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Research Article

IMPACT OF PLASTIC MULCHING WITH FURROW IRRIGATION ON TOMATO CROP AT FARMER'S FIELD IN UNNAO DISTRICT

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Abstract- Declining ground water resources have become a major problem to the farmers in Uttar Pradesh, India. Mismanagement of groundwater use for irrigation without adopting any water resource conservation techniques may cause a serious problem to the agriculture in the state. The present study was carried out at the farmer's field to utilize the resource conservation techniques to check the upcoming threat of groundwater scarcity. Resource conservation practice of Plastic Mulch (PM) was used to conserve the soil moisture and other resource under low cost Furrow Irrigation System (FIS) on tomato crop. Two farmers from each of four villages were selected for the experiment. Three treatments were made at each farmer's field *liz.,* farmers practice with flood irrigation as a control (T_1), raised bed with FIS (T_2), raised bed with PM and FIS (T_3). Area under each trail was 35x30 m^2 and bed width of raised bed was 0.9 m and furrow to furrow distance and length was 1.15 m and 30 m, respectively. The parameters included Depth of water irrigated, Yield, Water Use Efficiency (WUE) and Benefit Cost Ratio (BCR) in the study and statistically analyzed. Results revealed that total irrigation water saving, yield, WUE and BCR values were significantly high ($P<0.05$) in T_3followed by $T_2$and T_1. Plastic mulching (T_3) effected 27.44 and 59.52 per cent of water saving in T_2 and T_1, respectively and corresponding increase in yield was 26.27 and 47.59 per cent. Plastic mulching with furrow irrigation than pressurized irrigation may prove to be cost-effective measure for moisture conservation in Unnao district of Uttar Pradesh, which can effectively control the declining water table and farmers may get higher profit from crop production.

Keywords- Furrow Irrigation, Plastic Mulching, Resource Conservation, Water Use Efficiency and Yield

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Introduction

Optimized water management techniques at the farm level are required in view of increasing water demand and limited resources [1]. Flood irrigation method (FIM) is the most effective and ready to adopt surface irrigation method and widely used for all crops (cereal, pulses, fruits and vegetables) in Uttar Pradesh as well as in Unnao district. Large amount of water is wasted in FIM, which resulted the alarming situation of ground water use in some region of the district, affecting crop cultivation. The district has about 95% irrigated cultivation area, out of which only 24% is irrigated by surface water resources and rest 76% by the ground water resources. The continuous drafting of groundwater for flood irrigation resulted the groundwater depletion rate up-to 0.3117 m/year in some region [2]. Maximum use of groundwater is in irrigation *i.e.* 80%, therefore it becomes necessary to adopt water conservation practices for agriculture. A massive awareness of water conservation is necessary to the farmers for preventing declining ground water table and high cost of irrigation (operating and maintenance charges). Pressurized irrigation methods can be a good choice but its high cost (initial and maintenance) and lack of know how; hindering its on-farm use by the farmers [3]. Furrow irrigation can be a good alternative of surface irrigation than FIM and micro-irrigation systems (MIS) to reduce the groundwater drafting. Furrow irrigation can be adopted for most of the crops and correlated best with the crop yield [3]. Water application efficiency, water storage efficiency, and distribution efficiency are the major performance parameter of furrow irrigation variables (inflow discharge, furrow length and time of irrigation cutoff) can be used for design, management and operation of furrow irrigation systems [4]. Utilization of water use can further be reduced if the crops are foiled with mulches; either organic or chemical. The water use efficiency remains high in FIS in comparison of flood irrigation and it is higher when it is coupled with the mulched crop [4]. Mulching practices along with furrow irrigation are very useful to control the weeds and conserve soil moisture contents that in turn enhanced the plant growth [5]. Moisture conservation is always promoted in the farming for improving the soil productivity and decreasing the input cost, which results the high BCR; subsequently the quality of produce. The farmer's adoption of resource conservation practices in India and UP is still quite low and need to be infused in agriculture to further enhance and sustain the productivity as well as to tap new sources of agricultural growth [6]. Basically there are two type of mulching *i.e.* organic and inorganic. Organic mulch includes the organic material *like*; straw, husk, stubble, leaf mold, compost, sawdust, and animal manures, while inorganic includes plastic sheets/film. Mulching raise soil temperatures quickly, so the plants can increase growth resulting in earlier and higher yields (possibly up to 15 per cent or more) compared to bare ground production [7]. Mulching also enhance the biological activity and improves the physical and chemical property of the soil [8]. The mulching film/sheet used in furrow irrigation enhance soil microbial biomass resulting the improved soil productivity [9]. Tomato *(Solanum Lycopersicum L.)* is a very important crop of India and is consumable throughout the year. Its production is about 1.82 million MT cultivated over 879.64 thousand hectares in India, out of which Uttar Pradesh contributes only 310.86 thousand MT cultivated over 7230 ha land and stands at

15th place in all India states [10]. There is a need to promote the farmer for the tomato production with the most recent techniques to acquire the high benefit cost ratio (BCR) from the crop without compromising the available resources. The resource management practices can encourage the farmers of Uttar Pradesh to grow tomatoes by decreasing the input cost of production which may result higher BCR. The tomato crop is most profitable with high BCR of 1.85 or little more [11].
The major objective of the experiment is to examine the response of mulching on utilization of water, tomato yield and water use efficiency and benefit cost ratio (BCR). The experiments laid on farmer's field to popularize furrow irrigation coupled with plastic mulching in their cultivation practices for tomato production as well as on other vegetables and crops *etc*. Various studies were made around to find out the effect of mulching under the furrow irrigation but with the farmers point of view, on farm experiment is necessary for better understating of the titled approach to the farmers.

Material and Methods

The experiment was laid out at Maljha, Pilakhna, Baxikhera and Farhatpur villages of Hasanganj block of Unnao district designated as F_1, F_2, F_3, and F_4 respectively, Uttar Pradesh (lies between 26˚05' and 27˚02' north latitudes and 80˚03' and 81˚03' east longitudes) in Rabi season, October 2016 and last up to February 2017. The above villages are close to each other within 10 km perimeter so that the climate remains constant throughout the crop period. The physical and chemical properties of the soil of each village are given in [Table-1]. Very light shower (4.18 cm) of rainfall was recorded in during the crop period and the maximum and minimum temperature were recorded as 33^{0}C and 9.5^{0}C respectively (https://www.accuweather.com). The soils in the villages were sodic in nature and no measures were taken for its amendment during the experiment. Three treatments were conducted at each farmer's field *liz.* Farmers practice with flood irrigation as a control (T_1), raised bed with furrow irrigation system (FIS)(T_2), raised bed with plastic mulch (PM) and FIS (T_3).The area under each treatment (T_1, T_2, and T_3) was 35×30 m^2(0.105 ha). Groundwater was used for irrigation. The bed width of raised bed was 0.9 meter (m) and V shape furrow was selected with 40 cm top width and 10 cm depth. The furrow to furrow length and distance was 35 m and 1.15 m respectively for T_2 and T_3 [Fig-1]. The duration of application of water in the furrow (both in T_2 and T_3) was determined by Micheal's equation (2013). The slope gradient in each furrow was in between 0.18 to 0.24% and accordingly [12]. Before every irrigation, the weeds on furrow were removed by ridge-maker and maintained its shape as per design in the plot T_2 and T_3. The weeds were removed manually in T_1.The duration of irrigation in plot T_1 was on the basis that it can achieve a depth of 10.16 cm (4 inch) of water at the farthest point of the plot from the water inflow point in the plot (as per farmer's methodology). The black plastic film of 25µ thin and 1 m wide was used as mulching material and provided to the farmers for laying out the experiment. The irrigation was schedule on the basis of farmer's inspection of soil moisture and crop condition. [Table-3] describes the irrigation schedule in all the treatments. A small portable rectangular weir with 20 cm length (L) was installed at the head of the furrow in both T_2 and T_3. Discharge was calculated from the equation $Q=0.0184LH^{3/2}$ where L and H are weir length and head in cm and Q is in *lps* [12]. Number of irrigation and irrigation scheduling in each treatment were observed as [Table-2]. Tomato seedlings (c.v. NTH 1831) were raised in the nursery with the recommended seed rate of 125 g/ha and recommended dose of Farm Yard Manure (FYM) 10kg/125gm of seed. Seedlings were transplanted used after 30-35 days of sowing. Plant to plant distance was 70 cm in T_1 (in line) and zigzag in T_2 and T_3 in layout. Plants were transplanted 10 cm inside the bed from its edge in T_2 and T_3 [Fig-1]. Before transplanting the seedlings, each plot was ploughed to the fine tilth by rotavator. Plot T_1 was dressed with the basal dose of FYM with the rate of 30 t/ha and 20 t/ha was applied to the bed of T_2 and T_3 plot. 2 kg/ha of *Azospirillum* and 2 kg/ha of *Phosphobacteria* were mixed in FYM before applying to the field by mixing it in 50 kg FYM. Basal dose of fertilizer was applied to the soil at the rate of 130 kg/ha in T_1 and 100 kg/ha in T_2 and T_3. Nitrogen (N) and Potash (K) each 150 kg/ha in 3 equal splits at 30, 45 and 60 days after planting. The wilt disease was spotted in some plots and controlled by spraying of Mancozeb 75 wp with the rate of 2.5 g/lit 55 days after transplanting. The major parameters to determine the effectiveness of mulching and furrow irrigation were Depth of water given as an irrigation, Yield, WUE and BCR. The cost includes the preparation of field for nursery, and field for transplanting, plastic mulching sheet, basal dose, and fertilizer, insecticides, labor for weeding, irrigation and harvesting. The adaptation of any agricultural technique, the cost is the main perspective of farmers.

Table-1 *Physical and Chemical properties and Available Nutrient of soil in different villages.*

Soil Parameters/Villages	F_1	F_2	F_3	F_4
Soil pH	8.6	8.8	8.7	9.3
Irrigation Water pH	8.1	7.9	8.0	8.0
Soil EC (mmhos/cm)	0.28	0.35	0.36	0.37
Water EC (mmhos/cm)	0.75	0.77	0.72	0.74
Organic Carbon (%)	0.20	0.19	0.14	0.16
Available N (kg/ha)	215	222	200	210
Available P (kg/ha)	16	13	13	14
Available K (kg/ha)	256	265	282	275
Exchangeable Na (%)	33	42	38	32
Soil Nature	Sodic	Sodic	Sodic	Sodic
Bulk Density (gm/cc)	1.56	1.56	1..52	1.51
Soil Texture class	Clay Loam	Clay Loam	Clay Loam	Clay Loam

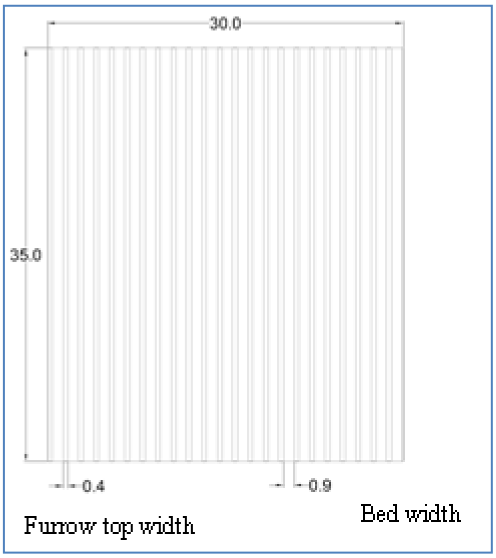

Fig-1 Furrow & Bed Spacing

Result and Discussion

Water Used in Irrigation:

6, 7 and 5 watering were recorded in T_1, T_2 and T_3, respectively [Table-2]. The portable rectangular weir recorded 4.2 to 4.7 liter per second (*lps*) flow of irrigation water in furrow. The experiment revealed that the maximum and minimum irrigation water was used in T_1 (62.88 cm) and T_3(25.45 cm), respectively which resulted about 59.52 % water saving by the use of mulching. T_2used 9.63 cm more compared to the mulched crop in T_3; marginally high use of water. Furrow irrigation method dominantly reduced the application of water over the control. About 44% water saving was resulted in T_2 in comparison of T_1, while mulching saved about 27.44% water in T_3 in comparison of T_2. The above difference is because of the presence of mulch that reduced the evaporation from the wet soil surface; supporting the findings [13]. The high water saving associated with the short furrow length with high discharge for the clay loam soil may give the higher water application efficiency, as per the findings of [14]. The outcome of statistical analysis also supports that the irrigation depth was significantly low ($P<0.05$) in furrow irrigation method [Table-3].

Yield:

There is higher yield by 4 t/ha over the conventional plantation of tomatoes. Furrow irrigation method showed the significant effects on yield in ($P<0.01$) the comparison of flood irrigation method. Application of plastic mulching raised the yield to 36.35 ton/ha in T_3 treatment which was on an average 55.73 % high from

Table-2 *Irrigation schedule during experiment*

S. No.	Month	Irrigation after Days of Transplanting (Days)											
		F_1			F_2			F_3			F_4		
		T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
1	Nov	1	0	0	1	0	0	0	0	0	0	0	0
2		12	10	10	14	11	13	12	11	16	9	9	13
3		28	22	28	30	22	28	30	21	35	27	20	28
4	Dec	43	33	52	43	32	46	45	30	51	42	29	42
5		55	42	72	58	45	64	59	41	70	54	40	64
6	Jan	68	53	-	73	58	-	74	52	-	66	52	-
7		-	64	-	-	70		-	63	-	78	64	-

Table-3 *Main parameter and effects of furrow irrigation methods and mulching.*

Attributes	T3	T_2	T_1	P-Value
Irrigation Depth (cm)	$25.45^a \pm 0.13$	$35.08^b \pm 0.19$	$62.88^c \pm 1.09$	0.00
Yield (t/ha)	$36.35^a \pm 0.43$	$28.98^b \pm 0.76$	$24.80^c \pm 0.36$	0.00
Water Use Efficiency (t/ha-cm)	$1.44^a \pm 0.054$	$0.83^b \pm 0.010$	$0.40^c \pm 0.012$	0.00
Benefit-Cost-Ratio(BCR)	$2.46^a \pm 0.02$	$2.01^b \pm 0.05$	$1.93^c \pm 0.03$	0.00

control T_1. Further it is interesting to see that the production was increased by more than about 11.8 t/ha and 7.6 t/ha in T_3 than that of T_1 and T_2 respectively. The production in T_2 was 24.18% high from T_1 which tuned to 28.98 ton/ha. Studies on Precision Farming Development Centers [15] (PFDC's) 2012 revealed 46.5% to 85.6% yield increase in Tomatoes. Use of plastic mulching increases the availability of moisture and better nutrient intake by the plants in T_3that resulted the high yield in furrow irrigation system, the findings consistent with those of [4].Plastic mulches reduce nutrient leaching, and stabilize soil moisture, which in turn may enhance rapid and uniform crop soil coverage and increase yield, thus supporting the findings of [16].

Water Use Efficiency:

Investigation showed that the furrow irrigation method affected the water use efficiency (WUE) in tomato. The conventional flood irrigation methodgave the lower water uses efficiency of 0.40 t/ha-cm than that of furrow irrigation method [Table-3]. Highest water efficiency is associated with T_3 of 0.83 t/ha-cm followed T_2 that is 1.44 t/ha-cm. Statistical approaches also indicate thatthe water use efficiency is highly significant ($P<0.01$) in furrow irrigation methods over traditional. The above findings are in the agreements with the [17] that the weed control measures (mulching) significantly contribute to increase crop WUE by reducing competition for nutrients and moisture in the root zone and for light above the ground.

Benefit-Cost-Ratio:

[Table-4] revealed the details of per hectare cost of tomato cultivation. Field preparation in T_2 and T_3 was high because of bed and furrow making after bed preparation. Fertilizer and manure were broadcasted over the bed in T_2 and T_3whereas in T_1over the land. Nursery and insecticide cost was remaining same for all the treatments. Cost of irrigation impacted the cost of cultivation in T_1 and T_2 while plastic mulching reduces the irrigation cost T_3. Also, plastic mulching effected the labor cost for removing weeds T_1 comparing with T_2 and T_3. Furrow irrigation method increases the cost of cultivation by 6.31% which includes weeding and furrow maintenance but reduces the water application. However, the use of plastic mulching increases the cost of cultivation by 6.67% in comparison of T_1; approaching the findings of the research [8] which states that 7.5-15.70% increment of cost of cultivation by the use of mulching. The irrigation management practice increases the income by 16,740/-Rs/ha additionally when sold on the marketable price of tomato of 4000 Rs/ton. Use of plastic mulching enhances the income by 47,200/-Rs/ha. Benefit cost ratio (BCR) was calculated as 1.79, 1.97 and 2.48 in T_1, T_2, and T_3, respectively [Table-3]. The additional income of T_2 and T_3 increases the BCR values over T_1. Resource conservation technique impacted on BCR values in T_3.

Table-4 *Cost of cultivation (Rs/ha) during experiment*

Parameters	T1	T_2	T3
Field preparation	4800	7800	7800
Fertilizer cost	6095.23	4353.21	4353.21
Manure cost	6827.83	4875.84	4875.84
Nursery cost	9142.85	9142.85	9142.85
Insecticide	2147.98	2147.98	2147.98
Plastic mulch	-	-	16000
Irrigation	7200	5040	3600
Labour cost	19200	25600	11200
Total	55413.9	58959.88	59119.88

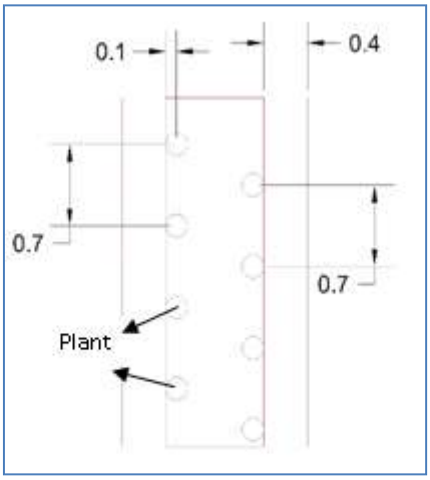

Fig-2 Plant Spacing

Conclusion

Acceptance and adaptability of any new agricultural technique depends on degree of scarcity of available resources in the locality. There is a need to motivate the farmers of Unnao district to seek the new water saving techniques for their cultivation to combat the upcoming water scarcity scenario. The cost of new technology always remains the matter of concern and feasibility. The cost effectiveness of furrow irrigation comparing with pressurized irrigation can be feasible in the district. The present experiment was setup on farmer's field to demonstrate how the wastage of water could be saved along with getting the higher yield of tomato. Furrow irrigation saved about 57 % of water and if it is coupled with plastic mulching; 69% water could be saved. Experiment revealed that under water deficit conditions, furrow irrigation may increase the tomato cultivation area by 49% over the T_1 whereas use of mulching may increase the same by 224% and 40% over T_1 and T_2 respectively. Effect of furrow irrigation in tomato production was experienced higher in T_2 over T_1 by 7.62 t/ha while use of mulching boosted the production by 11.8 t/ha over T_1. The cost of cultivation was high in in mulching but gave a good BCR value of 2.48.

Application of research: Farmer may adopt the mulching with furrow irrigation not only for tomato but other vegetable crops to face the ground water declining challenges subsequently may get the higher BCR.

Research Category: Furrow Irrigation

Abbreviations:
FLD: Front line demonstration
BCR: Benefit cost ratio
FIS: Furrow irrigation system

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