management in jute (*Corchorus olitorius*) and their impact on soil microbes. *Journal of Agriculture Search* **2**(1): 24–27.

Kumar, V. and Ladha. J.K. 2011. Direct-seeding of rice: recent developments and future research needs. *Advances in Agronomy* **111**: 297–413.

Malik, R.S., Yadav, A., Malik, R.K. and Banga, R.S. 2000. Effect of tank mix spray of herbicides and fertilizer against weeds in wheat. *Haryana Journal Agronomy* **16**: 40–43.

Martin J.P. 1950. Use of acid, rose bengal and streptomycin in the plate method for estimating soil fungi. *Soil Science* **69**: 215–232.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.

Patil, B., Reddy, V.C., Mallesha. Kombali, G. and Shruthi, M.K. 2014. Crops weed competition for nutrient uptake in transplanted organic finger millet (*Eleusine coracana* L.). *Green Farming* **5**(2): 283–285.

Pisal, R.R. and Sagarka, B.K. 2013. Integrated weed management in wheat with new molecules 2013 *Indian Journal of Weed Science* **45**(1): 25–28.

Rao, A.N., Johnson, D.E., Sivaprasad, B., Ladha, J.K. and Mortimer, A.M. 2007. Weed management in direct-seeded rice. *Advances in Agronomy* **93**: 153–255.

Riemens, M.M., Vander Weide, R.Y., Bleeker, P.O. and Lotz Lap. 2007. Effect of stale seed bed preparation and subsequent weed control in lettuce (cv. iceboll) on weed density. *Weed Research* **47**: 149–156.

Singh, R.P., Verma, S.K., Prasad, S.K., Singh, H. and Singh, S.B. 2017. Effect of tillage and weed-management practices on grassy weeds in wheat. *International Journal of Science, Environment and Technology* **6**(1): 404–412.

Sukul, P. 2006. Enzymatic activities and microbial biomass in soil as influenced by metalaxyl residues. *Soil Biology and Biochemistry* **38**: 320–326.

Thalmann, A. 1968. Zur Methodik der Bestimmung der Dehydrogenaseaktivit im Boden mittels triphenytetrazoliumchlorid (TTC). *Landwirtsch Forsch* **21**: 249–258.

Verma, S.K., Singh, S.B., Rai, O.P., Sharma, R. and Singh, G. 2008. Effect of cultivars and herbicides on yield and nutrient uptake by weed and wheat under zero-tillage system. *Indian Journal of Agricultural Sciences* **78**(11): 984–987.

Vischetti, C., Casucci, C. and Perucci, P. 2002. Relationship between changes of soil microbial biomass content and imazamox and benfluralin degradation. *Biology and Fertility of Soils* **35**: 13–17.

Zabaloy, M.C., Garland, J.L. and Gomez, M.A. 2008. An integrated approach to evaluate impacts of the herbicides glyphosate, 2, 4-D and metsulfurom-methyl on soil microbial communities in the pampas region, Argentina. *Applied Soil Ecology* **40**: 1–12.

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Research Paper

Effect of irrigation scheduling and organic manures on wheat (*Triticum aestivum*) yield and soil nutrient status

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ABSTRACT

A field experiment was conducted in a loamy sand during the winter (*rabi*) seasons of 2014–15 and 2015–16 at Jobner, Rajasthan, study to the effect of irrigation scheduling and organic manures on growth, yield and quality of wheat (*Triticum aestivum* L.). The treatments consisted of 5 irrigation scheduling in main plots and 4 organic manures in subplots were replicated 4 times in a split-plot design. The results showed that irrigation applied at an irrigation water: cumulative pan evaporation (IW: CPE) ratio of 0.9 (I_2) resulted in the maximum values of yield (grain and straw) and proved significantly superior to the remaining treatments except treatment I_5 (IW: CPE of 0.8). Irrigation at an IW: CPE ratio of 0.9 (I_2) exhibited the maximum value of consumptive use (395 mm) and treatment I_5 revealed significantly highest water-use efficiency (11.34 kg/ha-mm) over rest of the treatments. The treatment I_5 failed to show significant variation in organic carbon, available nitrogen, phosphorus and potassium after harvesting of the crop. An application of FYM at 7.5 t + VC at 3 t/ha (M_3) resulted in significantly higher yield (grain and straw) over rest of the treatments but at par with M_2 (VC at 6 t/ha). The highest consumptive use (409 mm) by crop was shown by the treatment M_0 (Control). The significantly highest WUE was recorded under M_3 (12.40 kg/ha-mm). The highest organic carbon (0.149%) was also recorded under this treatment M_3. which remained at par with M_1 (farmyard manure @15 t/ha) but significantly higher than M_0 and M_2. The significantly higher available N, P and K contents in soil after harvesting were recorded under the treatment M_3, being at par with M_2 but superior to rest of the treatments. Thus scheduling of irrigation to wheat either at 0.9 IW: CPE ratio throughout the growth or 0.8 IW: CPE ratio at vegetative phase + 1.0 IW: CPE ratio at reproductive phase resulted in significantly higher yield. Manuring the crop either at 7.5 t FYM + 3 t/ha VC or 6 t/ha VC were the equally effective treatments for available N, P and K status in soil after harvesting.

Key words: FYM, Irrigation Scheduling, NP, Organic manure, K, Organic carbon, Vermicompost, WUE and Yield

Wheat is one of the most important staple food crops of the world as well as India. It is cultivated under diverse growing conditions of soil and climate. In India, it is the second most important food crop after rice. It is an excellent health-building food containing approximately 78% carbohydrates, 11–12% protein, 2% fat and minerals each and considerable amount of vitamins (Kumar *et al*., 2011). About an 80–85% of wheat grains are ground into flour (*atta*) and consumed in the form of *chapaties*. Soft wheat is used for making *chapaties*, bread, cake, biscuits, pastry and other bakery products. The crop straw is mainly used as fodder for livestock. Wheat is highly sensitive to water stress during the crown-root imitation (CRI) and flowering stages but excess irrigation may lead to heavy vegetative growth and shortening of reproductive period ultimately resulting decrease in the yield. Thus, timing the length of irrigation interval with the stages of crop growth might bring about a reduction in the number of irrigations and results in an economic crop yield. In principle, irrigation should take place while the soil water potential is still high enough to enable soil supply water fast enough to meet the local atmospheric demands without placing the plants under stress that would reduce yield and quality of crop. 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

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irrigation intervals during vegetative or maturation by way of narrowing or widening irrigation water: cumulative pan evaporation (IW: CPE) ratio could attain similar economic yields as well as result in saving of irrigation water and improving water-use efficiency. In general, irrigation is being scheduled on the basis of climatological approach (IW: CPE ratio) during entire period of crop irrespective of the stage of growth. But proper scheduling of irrigation is necessary at both 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 (VC) 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. Keeping these facts in view, a field experiment was conducted to evaluate irrigation scheduling and organic nutrition of wheat crop under arid and semi-arid agro-climatic condition.

MATERIALS AND METHODS

A field experiment was carried out during the winter (*rabi*) seasons of 2014–15 to 2015–16 at S.K.N. College of Agriculture, Jobner (26° 05' N and 75° 28' E, of 427 metres above mean sea-level), Rajasthan.The soil was sandy loam, having bulk density 1.52 Mg/m^3 and *p*H 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.e. I_1 (irrigation at critical stages), I_2 (0.9 IW: CPE ratio), I_3 (0.6 IW: CPE ratio at vegetative phase + 0.8 IW: CPE ratio at reproductive phase), I_4 (0.6 IW: CPE ratio at vegetative phase + 1.0 IW: CPE ratio at reproductive phase) and I_5 (0.8 IW: CPE ratio at vegetative phase + 1.0 IW: CPE ratio at reproductive phase) in main plots; and 4 organic manures, i.e. M_0 (control), M_1 (FYM at 15 t/ha), M_2 (VC at 6 t/ha) and M_3 (FYM at 7.5 t/ha + VC at 3 t/ha) in subplots. Wheat variety 'Raj 4037' was sown on 16 December and 18 December during 2014 and 2015 and on harvested at 8 April and 10 April during 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 was used. The field plots of size 4.0 m × 2.7 m were separated from each other by using 0.50 m buffer rows. Irrigations were applied as per treatments on the basis of IW: CPE ratio approach using 4.5 cm depth of irrigation water. Six irrigations in I_1 (irrigation at critical stages), 7 irrigations in I_2 (irrigation at 0.9 (IW: CPE ratio), 4 irrigations in I_3 (irrigation at 0.6 IW: CPE ratio at vegetative phase + 0.8 IW: CPE ratio at reproductive phase), 5 irrigations in I_4 (irrigation at 0.6 IW: CPE ratio at vegetative phase + 1.0 IW: CPE ratio at reproductive phase) and 6 irrigation in I_5 (irrigation at 0.8 IW: CPE ratio at vegetative phase + 1.0 IW: CPE ratio at reproductive phase). Recommended dose of fertilizer was 90, 30 and 0 kg N, P_2O_5 and K_2O/ha. Half dose of nitrogen and full dose of phosphorus was applied basal through urea and DAP, and the remaining dose of nitrogen was top-dressed at the time of first and second irrigation.The FYM was applied 2 weeks before sowing and VC just before sowing as per treatment. The FYM contains 0.49, 0.28 and 0.42% and vermicompost contains @ 1.21, 0.69 and 1.02%, N, P, and K respectively.The crop was harvested manually with the help of sickle when grains were almost matured and straw had 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 using the formula described by Dastane (1972) and that was used for calculating water use efficiency (WUE). Grain and straw yield (kg/ha) were determined from each plot and converted to tonnes per hectare. All the observation during individual years as well as in pooled analysis was statistically analyzed for their test of significance using the *F*-test (Gomez and Gomez, 1984). The significant of difference between treatment means were compared by using critical difference (CD) at 5 % level of probability.The following formula was used to work out WUE.

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

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_2 (Irrigation at 0.9 IW: CPE ratio), being at par with I_5 and significantly superior to rest of the treatments (Table 1). It was also found that under higher irrigation frequency owing to sufficient moisture in the soil profile and better availability of plant nutrients, particularly of N, P and K, might have helped in efficient translocation of photosynthates to produce more grain yield. Secondly, higher yield with higher levels of irrigation might be due to its key role in root development by reducing mechanical resistance of soil, higher transpiration, greater nutrient uptake and more photosynthesis due to metabolic activities in plant (Bhunia *et al.,* 2006). The other reason of yield increase might be that scheduling irrigation at 0.9 IW: CPE ratio and 1.0 IW: CPE ratio 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) reported similar result.

The irrigation at an IW: CPE ratio of 0.9 (I_2) resulted in the maximum straw yield (6.34 t/ha) which was at par with I_5, but significantly higher than rest of the treatments. By and large, I_2 and I_5 treatments were 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 obviously resulted in to more straw yield (Narolia *et al*., 2016). The treatment I_2 (Irrigation at an IW: CPE ratio of 0.9) exhibited the maximum consumptive use (398 mm) over all other treatments, while the minimum consumptive use was observed in I_3 treatment. Thus, consumptive use of water increased with the increase in quantity of irrigation water. This might be owing to a greater number of irrigations that increased the transpiration resulting in 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 ratio at vegetative phase + 1.0 IW: CPE ratio at reproductive phase) recorded the significantly highest WUE (11.34 kg/ha-mm), while treatment I_3 the lowest WUE (10.24 kg/ha-mm). The highest WUE in the treatment I_5 might be owing to the fact that crop was supplied with adequate soil moisture and without moisture stress during the 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 to significantly highest WUE (Bikrmaditya *et al*., 2011).

Effect of organic manures: The significantly higher values of grain and straw yield (4.57 and 6.58 t/ha) were recorded with the application of 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 treatment (Table 1). It is well known that addition of FYM and vermicompost (VC) could increase the micronutrient concentration in the soil and increase the adsorption power of soil for cations and anions, particularly, phosphates and nitrates, and these were released slowly for the benefit of the crop during entire growth period. These results are in agreement with those of Singh and Agarwal (2004). The highest consumptive use shows that the maximum consumptive use (409 mm) by crop was recorded under the treatment M_0 (control) as compared to rest of the treatments. The minimum consumptive use was obtained where FYM 7.5 t + VC 3 t/ha (M_3) was applied. Lower consump-

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)	Consumptive use (mm)	Water-use efficiency (kg/ha/mm)
Irrigation scheduling				
I_1	4.24	6.06	380	11.14
I_2	4.45	6.34	398	11.20
I_3	3.78	5.76	369	10.24
I_4	4.14	6.05	378	10.95
I_5	4.37	6.25	385	11.34
SEm±	0.07	0.07	-	0.04
CD (p=0.05)	0.20	0.19	-	0.12
Organic manures				
M_0	3.48	5.12	409	8.53
M_1	4.29	6.26	365	11.73
M_2	4.43	6.42	379	11.79
M_3	4.57	6.58	369	12.40
SEm±	0.06	0.06	-	0.03
CD (p=0.05)	0.18	0.17	-	0.11

I_1, Irrigation at critical stages; I_2, 0.9 IW: CPE ratio; I_3, 0.6 IW: CPE ratio at vegetative + 0.8 IW: CPE ratio at reproductive phase; I_4, 0.6 IW: CPE ratio at vegetative + 1.0 IW: CPE ratio at reproductive phase; and I_5, 0.8 IW: CPE ratio at vegetative + 1.0 IW: CPE ratio at reproductive phase; Mo, control, M_1 (FYM @ 15 t/ha); M_2, vermicompost @ 6 t/ha; M_3, FYM @ 7.5 t/ha + vermicompost @ 3 t/ha tive 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 water-use effeiciency (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 due to combined application of FYM and VC. Thus, WUE enhanced significantly over sole application of organic manures or no-organic manure treatment where increase in yield was lesser than the loss of water through evapo-transpiration (Ebtisam *et al*., 2013).

Nutrient status in soil after harvest

Effect of irrigation scheduling: Data given in Table 2 clearly indicated that irrigation treatments failed to bring any significant variation in organic carbon and available NPK after harvesting.

Effect of organic manures: Significantly higher organic carbon (0.149%) was recorded under the treatment M_3 (FYM @ 7.5 t/ha + vermicompost @ 3 t/ha) over M_0, M_1 and M_2 (Table 2). Organic matter has solubilizing effect on some mineral compounds present in soil and brings about the conversion of a number of chemical elements to available form (Prakash *et al*., 2002). The beneficial effect of FYM application on soil organic carbon content might be owing to carry-over residues left in the manured plots (Kumawat and Jat, 2005; Pandey *et al*., 2006). The highest nitrogen, phosphorus and potassium with the values of 158, 24.40 and 216 kg/ha were recorded under the treatment M_3 (FYM @ 7.5 t/ha + VC @ 3 t/ha), being significantly at par with M_1 but superior to M_0 and M_2 treatments. The superiority of VC in increasing the available N status might be due to presence of higher content of N and the beneficial microbes. The earthworm output comprises almost assimiable products of excretion such as ammonia and urea, which is rapidly mineralized due to narrow C : N ratio (Kumawat and Jat, 2005). Thus, it represents a potentially significant source of readily available nutrients for plant growth. Organic manures on decomposition solubilize insoluble organic P fractions through release of various organic acids and increase the P status of soil (Prakash *et al*., 2002). It also forms chelates with essential plant nutrients and reduces their fixation which favours availability of nutrients to the crop. The available K content of soil before the experiment was of medium range and, hence, different, organic manures performed equally well. Monika *et al*. (2006) also reported similar results in wheat.

CONCLUSION

It can be concluded that scheduling of irrigation to wheat either at 0.9 IW: CPE ratio throughout the growth or at 0.8 IW: CPE ratio at vegetative phase + 1.0 IW: CPE ratio at reproductive phase significantly produced higher yield (grain and straw). So far as saving of irrigation water is concerned, irrigating the crop with 0.8 IW: CPE ratio at vegetative phase + 1.0 IW: CPE ratio at reproductive phase was most effective, as the above schedule besides giving almost equal yields also curtailed 1 irrigation with highest water-use efficiency. Manuring the crop either at 7.5 t

Table 2. Effect of irrigation scheduling and organic manures on organic carbon and available NPK content in soil after harvesting of wheat

Treatment	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Irrigation scheduling				
I_1	0.142	147	22.0	199
I_2	0.147	145	24.0	202
I_3	0.138	153	21.0	192
I_4	0.141	150	21.6	194
I_5	0.144	150	23.3	198
SEm±	0.002	2.23	0.74	2.50
CD (p=0.05)	NS	NS	NS	NS
Organic manures				
M_0	0.133	134	18.6	152
M_1	0.146	150	22.7	207
M_2	0.141	154	23.5	212
M_3	0.149	158	24.4	216
SEm±	0.001	1.53	0.49	1.81
CD (p=0.05)	0.004	4.21	1.44	5.10

I_1, Irrigation at critical stages; I_2, 0.9 IW: CPE ratio; I_3, 0.6 IW: CPE ratio at vegetative + 0.8 IW: CPE ratio at reproductive phase; I_4, 0.6 IW: CPE ratio at vegetative + 1.0 IW: CPE ratio at reproductive phase; and I_5, 0.8 IW: CPE ratio at vegetative + 1.0 IW: CPE ratio at reproductive phase; Mo, control, M_1 (FYM @ 15 t/ha); M_2, vermicompost @ 6 t/ha; M_3, FYM @ 7.5 t/ha + vermicompost @ 3 t/ha