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Water productivity of wheat crop with different sowing methods under drip irrigation

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Abstract

The need for judicious and economical use of scarce water resources for sustainable agriculture is becoming increasingly important day by day due to constantly escalating water shortages. Various water management technologies and techniques for improving water productivity are being promoted by the Water Management wing of Agriculture Department Punjab, Pakistan at the farm level. There is, however, a huge gap in the amount of water being applied and actual irrigation requirements. The excessive use of water is required to be curtailed by modernizing application methods and scheduling the irrigation on scientific basis. In this regard, various studies are being carried out at Water Management Research Farm (WMRF), Renala Khurd. The WMRF is being used to evaluate, indigenize, and demonstrate improved water management technologies and techniques. The same will help in obtaining accurate information on their impacts and economic returns per unit volume of water i.e. water productivity. This study has been conducted to evaluate water productivity. The factors causing variations in crop water productivity are identified and the scope to enhance food production via refining water productivity is discussed. The wheat crop was sown in the year 2019-20 at WMRF to estimate its Water Productivity. For this purpose, 4 different treatments were suggested for the water productivity experiment. Sowing systems adopted were by broadcasting and drill sowing manually and mechanically. In this regard, T1 wheat seed was manually broadcasted, and surface irrigation (Border) was applied. Sowing for T2 was done by mechanical seed drill. T3 and T4 treatments were applied, and a seed drill was used for sowing on bed furrow. Drip irrigation method was applied for T2, T3 and T4. The results of experiments conducted at WMRF Renala Khurd shows the evidence in Water Productivity difference for the wheat crop. The variation in Water Productivity for different treatments was quite noticeable from these experimental results. In T1 the Water Productivity was 1.08kg/m3 against the plot yield of 98.25kg by the application of flood irrigation, vol. of H2O used is 65% higher than T2 with drip irrigation. T3 and T4 treatments show low yield results following Water productivity values. In T3 the Water productivity was 1.26kg/m3 against the plot yield of 74.17kg and in T4 the Water Productivity was 0.97kg/m3 and the plot yield was 62.16kg. The yield in T3 and T4 were reduced as compared to T2 which was 82.34kg against the Water Productivity 1.40kg/m3 by using drip irrigation. It revealed that water productivity is achieved better in drill sowing on flat land irrigated with a drip system. The volume of water consumed in flood irrigation is 64% more than drip irrigation. The experiment shows that line sowing of wheat crop irrigated with drip irrigation is more viable from a water-saving point of view. Farmer should be motivated for drill sowing of wheat. For the better production of wheat crop drip system should be installed to get efficient water consumption.

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Introduction

It is generally accepted that human beings are confronting an exceptional worldwide water emergency. Without improvement in water resources management and more cohesive policymaking in both developed and developing countries, water-related problems are expected to significantly deteriorate over the next several decades (Mahmudul Hassan, 2017). It will also cause dramatic consequences for the sustainability of economic growth, the integrity of eco systems, and the welfare of the poor who often end up bearing a disproportionate share of the costs (Sander, 2004). The key factor, influencing this situation, is water management issues in the agricultural sector. Two basic facts are critical for understanding agriculture's role in this water crisis (Najum Uddin in 2019). First, the agricultural sector is so far the biggest user of water. Worldwide, irrigated agriculture accounts for about 70 percent of total surface water extractions (Molden, 2007). An estimated 20 percent of cultivated land is irrigated, accounting for 40 percent of total agricultural production (Rosegrant *et al.*, 2009). And second, water use in agriculture also tends to have relatively low net returns as compared to other uses (Young, 2005).

Pakistan is the sixth most populous country in the world with its population estimated at 207.8 million in 2017. Its population growth rate of 2.40 percent is the highest in South Asia and stands in sharp contrast to the 1.0–1.5 percent growth rate of other South Asian countries. Pakistan's population has increased by more than six-folds since the first post-independence census held in 1951. This massive growth in population possesses serious challenges for the country's socio-economic development. (UNDP, 2019). Producing enough food and generating adequate income in the Punjab to better feed the poor and reduce the number of those suffering is a great challenge (Ahmed, 2004). This challenge is likely to intensify, with the increasing population that is projected to increase to 300 million in 2025, putting even greater pressure on province food security. Irrigated agriculture has been an important contributor to the expansion of national food supplies and expected to play a major role in feeding the growing population (Foley, 2019). However, irrigation accounts for about 90% of developing-country water withdrawals, and water availability for irrigation may have reduced in many regions in favor of rapidly increasing non-agricultural water uses in industry and households, as well as for environmental purposes (Cai, 2003). With growing irrigation-water demand and increasing competition across water-using sectors, the world now faces a challenge to produce more food with less water. This goal will be realistic only if appropriate strategies are found for water savings and for more efficient water uses in agriculture. One important strategy is to increase the productivity of water. (Cai and Rosegrant 2003).

The United Nations World Water Assessment Program calls for crop water productivity increases with the aim of reducing pressure to develop new supply sources or increasing water allocation to agriculture (UNESCO, 2009). FAO (2012) considers demand management as an important option to cope with water scarcity, with increasing agricultural water productivity as the single most important avenue for managing water demand in agriculture. Several recent reports of the World Bank Group have also called for a stronger focus on agricultural water productivity (World Bank, 2003). For example, the water strategy Sustaining Water for All in a Changing Climate for the period FY2010-13 mentions water productivity as a critical issue in agriculture (World Bank, 2010). The Agriculture Action Plan for the period FY2013-15 points out that especially in regions where expanding the scope for irrigated agriculture is limited, more efforts are needed to improve the use of available water, by raising its productivity and sustainable use (World Bank, 2013).

As water resources around the world are threatened by scarcity, degradation, overuse, and food demands are projected to increase. It is important to improve our ability to produce food with less water (Cook *et al.*, 2006). There are only a few basic methods of using the water resources to meet the growing food demands, continuing to expand rainfed and irrigated lands, increasing production per unit of water, trade in food commodities; and changes in consumption practices. Land expansion is no longer a viable solution (Godfray *et al.*, 2010). Therefore, improving agricultural productivity on existing lands using the same amount of water will be essential. Increasing water productivity means using less, water to complete a particular task, or using the same amount of water, but producing more (Perry, 1999). Increased water productivity has been associated with improved food security and livelihoods (Kannan and Anandhi, 2020). In recent years though, a growing body of evidence is creating a clearer picture on the potential solutions and ways forward (Kumar, *et al.*, 2008). Especially where yield gaps are large, there is large scope for improvement. Comparing bright spots (examples of high-water productivity) with hot spots (examples of low water productivity) across ten different basins showed that yield increases through tailored interventions are possible at many locations and would lead to major gains in water productivity (Cai *et al.*, 2011; Cook *et al.*, 2009; de Fraiture and Wichelns, 2010). Additionally, it leads to savings in fresh water, making it available for other uses, such as healthy ecosystem functioning. Increased water productivity is, therefore an important element in improved management of water and ecosystems for sustainable agriculture and food security. Water productivity is the amount of beneficial output per unit of water depleted (Cai and Rosegrant 2003). In its broadest sense, it reflects the objectives of producing more food, and the associated income, livelihood and ecological benefits, at a lower social and environmental cost per unit of water used (Molden *et al.*, 2007).

Growing water scarcity has further constrained the attainment of goals of food security and sustainable natural resource management (Lampayan, *et al.*, 2019). The irrigation sector will have less water in future as competition and demands from the domestic, industrial, and environmental sectors keeps on increasing. The challenge for irrigated agriculture will be to produce more food with less water (Foley, *et al.*, 2019). The worsening situation can only be reverted if water is managed more efficiently and judiciously. Water productivity can be increased by increasing yield per unit land area, for example, by using better varieties or agronomic practices, or by growing the crop during the most suitable period (Ahmed, *et al.*, 2004). Water productivity is also determined by factors other than water management.

To use this concept for the purpose of improving water management, the contributions of other factors that contribute to crop yield must be considered (Ali and Talukder, 2008). Higher productivity does not necessarily mean that the crop effectively uses a higher proportion of the water input (Biradar, 2008). For this reason, water productivity alone would not be particularly useful in identifying water savings opportunities of the system under consideration (Guerra *et al.*, 1998).

Increasing Crop Water Productivity opportunities for improving crop water productivity mainly lie in choosing adapted, water-efficient crops, reducing unproductive water losses and ensuring ideal agronomic conditions for crop production Molden *et al.*, 2003). There is great variation in water productivity across cropping systems, under both irrigated and rainfed conditions (Keller *et al.*, 1996).

It has been estimated that three quarters of the additional food we need for our growing population could be met by increasing the productivity of low-yield farming systems, probably to 80% of the productivity that high-yield farming systems obtain from comparable land.

Report Water for Food, Water for Life. (Kijne *et al.*, 2003; Bouman, 2007; Molden, 2007; Rockström and Barron, 2007, (Deschee maeker *et al.*, 2011) Research on the performance of various interventions for crop water productivity improvement has included, among others, supplemental irrigation, precision irrigation and drainage, soil fertility management, reduced tillage operations, soil moisture conservation, and the use of drought- and disease-resistant crop varieties (Fischer *et al.*, 2009; Geerts and Raes, 2009; Gowda *et al.*, 2009; Oweis and Hachum, 2009; Stuyt *et al.*, 2009; de Vries *et al.*, 2010; Arora *et al.*, 2011; Balwinder *et al.*, 2011; Mzezewa *et al.*, 2011). In that respect, the highest potential water productivity gains can be achieved in low-yielding rainfed areas in pockets of poverty across much of sub-Saharan Africa and South Asia (Rockstrom *et al.*, 2010).

As many of the world's poorest people live in currently low-yielding rain fed areas, improving the productivity of water and land in these areas would result in multiple benefits. Thus, by getting more value out of currently underutilized rainwater, agricultural land expansion would be limited, and the livelihoods of these poor men and women would be improved, without threatening other ecosystem services (WRI *et al.*, 2008).

A recent global analysis on closing yield gaps indicated that appropriate nutrient and water management are essential and have to go hand in hand (Mueller *et al.*, 2012). Gaps in crop water productivity are often linked to access to water, but also to access to other inputs such as seeds and fertilizers, which illustrates the importance of markets and infrastructure (Ahmad and Giordano, 2010). However, in highly productive areas, caution on the scope for gains in crop water productivity is warranted (Molden *et al.*, 2010).

Water accounting and water productivity concepts are useful to evaluate the existing performance and to explore options for real water saving from field to basin scale (Molden, 1997). These concepts require complete understanding of the exiting water use pattern and the interaction of different water balance components, which are complex, at different spatial and temporal scales (Descheemaeker *et al.*, 2013).

This study was carried out with the specific objectives to diagnose the variations of water productivity for wheat crops in Punjab, Pakistan. The analysis will provide a picture of existing water use pattern and initial insight whether the water is being used optimally, or there is a scope for water saving and increasing economic efficiency.

Materials and methods

Experimental Site

The experiment was conducted on the land of Water Management Research Farm (WMRF) situated in Renala Khurd, district Okara. Study area is situated in the Punjab province of Pakistan between 73° 54′ E and 30° 85′ N with an average elevation of 570 feet. Okara District is famous for its fertile lands, peaceful natural environment and green fields of Potato, tomato, sugarcane, wheat, rice and maize crops. Oranges and Mangoes orchards are common.

Most areas in Renala Khurd experience fairly cool winters, often accompanied by rain. By mid-February, the temperature begins to rise; springtime weather continues until mid-April, when the summer heat sets in, June and July are oppressively hot. The maximum temperature was observed 45C°, Minimum temperature 35C° and average temperature was 41C° in summer while the maximum temperature 18C°, Minimum temperature 10C° and average temperature 15C° were observed in winter.

The average annual rainfall is 106.9mm with 76.5mm expected in monsoon season. October and November are the dry months with average rainfall of 5.5mm per month except in the most areas.

Experimental Treatments

Four treatments were planned with different irrigation and sowing techniques.

Treatment 1 (T1) = Seeding by broad casting and flood/surface irrigation.

Treatment 2 (T2) = Drill sowing on flat land and drip irrigation.

Treatment 3 (T3) = Sowing on 69cm wide bed/46cm furrow with single lateral.

Treatment 4 (T4) = Sowing on 112cm wide bed /46cm furrow with double lateral.

16 plots were marked for 4 treatments and 4 replicates of each treatment. Plot size for all the treatments was 31 x 8 meter except for T4R1 which was 31 x 7 due to site situation. Treatments and replicates were randomly distributed over the area.

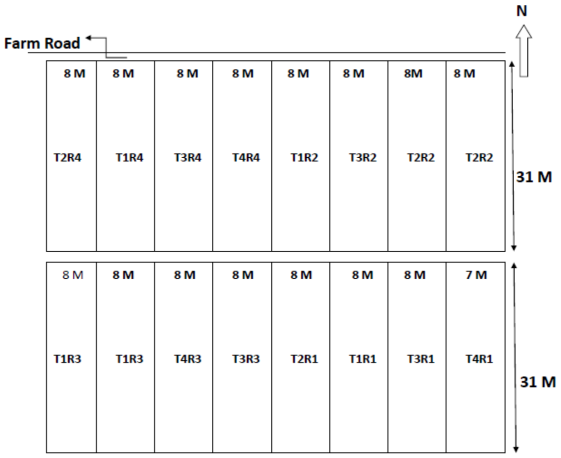

Fig. 1. Layout plan for water productivity of wheat crop under drip irrigation.

Seed bed was prepared by Plowing and planking after rotavating the land. Beds of 69cm and 112cm were made with the bed planter. Each plot for T3 consists of 6 beds of 69cm width with 46cm furrow. For plots of T4, 5 beds of 112cm width and 46cm furrow were made. Manual double row seed drill was used to sow the crop on beds of treatment T3 and T4. Single drip line was laid for each bed of T3 while double drip line was laid for the beds of T4. Sowing for T2 was done by tractor operated seed drill. For T1 wheat seed was manually broadcasted. 50kg per acre seed rate for each plot was maintained. Experimental plots were sown on 08-12-2019.

Sowing of seeds, application of fertilizers and irrigation practices

Faisalabad 2008 variety of Wheat was sown in block 'F' of Research area at Water Management Research Farm (WMRF) Renala Khurd District Okara. Diesel engine operated Drip Irrigation System is available for the research purpose at Water Management Research Farm.

Both canal and ground water for irrigation of experimental plot was used by diverting it in the *pacca* Water storage pond existing at site. Water was lifted by drip system from the pond and delivered to crop. Water delivered to an Individual plot was calculated by noting volume of water from the flow meter of drip irrigation system.

Same number and quantity of fertilizers were applied on all treatments. Weedicides and fungicides were also used in a uniform quantity for all the treatment/replicates.

Determination of applied crop water

The water applied to wheat crop field was computed by measured and effective rainfall was also calculated. Effective rainfall is the rainfall that is available in the plant rooting zone, allows the plant to germinate or maintain its growth. For any crop RENFRO Equation, Chow (1964), calculates growing season effective rainfall.

ER = E Rg + A

Where,

ER = Effective Rain fall

E = Ratio of water Consumptive use to rainfall during Growing season (Cu/Rg).

Rg = Growing Season Rain fall

A = Average Irrigation application

Cu = Consumptive Use of water for any crop

Crop Water Productivity

Water productivity (WP) is generally defined as crop yield per cubic meter of water consumption, including 'green' water (effective rainfall) for rain-fed areas and both 'green' water and 'blue' water (diverted water from water systems) for irrigated areas. Water Productivity is simply a measure of total yield output or total value, divided by the amount of a single input i.e. water used in production. The resulting ratio describes the average amount of output or value associated with the water applied or consumed. Water productivity defined as above varies from region to region and from field to field, depending on many factors, such as crop patterns & climate patterns (if rainfall fits crop growth), irrigation technology & field water management, land & infrastructure, & input, including labour, fertilizer and machinery.

Water Productivity = WP (kg/m^3) = Yield (kg)/Vol. of water used (m^3)

Usually, water productivity is defined as a mass (kg), monetary or energy value of produce per unit of water (cubic meters) and, as such, it is a measure of the ability of agricultural systems to convert water into food (Kijne *et al.*, 2003; Molden *et al.*, 2010).

Data Collection and Calculation

Rainfall was collected from PMD for Okara district. Data collection regarding the volume of irrigation water applied was collected on each application.

Data for water application, number of plants in one square meter area, number of Tillers per plant were noted during the vegetation stage. After harvesting of 3 random samples from each experimental plot, Plant height, number of spikes per square meter of sample area, Length of spike, grains per spike, weight of grains from one square meter area and 100 grain weight were noted Annexure "C".

At the maturity of crop in last week of April 2020, three random samples from each experimental plot were cut manually and labeled for further processing. Sample of one square meter was obtained from flat sowing areas. In case of bed sowing, width of one bed plus one furrow 1.15 (69+46) for single lateral and 1.58 (112+46) for double lateral along one meter length was taken as sample area. Samples collected from field were labeled and preserved under the roof for authenticity and security. Manual threshing was managed for samples collected and data was recorded. Counting of Spikes, and grains per spike, was done manually. Weight was recorded using Digital Weighing Balance (DWB). Grains from each sample were put in separate plastic bags and labeled.

Results & discussion

Two spells of rain fall in the month of January and March 2020 were observed in the area. Rainfall data was obtained from Pakistan Meteorological Department (PMD) Okara Annexure "B". Effective rainfall was calculated from rainfall data collected from PMD by using RENFRO equation.

Plant Features

It has been observed that T2 has maximum 92mm spike length and T1 has minimum 86mm spike length. As the spike length is more in T2, the number of grains per spike are also maximum (41) and minimum in T4 (35). No. of grains per square meter are maximum in case of flat sowing with drip irrigation. It is evident from fig. 3 that number of grains per spike is higher in T2 as compared to other treatments.

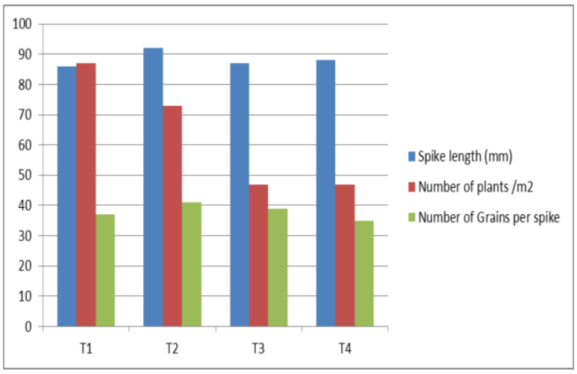

Fig. 2. Plant features under different treatments.

Table 1. Summary of crop area, yield, volume of water availed and water productivity.

Treatment /replication	Plot Area	Plot Yield	Yield per Acre		Volume of Water applied	Water Productivity
	m^2	kg	Kg	Monds	m^3	kg/m^3
T1R1	248	103.50	1,690	42	87.3	1.19
T1R2	248	104.99	1,714	43	87.3	1.20
T1R3	248	89.11	1,455	36	96.0	0.93
T1R4	248	95.40	1,557	39	96.0	0.99
Treatment Average		98.25	1,604	40	91.6	1.08
T2R1	248	77.29	1,262	32	60.5	1.28
T2R2	248	85.64	1,398	35	58.3	1.47
T2R3	248	77.54	1,266	32	58.3	1.33
T2R4	248	88.87	1,451	36	58.3	1.53
Treatment Average		82.34	1,344	34	58.8	1.40
T3R1	248	68.43	1,117	28	58.3	1.17
T3R2	248	85.40	1,394	35	58.3	1.47
T3R3	248	72.82	1,189	30	58.3	1.25
T3R4	248	70.02	1,143	29	60.2	1.16
Treatment Average		74.17	1,211	30	58.7	1.26
T4R1	217	53.47	998	25	55.0	0.97
T4R2	248	59.96	979	24	67.4	0.89
T4R3	248	68.59	1,120	28	67.4	1.02
T4R4	248	66.60	1,087	27	67.4	0.99
Treatment Average		62.16	1,046	26	64.3	0.97

69cm wide bed with single drip line also performed well in achieving the better water productivity. Water productivity in case of line sowing and irrigation with drip system is 27% more as compared to general sowing method used by the farmers i.e broad cast seeding and irrigating by flooding.

Per acre yield is much more in case of growing crop with broadcasting and flood irrigation as compared to drip irrigation. This might be due to the reason that 55% more water was available for

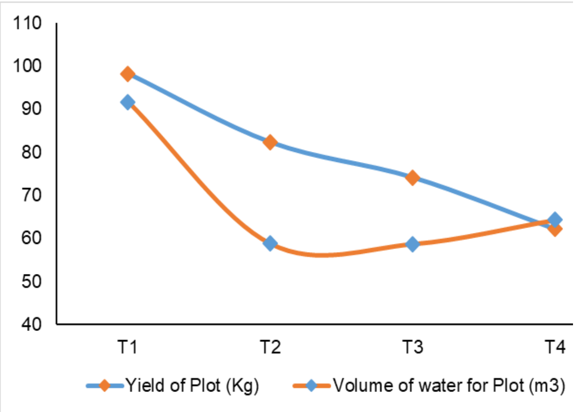

Fig. 3. Yield of experimental plots and volume of water availed.

crop in flood irrigation. 100 grain weight is 10% more in case of T4 as compared to T2. This is because per Sq. meter plant population is 60 to 80% less in plots for T4 as compared to T1 and T2.

Reason for higher per acre yield in T1 is also indicator of higher number of plant population as compared to other treatments (Table-6). This shows that higher plant population is an effective tool in increase of crop production at farm level.

From the fig. 4 drawn for different treatments and Water Productivity (kg/m3), it was revealed that water productivity is higher in drill sowing on flat land irrigated with drip system.

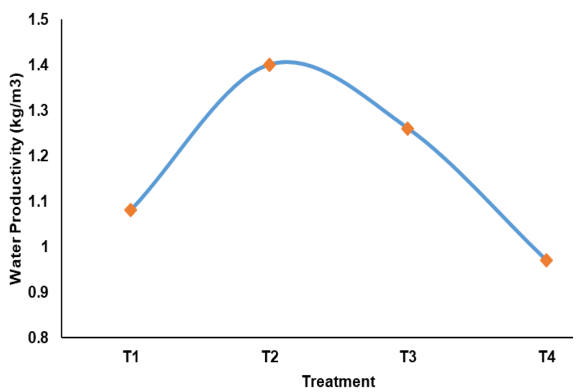

Fig. 4. Graph showing Water Productivity for different treatments.

With the same quantity of water applied, per acre yield in case of drill sowing with drip irrigation is 11% more as compared to 69cm bed with single line drip irrigation.

From water saving point of view, drill sowing on flat land with drip irrigation and single drip line on 69cm bed width are more feasible.

Conclusion

With increasing water scarcities, Water Productivity enhancement in agriculture is not only relevant, but also very crucial in meeting future water demands of the agriculture and other sectors. There are several constraints in enhancing Water Productivity in agriculture, but there are several opportunities too. However, the constraints can be reduced, and the opportunities enhanced through appropriate institutional and policy interventions. WP improvement would reduce the need for future investments in the new development of water resources in some regions. But, due to regional variations of water supply and use, the extent of reduction in demand for additional water for meeting future needs will not be the same as the scale of aggregate savings of water achieved by enhancing WP. However, it might result in more water being available for environmental uses or reallocation to other sectors in some regions which were earlier used for growing crops.

The other outcomes of WP improvement are reduced poverty due to rise in farm income in the agriculturally backward regions; reduced environmental stresses caused by excessive pumping of groundwater or diversion of water from streams/ rivers; and better availability of water from basins for allocation to environmental uses or freeing up of a large amount of cultivated land under rain-fed production, resulting in increased streamflow generation from catchments. They all help meet the future water demand of different water use sectors. In fact, WP improvements in agriculture can be a major component in a water-sector perspective plan in India.

From the experiment it is revealed that line sowing of wheat crop, irrigated with drip irrigation, is more economical from water saving point of view. Farmers should be inclined for drill / line sowing of wheat. Though drip irrigation is more beneficial in vegetable growing and cash crops, yet wheat should be grown in field where drip system is already installed to get better water utilization.

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Annexure "A"

Fertilizer Application Data:

Treatment	Date of sowing	Plot Area	Fertilizer application with Seed Bed	Date, Type, and Rate of Fertilizer application			
			DAP 50/Kg/Acre	DATE	Nitrophos 10kg/acre	SOP 2.78kg/acre	Urea 8.5kg/acre
		Sq. M	Kg		Kg	Kg	Kg
T1R1	12/9/2019	248	3.13	2/15/2020	1.25	0.35	1.05
T1R2	12/9/2019	248	3.13	2/15/2020	1.25	0.35	1.05
T1R3	12/9/2019	248	3.13	2/15/2020	1.25	0.35	1.05
T1R4	12/9/2019	248	3.13	2/15/2020	1.25	0.35	1.05
T2R1	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T2R2	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T2R3	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T2R4	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T3R1	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T3R2	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T3R3	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T3R4	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T4R1	12/9/2019	217	2.74	2/15/2020	1.11	0.31	0.92
T4R2	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T4R3	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05
T4R4	12/9/2019	248	3.13	2/15/2020	1.26	0.35	1.05

Annexure "B"

Rainfall Data:

Date	Day	Rainfall (mm)
13-12-19	Friday	10.5
06-01-20	Monday	4
07-01-20	Tuesday	9
08-01-20	Wednesday	1
13-01-20	Monday	16.3
14-01-20	Tuesday	2.4
28-01-20	Tuesday	20.2
29-01-20	Wednesday	21.3
28-02-20	Friday	9.61
05-03-20	Thursday	32.4
06-03-20	Friday	46
07-03-20	Saturday	5
12-03-20	Thursday	20.8
13-03-20	Friday	13.4
14-03-20	Saturday	4.2
24-03-20	Tuesday	1.2
25-03-20	Wednesday	12.2
27-03-20	Friday	10.2
28-03-20	Saturday	11.4
18-04-20	Saturday	48.1
		299.21

Annexure "C"

Crop Area, Yield, Volume of Water and Water Productivity:

Experiment	Treatment/replicate identification	plot Area	Plant Hight	No. of Plants /M²	No. of Tillers per plant	Length of Spike	Grains per Spike	Total weight/M² (Straw+ Grain)	Grain weght/M²	100 Grain Weight	Plot Yield	Yield per Acre	Water depth applied	Effective Rain Fall	Depth of Water available for crop	Volume of Water available for plot area	Water Productivity
		m2	cm	no.	no.	cm	no.	kg	g	g	kg	kg	mm	mm	mm	m^3	kg/m^3
1	2	3	4	5	6	7	8	10	11	12	13	14	16	17	18	19	20
Experiment 1	T1R1	248	86.0	92	5	9.0	36	1.25	417	3.14	103.50	1690	172.2	179.72	351.9	87.3	1.19
	T1R2	248	90.7	84	6	8.3	41	1.45	423	3.03	104.99	1714	172.2	179.72	351.9	87.3	1.20
	T1R3	248	81.0	95	6	8.3	36	1.33	359	2.73	89.11	1455	207.5	179.72	387.2	96.0	0.93
	T1R4	248	81.3	76	7	8.7	35	1.12	385	2.81	95.40	1557	207.5	179.72	387.2	96.0	0.99
	Treatment Average		**84.8**	**87**	**6**	**8.6**	**37**	**1.29**	**396**	**2.93**	**98.25**	1604	**189.8**	**179.72**	**369.5**	**91.646**	1.08
	T2R1	248	76.0	81	6	9.3	40	1.13	312	2.62	77.29	1262	64.4	179.72	244.1	60.5	1.28
	T2R2	248	80.7	69	6	9.7	45	1.07	345	3.07	85.64	1398	55.2	179.72	234.9	58.3	1.47
	T2R3	248	73.3	57	7	8.0	38	1.15	313	2.81	77.54	1266	55.2	179.72	234.9	58.3	1.33
	T2R4	248	79.7	86	6	9.7	41	1.11	358	3.02	88.87	1451	55.2	179.72	234.9	58.3	1.53
	Treatment Average		**77.4**	**73**	**6**	**9.2**	**41**	**1.11**	**332**	**2.88**	**82.34**	1344	**57.5**	**179.72**	**237.2**	**58.831**	**1.40**
	T3R1	248	75	54	7	9	40	1.02	276	3.04	68.43	1117	55.2	179.72	234.9	58.3	1.17
	T3R2	248	77.0	49	8	8.3	36	1.23	344	3.11	85.40	1394	55.2	179.72	234.9	58.3	1.47
	T3R3	248	83.7	56	8	8.3	42	1.25	294	2.90	72.82	1189	55.2	179.72	234.9	58.3	1.25
	T3R4	248	80.0	29	8	9.0	40	1.06	282	2.87	70.02	1143	63.1	179.72	242.8	60.2	1.16
	Treatment Average		**78.9**	**47**	**8**	**8.7**	**39**	**1.14**	**299**	**2.98**	**74.17**	1211	**57.2**	**179.72**	**236.9**	**58.749**	1.26
	T4R1	217	71.3	41	7	8.7	37	0.80	246	3.33	53.47	998	73.6	179.72	253.3	55.0	0.97
	T4R2	248	81.0	47	6	8.7	35	0.84	242	3.17	59.96	979	92.0	179.72	271.7	67.4	0.89
	T4R3	248	78.7	49	5	8.7	33	1.01	277	3.08	68.59	1120	92.0	179.72	271.7	67.4	1.02
	T4R4	248	78.0	51	6	9.0	36	0.97	269	2.85	66.60	1087	92.0	179.72	271.7	67.4	0.99
	Treatment Average		**77.3**	**47**	**6**	**8.8**	**35**	**0.91**	**258**	**3.11**	**62.16**	1046	**87.4**	**179.72**	**267.1**	**64.283**	0.97