

## Effect of irrigation scheduling and organic manures on yield and economics of bread wheat (*Triticum aestivum* L.)

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### ABSTRACT

A field experiment was conducted during the winter (*rabi*) seasons of 2014–15 and 2015–16 at Jobner, Rajasthan to study the effect of irrigation scheduling and organic manures on growth, yield and quality of wheat (*Triticum aestivum* L.) under loamy sand soil. The treatments consisted of 5 irrigation scheduling, i.e. I<sub>1</sub>, (irrigation at critical stages); I<sub>2</sub>, [0.9 irrigation water: cumulative pan evaporation (IW : CPE ratio); I<sub>3</sub>, 0.6 IW : CPE ratio at vegetative phase + 0.8 IW : CPE ratio at reproductive phase; I<sub>4</sub>, 0.6 IW : CPE ratio at vegetative phase + 1.0 IW : CPE ratio at reproductive phase; and I<sub>5</sub>, 0.8 IW : CPE ratio at vegetative phase + 1.0 IW : CPE ratio at reproductive phase in main plots and 4 organic manures, viz. control (M<sub>0</sub>), FYM @ 15 t/ha (M<sub>1</sub>), VC @ 6 t/ha (M<sub>2</sub>) and FYM @ 7.5 t + VC @ 3 t/ha (M<sub>3</sub>) in subplots. The experiment was conducted in splitplot design with 4 replications. The pooled results showed that irrigation applied at 0.9 IW : CPE ratio (I<sub>2</sub>) resulted in the maximum yield (grain, straw, biological and harvest index) and net returns, being superior to I<sub>1</sub>, I<sub>4</sub> and I<sub>3</sub> treatments except treatment I<sub>5</sub>. The treatment I<sub>2</sub> exhibited the maximum value of consumptive use (395 mm). However, the treatment I<sub>5</sub> revealed significantly highest water-use efficiency WUE of 11.34 kg/ha-mm and excelled over rest of the treatments. Application of FYM at 7.5 t/ha + vermicompost at 3 t/ha (M<sub>3</sub>) resulted in significantly higher yield (grain, straw, biological and harvest index) which was at par with M<sub>2</sub> and superior to rest of the treatments. The highest consumptive use (409 mm) by the crop was recorded under the treatment M<sub>0</sub>. Significantly highest WUE was recorded under M<sub>3</sub> (12.40 kg/ha-mm). The maximum net returns (₹55,276) was recorded under the treatment M<sub>3</sub> (FYM @ 7.5 t/ha + vermicompost @ 3 t/ha) which remained at par with M<sub>1</sub> but significantly higher to M<sub>0</sub> and M<sub>2</sub> treatment. Thus, scheduling of irrigation to wheat either at 0.9 IW : CPE throughout the growth or 0.8 IW : CPE at vegetative phase + 1.0 IW : CPE at reproductive phase resulted significantly higher yields (grain, straw, biological and harvest index) and net returns. Irrigating the crop at an IW : CPE of 0.8 at vegetative phase + IW : CPE of 1.0 at reproductive phase was most effective as the above schedule besides producing almost equal yields also curtailed 1 irrigation with highest WUE. Manuring the crop either with 7.5 t FYM + 3 t/ha VC or 6 t/ha VC were the equally effective and net returns.

**Key words :** Farm yard manure, Harvest index, Irrigation scheduling, Net returns, Vermicompost, Water-use efficiency, Yield

### INTRODUCTION

Wheat is highly sensitive to water stress during the crown root-initiation (CRI) and flowering stages, but excess irrigation may lead to heavy vegetative growth and shortening of reproductive period which ultimately de-

creases the yield. Thus, timing the length of irrigation interval with the stages of crop growth might bring a reduction in the number of irrigations, resulting an economic crop yield. Although a high water status throughout the growing season is necessary to maintain unimpaired crop growth and high economic yield, the imposition of some stress by longer irrigation intervals during vegetative or maturation by way of narrowing or widening irrigation water : cumulative pan evaporation (IW : CPE) could attain similar economic yields as well as saving of irrigation water and improving water-use efficiency. In general, irrigation is being scheduled on the basis of climatological approach (IW : CPE) during entire period of crop irrespective of the stage of growth. But proper scheduling of irrigation is necessary

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both at vegetative and reproductive phases to maintain the optimum moisture regime for better growth and development of crop in the changing climatic scenario where abrupt variation in temperature takes place. Application of organic manures not only improves the soil organic carbon for sustaining the soil physical quality but also increases plant nutrients. In this context, farmyard manure (FYM) and vermicompost are of paramount importance for application in food crops. Addition of organic material to the soil such as FYM helps in maintaining soil fertility and productivity. It increases soil microbiological activities, plays key role in transformation, recycling and availability of nutrients to the crop. It also improves the physical properties like soil structure, porosity, reduces compaction and crusting and increases water-holding capacity of soil. Hence a study was carried for 2 years to observe the effect of irrigation scheduling and organic manures on yield and economics of bread wheat.

### MATERIALS AND METHODS

A field experiment was carried out during the winter (*rabi*) seasons of 2014–15 to 2015–16 at Sri Karan Narendra College of Agriculture, Jobner (26° 05' N, 75° 28' E, 427 m above mean sea-level), Rajasthan. The soil was sandy loam, having bulk density 1.52 Mg/m<sup>3</sup> and pH 8.3. The soil was poor in organic carbon (0.23%), low in available nitrogen (130.5 kg/ha) and phosphorus (15.1 kg/ha) and medium in potassium (148.9 kg/ha). The experiment was laid out in a split-plot design with 4 replications. The treatments comprising 5 irrigation scheduling, I<sub>1</sub>, irrigation at critical stages; I<sub>2</sub>, 0.9 IW : CPE; I<sub>3</sub>, 0.6 IW : CPE at vegetative phase + 0.8 IW : CPE at reproductive phase; I<sub>4</sub>, 0.6 IW : CPE at vegetative phase + 1.0 IW : CPE at reproductive phase; and I<sub>5</sub>, 0.8 IW : CPE at vegetative phase + 1.0 IW : CPE at reproductive phase and 4 organic manures i.e. M<sub>0</sub> (control); M<sub>1</sub> (FYM at 15 t/ha); M<sub>2</sub> (VC at 6 t/ha); and M<sub>3</sub> (FYM at 7.5 t/ha + VC at 3 t/ha). Wheat variety 'Raj 4037' was sown on 16 December and 18 December in 2014 and 2015 and was harvested on 8 April and 10 April in 2015 and 2016 respectively. Seed @ 100 kg/ha was used with 22.5-cm-row spacing. Crop was raised with recommended package of practices of weed management, viz. application of isoproturon 0.75 kg/ha and 2, 4-D @ 0.8 kg/ha at 30 days after sowing. The field plots of size 4.0 m × 2.7 m were separated from each other by using 0.50 m buffer rows. Irrigation was applied as per treatment on the basis of IW : CPE approach using 4.5 cm depth of irrigation water. Six irrigations in I<sub>1</sub> (irrigation at critical stages), 7 irrigations in I<sub>2</sub> (irrigation at 0.9 IW : CPE), 4 irrigations in I<sub>3</sub> (irrigation at 0.6 IW : CPE at vegetative phase + 0.8 IW : CPE at reproductive phase), 5 irrigations in I<sub>4</sub> (irrigation at 0.6 IW : CPE at vegetative phase + 1.0 IW : CPE at

reproductive phase) and 6 irrigations in I<sub>5</sub> (irrigation at 0.8 IW : CPE at vegetative phase + 1.0 IW : CPE at reproductive phase) were applied. Recommended dose of fertilizer (90 : 30 : 0 kg N : P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O/ha) was used. Half dose of nitrogen and full dose of phosphorus was applied basal through urea and diammonium phosphate, remaining dose of nitrogen was top-dressed at the time of first and second irrigation. Farmyard manure was applied 2 weeks before sowing and vermicompost just before sowing as per the treatment. The FYM contains NPK @ 0.49, 0.28 and 0.42% and vermicompost contains NPK @ 1.21, 0.69 and 1.02% respectively. The crop was harvested manually with sickle when grain almost matured and straw turned yellow, and data on grain and straw yields were recorded. The straw yield was obtained by subtracting the seed yield from the biological yield. Consumptive use of water was worked out as per Dastane (1972) and than water-use efficiency was calculated. Grain yield and straw yield (kg/ha) were recorded from each plot and converted into tonnes per hectare. All data recorded during individual years as well as in pooled analysis were statistically analyzed for their test of significant using the *F*-test (Gomez and Gomez, 1984). Significance of difference between treatment means was compared by critical difference at 5% level of probability. Water-use efficiency (WUE) was worked out as:

$$\text{WUE} = \frac{\text{Economic crop yield (kg/ha)}}{\text{Consumptive use (mm)}}$$

### RESULTS AND DISCUSSION

#### *Yield, consumptive use and water-use efficiency*

**Effect of irrigation scheduling:** Significantly higher grain yield (4.45 t/ha) was recorded under treatment I<sub>2</sub> (Irrigation at 0.9 IW : CPE ratio), being at par with I<sub>3</sub> and significantly superior to rest of the treatments (Table 1). It was also found that with sufficient moisture in the soil profile under higher irrigation frequency, there was better availability of plant nutrients, particularly N, P and K, which might have facilitated better translocation of photosynthates to produce more grain yield. Secondly, higher yield with higher levels of irrigation might be owing to its key role in the root development by reducing mechanical resistance of soil, higher transpiration, greater nutrient uptake and more photosynthesis due to metabolic activities in plant (Bhunja *et al.*, 2006). The other reason of yield increase might be that scheduling irrigation at 0.9 IW : CPE and 1.0 IW : CPE at reproductive phase created longer reproductive period with larger photosynthetic surface and reproductive storage capacity to attain higher allocation of net photosynthates to grain yield (Mishra and Kushwaha, 2016).

The irrigation at 0.9 IW : CPE (I<sub>2</sub>) resulted in the maxi-

imum straw yield (6.34 t/ha) which was at par with  $I_5$  but significantly higher than rest of the treatments. The  $I_2$  and  $I_5$  were treatments equally effective in respect of straw yield. Higher straw yield under optimum level of irrigation schedules might be owing to healthy vegetative crop growth in terms of dry matter which resulted in more straw yield (Narolia *et al.*, 2016). The treatment  $I_2$  (irrigation at 0.9 IW : CPE) exhibited the maximum value of consumptive use (398 mm) over all other treatments, while the minimum consumptive use was recorded under  $I_3$  (369 mm) treatment. Thus, consumptive use of water increased with increasing in quantity of irrigation water. Higher number of irrigations might have increased the consumption of water because of better growth of crop, and simultaneously the loss of water through evaporation under treatment  $I_2$  (Bandyopadhyay and Mallick, 2003; Singh *et al.*, 2012). Treatment  $I_5$  (irrigation at 0.8 IW : CPE at vegetative phase + 1.0 IW : CPE at reproductive phase) exhibited significantly highest WUE (11.34 kg/ha-mm), while the lowest WUE (10.24 kg/ha-mm) was registered under treatment  $I_3$  (Table 2). The highest WUE under treatment  $I_5$  might be due to the fact that crop was supplied with adequate soil moisture without moisture stress during reproductive phase. Moreover, the above treatment utilized lesser water consumptively as compared to  $I_2$ . Hence proportionately higher yield with the judicious use of limited water resulted in significantly highest WUE (Bikrmatitya *et al.*, 2011). Significantly higher harvest index was observed in the treatment where irrigation was scheduled at 0.9 IW : CPE throughout the growth ( $I_2$ ), 0.8 IW : CPE at vegetative + 1.0 IW : CPE at reproductive phase ( $I_5$ ) and irrigation at

critical stages ( $I_1$ ) as compared to the other treatments. With the sufficient water applied in the reproductive phase, more amount of assimilates were diverted towards sink which provided larger ratio of grain to biological yield. Harvest index of rest of the treatments was more or less same. These results are in conformity with those of Ahmad *et al.* (2002) and Mehta *et al.* (2010).

#### Effect of organic manures

Significantly higher values (4.57 and 6.58 t/ha) of grain and straw yields were recorded with FYM @ 7.5 t/ha + vermicompost @ 3 t/ha ( $M_3$ ) which superseded rest of the treatments, while it remained at par with  $M_2$  (Table 1). Addition of FYM and vermicompost could increase the macro as well micronutrient benefit of the crop during entire growth period. These results are in close proximity with those of Singh and Agarwal (2004). The results on consumptive use represent that the maximum consumptive use (409 mm) by crop was shown by the treatment  $M_0$  (control) as compared to rest of the treatments. The minimum consumptive use was observed where FYM 7.5 t + vermicompost 3 t/ha ( $M_3$ ) was applied. Lower consumptive use in organic manure-treated plots might be due to better conservation of soil moisture and reduced evaporation as compared to no manure treatment (Vishuddha *et al.*, 2014). The significantly highest WUE was obtained under treatment  $M_3$  (12.40 kg/ha-mm). The reason may be ascribed to the fact that proportionate increase in grain yield was greater than the evapo-transpiration owing to combined application of FYM and vermicompost (Table 2). Thus, WUE enhanced significantly over sole application of or-

**Table 1.** Effect of irrigation scheduling and organic manures on grain and straw yield, consumptive use and water-use efficiency of wheat (on pooled basis)

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield(t/ha)	Harvest index (%)
<i>Irrigation scheduling</i>				
$I_1$	4.24	6.06	10.31	41.16
$I_2$	4.45	6.34	10.80	41.29
$I_3$	3.78	5.76	9.55	39.61
$I_4$	4.14	6.05	10.208	40.66
$I_5$	4.37	6.25	10.62	41.18
SEm±	0.07	0.07	0.12	0.15
CD (P=0.05)	0.20	0.19	0.35	0.45
<i>Organic manures</i>				
$M_0$	3.48	5.12	8.61	40.50
$M_1$	4.29	6.26	10.57	40.71
$M_2$	4.43	6.42	10.86	40.86
$M_3$	4.57	6.58	11.12	41.07
SEm±	0.06	0.06	0.10	0.12
CD (P=0.05)	0.18	0.17	0.29	0.35

$I_1$ , irrigation at critical stages;  $I_2$ , 0.9 IW : CPE;  $I_3$ , 0.6 IW : CPE at vegetative + 0.8 IW : CPE at reproductive phase;  $I_4$ , 0.6 IW : CPE at vegetative + 1.0 IW : CPE at reproductive phase;  $I_5$ , 0.8 IW : CPE at vegetative + 1.0 IW : CPE at reproductive phase;  $M_0$ , control;  $M_1$ , FYM @ 15 t/ha;  $M_2$ , vermicompost @ 6 t/ha;  $M_3$ , FYM @ 7.5 t/ha + vermicompost @ 3 t/ha

ganic manures or no organic manure treatment where increase in yield was lesser than the loss of water through evapotranspiration (Ebtisam *et al.*, 2013).

Harvest index (HI) clearly indicated that the treatment, M<sub>3</sub> (FYM @7.5 t/ha + vermicompost @ 3 t/ha) significantly increased the HI over rest of the treatments while it remained at par with M<sub>2</sub> (vermicompost @ 6 t/ha). The HI indicates percentage of total biological yield, partitioned to the economic part of the plant, viz. the grain, in terms of dry matter (Verma *et al.*, 2015) in wheat. This might be owing to greater partitioning of photosynthates towards formation of yield components in the treatments receiving adequate manuring, i.e. M<sub>3</sub> or M<sub>2</sub>.

**Table 2.** Effect of irrigation scheduling and organic manures on consumptive use, water-use efficiency and net returns in bread wheat

Treatments	Consumptive use (mm)	Water-use efficiency (kg/ha/mm)	Net returns (₹×10 <sup>3</sup> /ha)
<i>Irrigation scheduling</i>			
I <sub>1</sub>	380	11.14	51.0
I <sub>2</sub>	398	11.20	54.0
I <sub>3</sub>	369	10.24	44.0
I <sub>4</sub>	378	10.95	50.3
I <sub>5</sub>	385	11.34	53.9
SEm±	-	0.04	0.9
CD (P=0.05)	-	0.12	2.7
<i>Organic manures</i>			
M <sub>0</sub>	409	8.53	45.4
M <sub>1</sub>	365	11.73	55.2
M <sub>2</sub>	379	11.79	47.5
M <sub>3</sub>	369	12.40	55.3
SEm±	-	0.03	0.8
CD (P=0.05)	-	0.11	2.2

I<sub>1</sub>, irrigation at critical stages; I<sub>2</sub>, 0.9 IW : CPE; I<sub>3</sub>, 0.6 IW : CPE at vegetative + 0.8 IW : CPE at reproductive phase; I<sub>4</sub>, 0.6 IW : CPE at vegetative + 1.0 IW : CPE at reproductive phase; I<sub>5</sub>, 0.8 IW : CPE at vegetative + 1.0 IW : CPE at reproductive phase; M<sub>0</sub>, control; M<sub>1</sub>, FYM @ 15 t/ha; M<sub>2</sub>, vermicompost @ 6 t/ha; M<sub>3</sub>, FYM @ 7.5 t/ha + vermicompost @ 3 t/ha

### Economics

**Effect of irrigation scheduling:** Data revealed that different irrigation schedules had significant influence on net returns. Treatment I<sub>5</sub> remained equally effective as I<sub>2</sub>. The lowest net returns (₹44,071/ha) were obtained under I<sub>3</sub> treatment. The enhancement in net returns owing to I<sub>5</sub> treatment was to the magnitude of ₹9,790, 3,579 and 2,840/ha over I<sub>3</sub>, I<sub>4</sub> and I<sub>1</sub> respectively (Table 2).

**Effect of organic manures:** Organic manures significantly increased net returns. The treatment M<sub>3</sub> and M<sub>1</sub> resulted in almost same net returns and proved significantly

superior to M<sub>0</sub> and M<sub>2</sub>. The lowest net returns (₹45,346/ha) were obtained in the treatment M<sub>0</sub>. The treatment M<sub>3</sub> fetched higher net returns by ₹9,930 and 7,784/ha, respectively over M<sub>0</sub> and M<sub>2</sub>.

The scheduling of irrigation to wheat at 0.8 IW : CPE during vegetative phase + 1.0 IW : CPE during reproductive phase resulted higher yields (grain, straw, biological and HI), curtailed 1 irrigation during with highest water-use efficiency. Application of FYM and vermicompost (VC) in 50 : 50 ratio, i.e. 7.5 t FYM + 3 t/ha VC or FYM entirely at 15 t/ha were the most remunerative options.

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