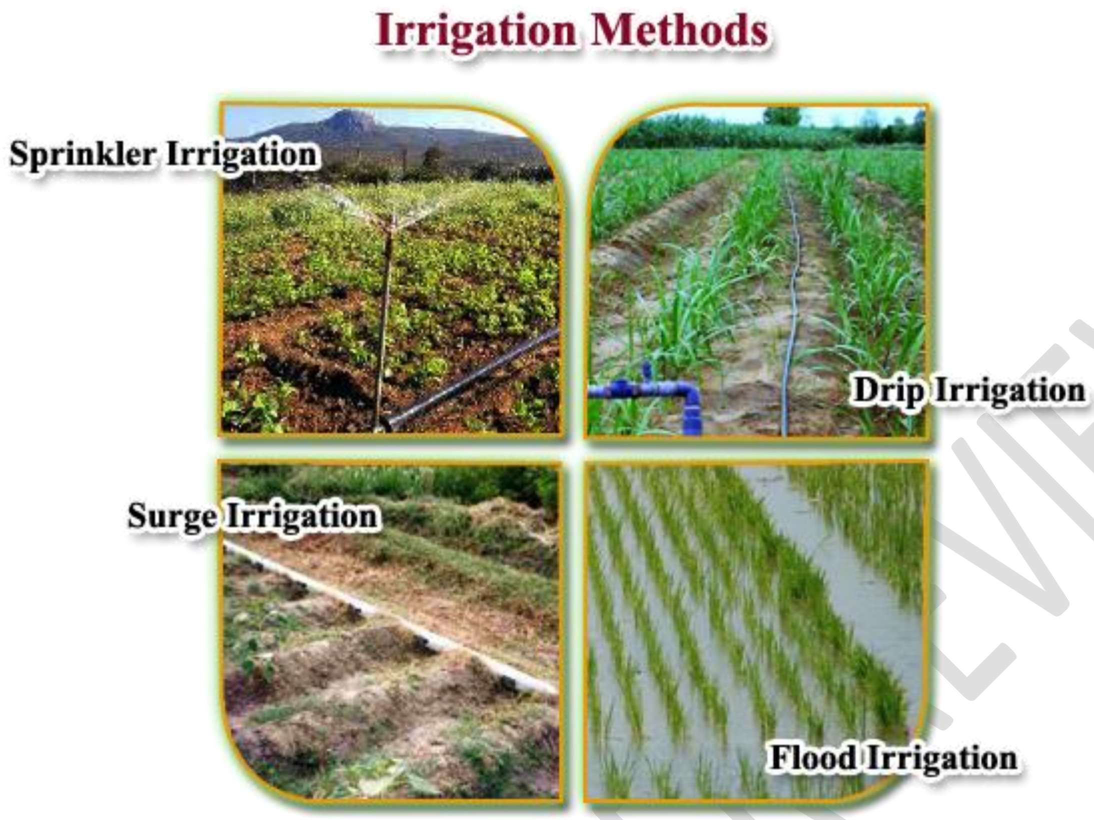

Fig.4 Improved methods of irrigation

Conclusions

The future of higher productivity levels for the crops, depend upon the how water is being used efficiently. Irrigationinfrastructureneeds to be further improved to harvest rainwaterand increase storage capacity in order to utilizerunoffwater.Micro irrigation hasscopeforimproving irrigation efficiency up to 90%. Further, micro irrigation and optimum crop planwill play decisive role in conservation of waterresources and food security of the nation. Launch of supportive national policies like PMKSY-with emphasis on Micro irrigation Techniques can play an important role for realizing the goal of increased productivity and water saving and Improve water use efficiency.

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