Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 1853-1856
Received: 12-06-2020
Accepted: 10-08-2020

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Effect of moisture conservation practices under limited irrigation on yield and economics of wheat (*Triticum aestivum* L.)

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Abstract
A field experiment entitled "Effect of moisture conservation practices under limited irrigation on yield and economics of wheat (*Triticum aestivum* L.)" 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 [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)]. Application of three irrigations as well as wheat straw mulch at 30 DAS recorded significantly higher plant height, number of tillers hill^{-1}, number of leaves plant^{-1}, dry matter accumulation plant^{-1} and relative growth rate. Yield attributing character *viz*. length of earhead, number of grains earhead^{-1}, grain weight plant^{-1} and test weight along with grain, straw and biological 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 respective treatments. Gross monetary returns, net monetary returns and B:C ratio also recorded the same trend.

Keywords: Wheat, irrigation levels, mulching, antitranspirant, RGR, economics

Introduction
In India, wheat is most important food after rice in term of both, area and production which contributes 12 per cent of the world wheat pool. In India, during 2017-18, area under wheat cultivation was 309.60 Lakh hectares and annual production was 98.38 Lakh Tons with an average productivity of 31.72 q ha^{-1}. In Vidarbha region of Maharashtra, area under wheat cultivation was 4.72 Lakh hectare with annual production of 7.31 Lakh tons and average productivity was 15.59 q ha^{-1}. (Ministry of Agriculture, New Delhi, Economics Times, Fourth Estimate 2017-18).

Wheat requires almost six to seven irrigations throughout its life cycle to realise its potential yield. However, it is possible to cut down on its irrigation frequency by skipping irrigations at relatively less sensitive stages, without sizable reduction in the yield, by maintain the available soil moisture for relatively longer period of time through adoption of some moisture conservation practices. This can be achieved by using mulch or by antitranspirants. Mulching, such as wheat straw mulch or weed biomass mulch, not only conserves the soil moisture, but also reduces weed problem. Antitranspirants like kaolin reduces the loss of water from plant body by checking transpiration process, and thus helps the plant to sustain comfortably under moisture stress condition. Thus, by adopting some Good Agronomic Practices like mulching or use of antitranspirant, water consumption in agriculture can be cut down. Thus, more and more land can be brought under irrigated farming.

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 Effect of moisture conservation practices under limited irrigation on yield and economics of wheat. 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}) with a pH of 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. No accountable incidence of any diseases and insect pest was observed during the crop life period.

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, number of tillers hill^{-1}, number of leaves plant^{-1}, dry matter accumulation plant^{-1} and relative growth rate (RGR). It also recorded the highest value of yield attributing characters *viz.* length of earhead, number of grains earhead^{-1}, grain weight plant^{-1} and test weight at harvest, over only one (I_1) and two (I_2) irrigations. However, number of tillers hill^{-1} was on par with two 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) [9], Rummana *et al.* (2018) [11] and Abhineet *et al.* (2019) [1].

Effect of moisture conservation practices

Among the different moisture conservation practices, significantly higher plant height, number of tillers hill^{-1}, number of leaves plant^{-1}, dry matter accumulation plant^{-1} at harvest and relative growth rate (RGR) with significantly highest value of yield attributing characters *viz.* length of earhead, number of grains earhead^{-1}, grain weight plant^{-1} and test weight were recorded under application of wheat straw mulch (M_1) over control (M_0), weed biomass mulch (M_2) and antitranspirant spray (M_3). However, number of grains earhead^{-1} was on par with antitranspirant spray (M_3). 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 crops 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) [12].

Table 1: Growth and yield attributes of wheat as influenced by different treatments

Treatments	Mean plant height (cm)	No. of tillers hill^{-1}	No. of leaves plant^{-1}	Dry matter plant^{-1} (g)	Relative growth rate (g g^{-1} day^{-1})	Length of earhead (cm)	No. of grains earhead^{-1}	Grain weight plant^{-1} (g)	Test weight (g)
A. Irrigation levels									
I_1- One irrigation (Late jointing stage)	71.3	7.9	15.6	10.4	0.0072	7.6	38.7	5.7	33.7
I_2- Two irrigations (CRI and Flowering stage)	74.7	8.8	20.9	12.3	0.0075	8.7	41.5	7.2	36.5
I_3- Three irrigations (CRI, Late jointing and Flowering stage)	78.5	9.0	22.4	14.3	0.0082	9.9	44.2	8.0	38.9
SE(m) ±	0.1	0.2	0.4	0.4	-	0.1	0.2	0.2	0.1
CD at 5%	0.4	0.5	1.1	1.0	-	0.2	0.5	0.7	0.3
B. Moisture conservation practices at 30 DAS									
M_1- Control	74.1	7.9	18.1	11.3	0.0069	8.2	40.4	6.3	35.4
M_2-Mulching with wheat straw	76.3	9.4	22.8	15.1	0.0084	9.1	42.4	7.5	37.2
M_3-Mulching with weed biomass	75.1	8.2	19.9	12.5	0.0079	8.7	40.9	6.9	36.1
M_3-Antitranspirant Spray (kaolin @ 5%)	73.9	8.8	17.8	10.5	0.0073	8.8	42.1	7.1	36.9
SE(m) ±	0.2	0.2	0.4	0.4	-	0.1	0.2	0.1	0.1
CD at 5%	0.5	0.6	1.2	1.2	-	0.2	0.6	0.2	0.2
Interaction (I x M)									
SE(m) ±	0.4	0.4	0.9	0.9	-	0.1	0.4	0.2	0.1
CD at 5%	**NS**	**NS**	**NS**	**NS**	-	**NS**	**NS**	**NS**	**NS**
G. M.	74.8	8.6	19.6	12.4	0.0076	8.7	41.5	6.9	36.4

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

Effect of irrigation levels

Each additional irrigation increased the grain, straw and biological yield of wheat significantly. Application of three irrigations at CRI, late jointing and flowering stages (I_3) produced significantly highest grain, straw and biological yield of 3035, 3883 and 6918 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) [10]. The results are in accordance with Dar *et al.* (2017) [3], Islam *et al.* (2018) [5] and Abhineet *et al.* (2019) [1].

Effect of moisture conservation practices

Different moisture conservation practices adopted at 30 DAS produced significant variation in grain, straw and biological yield of wheat. Mulching with wheat straw (M_1) recorded significantly highest grain, straw and biological yield of 2906, 3692 and 6598 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 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) [4], Kaur and Mahal (2016) [6] and Singh *et al.* (2019) [12].

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 three irrigations combined with wheat straw mulch at 30 DAS (I_3 x M_1) produced significantly highest grain yield of 3417 kg ha^{-1} than all other treatment combinations. Rummana *et al.* (2018) [11] 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			

Economics

Effect of irrigation levels

Treatment receiving three irrigations (I_3) registered significantly highest gross and net monetary returns of Rs. 74,446 and 50146 ha^{-1}, respectively over its lower levels. It also recorded the highest B:C ratio of 3.10 compared to 2.80 in two irrigations and 2.48 in one irrigation. The results are in confirmation with the findings of Mitra and Das (2015) and Singha *et al.* (2018) [13].

Effect of moisture conservation practices

Among the moisture conservation practices adopted at 30 DAS, mulching with wheat straw (M_1) registered significantly highest gross and net monetary return of Rs. 71,256 and 46,356 ha^{-1}, respectively, with B:C ratio of 2.86 over control (M_0,), mulching with weed biomass (M_2) and antitranspirant spray (M_3,). These results are in agreement with Kaur and Mahal (2016) [6] and Singha *et al.* (2018) [13].

Interaction effect (I x M)

Interaction effect between irrigation levels and moisture conservation practices on growth attributes, yield parameters and economics 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, number of tillers hill^{-1}, number of leaves plant^{-1}, dry matter accumulation plant^{-1}, relative growth rate. It also increased the yield attributes *viz.* length of earhead, number of grains earhead^{-1}, grain weight plant^{-1} and test weight along with grain, straw and biological yield of wheat, significantly. Combination of three irrigations and wheat straw mulch produced significantly highest grain yield of wheat.

Application of three irrigations and application of wheat straw mulch at 30 DAS gave significantly highest gross and net monetary return and highest B:C ratio.

Table 3: Yield and economics of wheat as influenced by different treatments

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	GMR (Rs. ha^{-1})	NMR (Rs. ha^{-1})	B:C Ratio
A. Irrigation levels						
I_1- One irrigation (Late jointing stage)	2344	3127	5471	57625	34425	2.48
I_2- Two irrigations (CRI and Flowering stage)	2707	3494	6201	66431	42681	2.80
I_3- Three irrigations (CRI, Late jointing and Flowering stage)	3035	3883	6918	74446	50146	3.10
SE(m) ±	29	13	42	229	229	-
CD at 5%	85	39	124	672	672	-
B. Moisture conservation practices at 30 DAS						
M_1- Control	2494	3461	5955	61446	38246	2.64
M_2-Mulching with wheat straw	2906	3692	6598	71256	46356	2.86
M_3-Mulching with weed biomass	2753	3527	6280	67534	43334	2.79
M_3-Antitranspirant spray (kaolin @ 5%)	2627	3324	5951	64401	40001	2.64
SE(m) ±	34	15	49	265	265	-
CD at 5%	98	45	143	776	776	-
Interaction (I x M)						
SE(m) ±	71	33	104	561	561	-
CD at 5%	**209**	**NS**	**NS**	**NS**	**NS**	-
G. M.	2695	3501	6196	66162	42169	2.97

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