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Water used studies in wheat (*Triticum aestivum* L.) with limited irrigation and moisture conservation practices

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Abstract
A field experiment was conducted at Agronomy Farm, College of Agriculture, Nagpur during *rabi* season of 2019-20. The experiment was laid out in Factorial Randomized Block Design with 12 treatment combinations, replicated thrice. The treatments consisted of three irrigation levels [Only one irrigation at late jointing stage (I_1), Two irrigations at crown root initiation (CRI) and flowering stages (I_2) and Three irrigations at CRI, late jointing and flowering stages (I_3)] combined with four moisture conservation practices [Control (M_0), Mulching with wheat straw (M_1), Mulching with weed biomass (M_2) and Antitranspirant spray {Kaolin @ 5%} (M_3)] adopted at 30 DAS. Growth and yield parameters along with grain and straw yield of wheat were significantly higher with application of three irrigations compared to its lower levels as well as with application of wheat straw mulch at 30 DAS over rest of the moisture conservation practices. Application of three irrigations recorded significantly highest consumptive use of water and lowest water use efficiency. Similarly, application of wheat straw mulch at 30 DAS recorded significantly lowest consumptive use and highest water use efficiency.

Keywords: Wheat, irrigation levels, mulching, antitranspirant, AGR, CU, WUE

Introduction
Wheat is a staple food crop after rice in India, in term of both, area and production contributing almost 12 per cent of the world wheat pool. During 2017-18, area under wheat cultivation was 309.60 Lakh hectares in India, and 4.72 Lakh hectares in Vidarbha region of Maharashtra (Anonymous, 2018). Water availability is one of the major constraints in limiting the area under wheat in Vidarbha region, as water requirement of wheat is more as compared to other *rabi* crops grown in the region. However, if wheat can be grown successfully with reduced irrigation requirement, more and more farmers with limited water availability may opt for wheat as a *rabi* crop in their cropping sequence.
Wheat requires almost six irrigations during its life period to realise its potential yield. However, it is quite possible to reduce down the water quantity used for this crop by skipping irrigations at relatively less moisture sensitive stages, without significant reduction in the yield, through maintaining the soil moisture in the root zone for relatively longer period of time by adopting some suitable moisture conservation practices. The loss in yield can be cope up by bringing some additional area under wheat cultivation with the use of saved water and moisture conservation practices. Hence present experiment was conducted to find out the feasibility of wheat production under reduced irrigation frequency supported with moisture conservation practices.

Material and Methods
A field experiment was carried out at Agronomy Section Farm, College of Agriculture, Nagpur during *rabi* season of 2019-20 to study the Water used studies in wheat (*Triticum aestivum* L.) with limited irrigation and moisture conservation practices. The soil of experimental plot was medium black, clayey in texture, containing 0.45% organic carbon, low in available nitrogen (235 kg ha^{-1}) very low in phosphorus (12.10 kg ha^{-1}) and very high in potash (350 kg ha^{-1}) having pH 7.8. The experiment was laid out in factorial randomized block design with 12 treatment combinations consisted of three irrigation levels [Single irrigation at late jointing stage (I_1), Two irrigations at crown root initiation (CRI) and flowering stages (I_2) and Three irrigations at CRI, late jointing and flowering stages (I_3)] combined with four moisture conservation practices at 30 DAS [Control (M_0), Mulching with wheat straw (M_1), Mulching with weed biomass (M_2) and Antitranspirant spray {Kaolin @ 5%} (M_3)] replicated thrice.

Wheat variety AKAW-4627 was line sown at a row spacing of 22.5 cm using 120 kg seed ha^{-1}. A uniform dose of 100:50:50 kg N:P:K ha^{-1} was applied to all the treatments. Nitrogen was applied in two equal splits as basal and top dressing at 30 DAS. Similarly all the moisture conservation practices were imposed at 30 days after sowing, treatment wise. The crop was grown with all the recommended package of practices, except for irrigation. No accountable incidence of any diseases and insect pest was observed during the crop life period. For the determination of moisture percentage, soil samples were taken from a depth of 0-15 cm and 15-30 cm with the help of screw auger. Then soil moisture percentage was determined from these samples by gravimetric method. The values of soil moisture percentage were used for computing consumptive use of water and water use efficiency.

Results and Discussion

Growth and yield attributes

Effect of irrigation levels

Data in Table 1 revealed that, Application of three irrigations (I_3) recorded significantly higher plant height, dry matter accumulation plant^{-1} and absolute growth rate (AGR) for dry matter and plant height. It also recorded the highest value of grain weight plant^{-1} over one (I_1) and two (I_2) irrigations. More frequent irrigations provided adequate soil moisture during critical growth stages like crown root initiation, late jointing and flowering stages. These stages, being critical for scheduling of irrigation, benefited wheat crop by getting adequate moisture at right time and was reflected in better performance of growth and yield attributes. The results are in close agreement with the findings of Pallekonda *et al.* (2018) [11], Rummana *et al.* (2018) [15] and Abhineet *et al.* (2019) [1].

Table 1: Growth, yield and water use of wheat as influenced by various treatments

Treatments	Plant height (cm)	Dry matter plant^{-1} (g)	Absolute growth rate for dry matter (g plant^{-1} day^{-1})	Absolute growth rate for plant height (cm plant^{-1} day^{-1})	Grain weight plant^{-1} (g)	Yield (kg ha^{-1}) Grain	Yield (kg ha^{-1}) Straw	Consumptive use (mm)	Water use efficiency (kg ha-mm^{-1})
A. Irrigation levels									
I_1- One irrigation (Late jointing stage)	71.3	10.4	1.87	1.09	5.7	2344	3127	159	14.98
I_2- Two irrigations (CRI and Flowering stage)	74.7	12.3	2.27	1.13	7.2	2707	3494	195	14.04
I_3- Three irrigations (CRI, Late jointing and Flowering stage)	78.5	14.3	3.48	1.20	8.0	3035	3883	256	11.95
SE (m) ±	0.1	0.4	-	-	0.2	29	13	5.8	0.55
CD at 5%	0.4	1.0	-	-	0.7	85	39	17.1	1.61
B. Moisture conservation practices at 30 DAS									
M_0- Control	74.1	11.3	2.38	1.08	6.3	2494	3461	222	11.25
M_1-Mulching with wheat straw	76.3	15.1	2.78	1.17	7.5	2906	3692	190	15.49
M_2-Mulching with weed biomass	75.1	12.5	2.55	1.09	6.9	2753	3527	195	13.70
M_3-Antitranspirant Spray (kaolin @ 5%)	73.9	10.5	2.44	1.02	7.1	2627	3324	204	14.19
SE (m) ±	0.2	0.4	-	-	0.1	34	15	6.7	0.63
CD at 5%	0.5	1.2	-	-	0.2	98	45	19.7	1.86
Interaction (I x M)									
SE (m) ±	0.4	0.9	-	-	0.2	71	33	14.3	1.34
CD at 5%	NS	NS	-	-	NS	209	NS	NS	NS
G. M.	74.8	12.4	2.54	1.11	6.9	2695	3501	203	13.66

Effect of moisture conservation practices

Among the different moisture conservation practices, significantly highest plant height, dry matter accumulation plant^{-1}, absolute growth rate (AGR) for dry matter and plant height, and grain weight plant^{-1} were recorded with application of wheat straw mulch (M_1). The rate of soil moisture loss through direct evaporation was reduced due to mulching, that resulted into relatively longer period of soil moisture availability for the crop. Thus, the moisture conserved in the root zone might have been useful to the crop during critical growth stages and might have positive effect on growth and yield attributes. Results obtained are in accordance with those recorded by Akter *et al.* (2018) [2] and Singh *et al.* (2019) [16].

Interaction effect (I x M)

Interaction between irrigation levels and moisture conservation practices on growth attributes and yield parameters was non significant.

Grain and straw yield (kg ha^{-1})

Effect of irrigation levels

Each additional irrigation increased the grain and straw yield of wheat significantly. Application of three irrigations at CRI, late jointing and flowering stages (I_3) produced significantly highest grain and straw yield of 3035, and 3883 kg ha^{-1}, respectively. Higher grain yield obtained with three irrigations (I_3) might be due to adequate soil moisture availability in the root zone during the crop growth period because of more frequent irrigations provided in this treatment. This, in turn, reflected as enhanced growth parameters, contributing to higher yield components and grain yield in this treatment. Proper scheduling of irrigation to supply adequate quantum of water during the moisture sensitive period of flowering and yield formation stages, and allowing moderate stress at vegetative and maturity stage produce the optimum yield (Reddy and Reddy, 1993) [14]. The results are in accordance with Dar *et al.* (2017) [4], Islam *et al.* (2018) [7] and Abhineet *et al.* (2019) [1].

Effect of moisture conservation practices

Different moisture conservation practices adopted at 30 DAS produced significant variation in grain and straw yield of wheat. Mulching with wheat straw (M_1) recorded significantly highest grain and straw yield of 2906 and 3692 kg ha^{-1}, respectively. Higher soil moisture status highlighted the role of mulch in conserving the moisture in soil, though the effect between mulches varied. Wheat straw seemed to be the best

in maintaining moisture in the root zone. The rate of loss of moisture from soil was slow, resulting into availability of moisture for relatively longer time period during crop growth and development phase. Conserving water in the root zone might have been useful for the crops during grain filling stage and might have positive effect on yield of wheat. This finding corroborates the findings of Depar *et al.* (2014) [5], Kaur and Mahal (2016) [8] and Singh *et al.* (2019) [16].

Interaction effect (I x M)

Interaction effect of irrigation levels and moisture conservation practices (I x M) found to influence the grain yield (kg ha^{-1}) of wheat.

Data in Table 2 indicated that application of three irrigations combined with wheat straw mulch at 30 DAS (I_3 x M_1) together produced significantly highest grain yield of 3417 kg ha^{-1} than all other treatment combinations. Rummana *et al.* (2018) [15] also reported similar advantage of irrigation combined with wheat straw mulch.

Table 2: Grain yield (kg ha^{-1}) as influenced by I x M interaction

I x M	Grain yield (kg ha^{-1})			
	M_0	**M_1**	**M_2**	**M_3**
I_1	2005	2382	2620	2367
I_2	2550	2920	2907	2450
I_3	2927	3417	2733	3063
SE(m) ±	71			
CD at 5%	209			

Soil moisture studies

Consumptive use of water (mm)

Effect of irrigation levels

Among irrigation levels, three irrigations given at crown root initiation, late jointing and flowering stages recorded highest consumptive use of water (256 mm). It was followed by two irrigations given at crown root initiation and flowering stages (195 mm). Single irrigation given at late jointing stage recorded the lowest consumptive use of water (159 mm). Consumptive use of water was higher with three irrigations due to more frequent irrigations resulting in more moisture availability to the crop and increased evapotranspiration. The observations are in agreement with Ranjita *et al.* (2007) [13] and Mitra and Das (2015) [10].

Effect of moisture conservation practices

Among the moisture conservation practices adopted at 30 DAS, highest consumptive use of water (222 mm) was observed in control (M_0), followed by antitranspirant spray (M_3, 204 mm), weed biomass mulch (M_2, 195 mm) and wheat straw mulch (M_1, 190 mm). Straw mulching helped in conservation of soil moisture and thereby reduced the moisture loss due to direct evaporation, particularly during initial phase of its application, which in turn resulted in lower consumptive use. Singha *et al.* (2018) [17], reported that a considerable amount of moisture was lost during initial period, through evaporation under non-mulch treatment that resulted into higher consumptive use Decreased evapotranspiration and reduced consumptive use in wheat due to mulching was also reported by Huang *et al.* (2005) [6].

Water use efficiency (kg ha-mm^{-1})

Effect of irrigation levels

Highest water use efficiency of 14.98 kg ha-mm^{-1} was observed single irrigation at late jointing stage. However, it was at par with two irrigations given at CRI and LJ stage (14.04 kg ha-mm^{-1}). Lowest water use efficiency of 11.95 kg ha-mm^{-1} was recorded with three irrigations given at CRI, LJ and flowering stages. Water use efficiency of wheat increased progressively with decreasing number of irrigations. It was highest in I_1 treatment receiving single irrigation, mainly due to restricted water supply, which indicated efficient use of water under limited availability of moisture. Lowest WUE was recorded with three irrigations. It might be due to more availability of moisture in the root zone, and consequently luxurious consumption of water in this treatment. The results obtained during this investigation are in agreement with the findings of Mitra and Das (2015) [10].

Effect of moisture conservation practices

Highest water use efficiency was recorded with wheat straw mulching (M_1, 15.49 kg ha-mm^{-1}) followed by antitranspirant spray (M_3, 14.19 kg ha-mm^{-1}), weed biomass mulching (M_2, 13.70 kg ha-mm^{-1}) and control (M_0, 11.25 kg ha-mm^{-1}), respectively. However, all the moisture conservation practices, being at par with each other, proved significantly superior over control (M_0). Application of mulch might have improved the hydrothermal properties of soil and thus might have helped in decreasing the evapotranspiration (Quanqui *et al.* 2010) [12] and increased the water use efficiency (Balwindersingh *et al.* 2011) [3].

Interaction effect (I x M)

Interaction between irrigation levels and moisture conservation practices on consumptive use and WUE was found to be non significant.

Conclusion

Application of three irrigations and application of wheat straw mulch at 30 DAS as a moisture conservation practice enhanced the growth attributes *viz.* plant height, dry matter accumulation plant^{-1}, absolute growth rate for dry matter and plant height. It also increased the grain weight plant^{-1} along with grain and straw yield of wheat, significantly. Combination of three irrigations and application of wheat straw mulch produced significantly highest grain yield of wheat.

Application of three irrigations recorded significantly highest consumptive use of water and lowest water use efficiency. However, application of wheat straw mulch at 30 DAS recorded significantly lowest consumptive use of water with higher water use efficiency.

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