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Effect of different levels of irrigation and integrated nutrient management on yield and water use efficiency of wheat (*Triticum aestivum* L.)

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ABSTRACT : The present investigation, Effect of different levels of irrigation and integrated nutrient management on yield and water use efficiency of wheat (*Triticum aestivum* L.), was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj) Ayodhya (U.P.), during *rabi* season of 2013-2014 and 2014-15. The experiment was laid out in split plot design having three irrigation levels (0.8 IW/CPE, 1.0 IW/CPE ratio and 1.2 IW/CPE ratio) as main plot treatments and six integrated nutrient management source (100% RDF through inorganic fertilizer, 75% RDF through inorganic fertilizer with 25% N through FYM, 75% RDF through inorganic fertilizer with 25% N through bio-compost, 125% RDF through inorganic fertilizer, 100% RDF through inorganic fertilizer with 25% N through FYM and 100% RDF through inorganic fertilizer with 25%N through bio-compost) as sub plot treatments. Eighteen treatment combinations were replicated three times. The soil of experimental site was silt loam in texture with low organic carbon (0.32%) and nitrogen (180.0 kg/ha) medium in phosphorus (14.3 kg/ha) and potassium (210.0 kg/ha). The wheat *cv.* Malviya-234 was sown. Yield was increased significantly due to various levels of irrigation and integrated nutrient management. The grain and straw yield significantly higher under 1.2 IW/ CPE and 100% RDF through inorganic fertilizer with 25% N through bio-compost at par with 100% RDF through inorganic fertilizer with 25%N through FYM. Maximum water use efficiency (315.67 kg/ha-cm) was worked out under 0.8 IW/CPE and 100% RDF through inorganic fertilizer with 25%N through bio-compost. Minimum water use efficiency (171.19 kg/ha-cm) was worked out under 1.2 IW/CPE and 100% RDF through inorganic fertilizer.

Key Words : FYM, Bio compost , RDF, IW/CPE, wheat, WUE and yield.

Wheat (*Triticum aestivum* L.) belongs to family Poaceae, is a staple food of the world. India is one of the major wheat producing and consuming countries in the world. In India, total area under wheat is 30.60 mha with the production and productivity of 98.38 mt and 3216 kg/ha (Anonymous, 2017). Among them Uttar Pradesh ranks first with respect to area (9.66 mha) and production of (30.06 mt) but the productivity (3113 kg/ha) is much lower as compared to Punjab (4704 kg/ha) and Haryana (4514 kg/ha) (Anonymous, 2017). It is well known that water management is one of the major factors responsible for achieving better harvest in crop production. Efficient irrigation through timely supply of water in desirable amount not only improves the crop yield but also enhances water use efficiency. Adequate soil moisture is required for normal development of wheat crop at all the critical growth stages which can be created by timely scheduling of irrigation (Parihar, 2003). The insufficient irrigation facilities in arid and semi-arid areas were identified as the major reason of decline productivity of the crops. It is universally acknowledged that wheat growth and yield increase significantly with water availability. Improvement in inheritent nutrient supplying capacity of the soil and improvement soil physical properties due to the application of organic manures has been well documented (Hati *et al.*, 2006), which might have promoted better rooting, higher nutrient and water uptake by crop and transpiration efficiency (Zhang *et al.*, 1988). The use of inorganic fertilizer and organic manure in soil create nutrient balance in both soil and plant system.

Materials and Methods

The present investigation was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj) Ayodhya (U.P.), during *rabi* season of 2013-2014 and 2014-15. The experiment was laid out in split plot design having three irrigation levels (0.8 IW/ CPE, 1.0 IW/CPE ratio and 1.2 IW/CPE ratio) as main plot treatments and six integrated nutrient management source *viz.*100% RDF through inorganic fertilizer, 75% RDF through inorganic fertilizer with 25%N through FYM, 75% RDF through inorganic fertilizer with 25% N through bio-compost, 125% RDF through inorganic fertilizer, 100% RDF through inorganic fertilizer with 25%N through FYM and 100% RDF through inorganic fertilizer with 25%N through bio-compost as sub plot treatments. Eighteen treatment combinations were replicated three times. The soil of experimental site was silt loam in texture with low organic carbon (0.32%) and ni-

trogen (180.0 kg/ha) medium in phosphorus (14.3 kg/ha) and potassium (210.0 kg/ha). The wheat *cv*. Malviya-234 was sown.

Water use efficiency : Water expense efficiency was worked out here which was treated as water use efficiency. Water expense efficiency (WEE) was a grain yield produced per unit of water received or expensed which was total water applied and effective rainfall.

$$\text{WEE (kg/ha-cm)} = \frac{\text{Grain yield (kg/ha)}}{\text{Total water received (cm)}}$$

Results and Discussion

Effect on grain yield

Grain yield (q/ha) : Grain yield is the ultimate result for final assessment of impact of various treatments in any agronomical investigation. The grain yield was influenced significantly due to levels of irrigation and integrated nutrient management.

A perusal of data clearly reveals that grain yield was affected significantly due to different level of irrigation during both the years. The maximum grain yield was recorded under irrigation at 1.2 IW/CPE followed by 1.0 IW/CPE and they were significantly higher over 0.8 IW/CPE during the course of investigation (Table-1).

The maximum grain yield was recorded (42.89 and 40.53 q/ha) under 1.2 IW/CPE and minimum grain yield was recorded (39.90 and 37.70 q/ha) under 0.8 IW/CPE during 2013-14 and 2014-15, respectively.

The various integrated nutrient management induced significant increase in grain yield during both the years. The data clearly reveal that maximum grain yield was recorded under 100 per cent RDF through inorganic fertilizer when coupled with 25% N through biocompost. It was significantly higher over 100 per cent RDF, 75 per cent RDF with 25% N through FYM, 75 per cent RDF with 25% N through biocompost, 125 per cent RDF and remained at par with treatment 100 per cent RDF with 25% N through FYM during both the years.

The maximum grain yield was recorded (43.25 and 40.87 q/ha) under the treatment of 100 per cent RDF through inorganic fertilizer with 25% N through bio compost and minimum grain yield (40.23 and 38.02 q/ha) under 100 per cent RDF during 2013-14 and 2014-15, respectively.

The interaction effect of different levels of irrigation and integrated nutrient management on grain yield was found significant during both the years.

Yield is the result of coordinated inter play of growth characters and yield attributes. Higher grain yield was recorded under irrigation at 1.2 IW/CPE ratio. This might be due to adequate moisture availability, which contributed to better growth parameters and yield attributes. Irrigation at 0.8 IW/CPE ratio recorded lowest grain yield due to poor irrigation supply during growth period. Poor irrigation supply during irrigation at 0.8 IW/CPE ratio reduced the yield attributes and resulted in poor grain and straw yield. . Similar findings were reported by Pradhan *et al*. (2013), Kumar *et al*. (2015), Salunkhe *et al*. (2015), Narolia *et al*. (2016), Rajanna *et al*. (2017) and Verma *et al*. (2018).

Grain and straw yield were affected significantly due to various integrated nutrient management (Table-1). This might be due to availability of adequate moisture availability and better root development increase more uptake of nutrient increases dry matter accumulation under which contributed to better growth parameters and yield attributes. Lowest grain and straw yield were recorded with the application of 100% RDF through inorganic fertilizer during both the years this was due to poor growth metabolic process and lower yield attribute. The results are in accordance to those of Shaktawat *et al*. (2013) and Zahoor (2014).

Interaction effect of different levels of irrigation and integrated nutrient management on grain yield

The interaction effect of irrigation level and integrated nutrient management was found significant during both the years. Increase in level of irrigation with increase in level of integrated nutrient management, increased grain yield. Irrigation at 1.2 IW/CPE with 100% RDF through inorganic fertilizer in addition to 25% N through biocompost recorded maximum grain yield. But, it remained was at par with 1.2 IW/CPE with 100% RDF through inorganic fertilizer with 25% N through FYM, 1.0 IW/CPE with 100% RDF through inorganic fertilizer with 25% N through biocompost and 1.0 IW/CPE with 100% RDF through inorganic fertilizer with 25% N through FYM during both the year. The maximum grain yield was noted 44.18 q/ha and 41.75 q/ha under 1.2 IW/CPE with 100 per cent RDF through inorganic fertilizer with 25% N through biocompost and lowest grain yield was noted 38.23 q/ha and 36.13 q/ha with 0.8 IW/CPE with 100% RDF during 2013-14 and 2014-15, respectively (Table-2).

Straw yield

A cursory glance over the data pertaining to straw yield in Table-1 reveal that straw yield was significantly influenced by levels of irrigation and integrated nutrient management.

A perusal of data in Table-1 reveals that straw yield affected significantly due to different level of irrigation during both years of present investigation. The maxi-

Table-1: Effect of different levels of irrigation and integrated nutrient management on grain yield, straw yield and water use efficiency of wheat**.**

Treatment	Grain yield (q/ha)		Straw yield (q/ha)		Water use efficiency (kg/ha-cm	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Irrigation						
0.8 IW/CPE	39.90	37.70	56.79	53.67	177.56	129.48
1.0 IW/CPE	42.61	40.26	60.36	57.04	149.66	114.65
1.2 IW/CPE	42.89	40.53	60.86	57.52	105.97	98.56
SEm±	0.12	0.12	0.27	0.24	0.50	0.37
CD (P=0.05)	0.34	0.32	0.75	0.68	1.38	1.03
Integrated nutrient management						
100 % RDF	40.23	38.02	57.25	54.10	138.91	109.90
75 % RDF + 25 % FYM	40.70	38.46	57.93	54.74	140.44	111.14
75 % RDF + 25 % Biocompost	41.13	38.87	58.81	55.58	141.93	112.33
125 % RDF	42.48	40.14	60.15	56.84	146.83	116.14
100 % RDF + 25 % FYM	43.00	40.63	60.78	57.44	148.73	117.60
100 % RDF + 25% Biocompost	43.25	40.87	61.11	57.75	149.54	118.26
SEm±	0.13	0.12	0.30	0.28	0.51	0.38
CD (P=0.05)	0.26	0.24	0.60	0.56	1.05	0.78
I X INM	S	S	NS	NS	S	S

Table-2 : Interaction effect of different levels of irrigation and INM on grain yield of wheat.

Treatment	**Grain yield (q/ha) during 2013-14**			
	0.8 IW/CPE	1.0 IW/CPE	1.2 IW/CPE	Mean
100 % RDF	38.23	41.14	41.31	40.23
75 % RDF + 25 % FYM	38.57	41.57	41.95	40.70
75 % RDF + 25 % Biocompost	38.93	42.08	42.39	41.13
125 % RDF	40.80	43.03	43.61	42.48
100 % RDF + 25 % FYM	41.37	43.75	43.88	43.00
100 % RDF + 25 % Biocompost	41.50	44.07	44.18	43.25
Mean	39.90	42.61	42.89	
	SEm±		**LSD (P=0.05)**	
MxS	0.22		0.45	
SxM	0.19		0.42	
Treatment	**Grain yield (q/ha) during 2014-15**			
	0.8 IW/CPE	1.0 IW/CPE	1.2 IW/CPE	Mean
100 % RDF	36.13	38.87	39.04	38.02
75 % RDF + 25 % FYM	36.45	39.28	39.64	38.46
75 % RDF + 25 % Biocompost	36.79	39.77	40.06	38.87
125 % RDF	38.56	40.67	41.21	40.14
100 % RDF + 25 % FYM	39.09	41.35	41.46	40.63
100 % RDF + 25 % Biocompost	39.22	41.64	41.75	40.87
Mean	37.70	40.26	40.53	
	SEm±		**LSD (P=0.05)**	
MxS	0.21		0.42	
SxM	0.18		0.40	

Table-3 : Interaction effect of different levels of irrigation and integrated nutrient management on water use efficiency of wheat.

Treatment	Water use efficiency (kg/ha-cm) during 2013-14			
	0.8 IW/CPE	1.0 IW/CPE	1.2 IW/CPE	Mean
100 % RDF	170.15	144.49	102.08	138.91
75 % RDF + 25 % FYM	171.64	146.02	103.66	140.44
75 % RDF + 25 % Biocompost	173.24	147.82	104.74	141.93
125 % RDF	181.58	151.15	107.75	146.83
100 % RDF + 25 % FYM	184.10	153.68	108.42	148.73
100 % RDF + 25 % Biocompost	184.69	154.78	109.16	149.54
Mean	177.56	149.66	105.97	
	SEm±		LSD (P=0.05)	
MxS	0.89		1.82	
SxM	0.76		1.70	

Treatment	WUE (kg/ha-cm) during 2014-15			
	0.8 IW/CPE	1.0 IW/CPE	1.2 IW/CPE	Mean
100 % RDF	124.07	110.69	94.94	109.90
75 % RDF + 25 % FYM	125.16	111.86	96.41	111.14
75 % RDF + 25 % Biocompost	126.32	113.24	97.42	112.33
125 % RDF	132.40	115.79	100.22	116.14
100 % RDF + 25 % FYM	134.24	117.73	100.84	117.60
100 % RDF + 25 % Biocompost	134.68	118.57	101.53	118.26
Mean	129.48	114.65	98.56	
		SEm±		LSD (P=0.05)
MxS		0.66		1.36
SxM		0.57		1.27

mum straw yields were recorded under 1.2 IW/CPE followed by treatment 1.0 IW/CPE and they were significantly higher over 0.8 IW/CPE during both years, respectively.

The maximum straw yield was recorded (60.86 and 57.52 q/ha) under 1.2 IW/CPE and minimum straw yield (56.79 and 53.67 q/ha) under the treatment 0.8 IW/CPE during 2013-14 and 2014-15, respectively.

Straw yield was significantly influenced due to various integrated nutrient management practices tested course of study. Scanning of data reveal that maximum straw yield was recorded under 100 per cent RDF through inorganic fertilizer with 25% N through bio compost which was significantly higher over 100 per cent RDF, 75 per cent RDF with 25% N through FYM, 75 per cent RDF with 25% N through bio compost, 125 per cent RDF. But, it remained at par with treatment 100 per cent RDF with 25% N through FYM during both the years, respectively.

The maximum straw yield was recorded (61.11 and 57.75 q/ha) under 100 per cent RDF through inorganic fertilizer with 25% N through biocompost and minimum straw yield (57.25 and 54.10 q/ha) under 100 per cent RDF during 2013-14 and 2014-15, respectively.

The interaction effect of different levels of irrigation and integrated nutrient management on straw yield was found non-significant during both the years.

This might be due to adequate moisture availability, which contributed to better growth parameters and yield attributes. Irrigation at 0.8 IW/CPE ratio recorded lowest grain yield due to poor irrigation supply during growth period. Poor irrigation supply during irrigation

at 0.8 IW/CPE ratio reduced the yield attributes and resulted in poor grain and straw yield.

Effect on water use efficiency

Water use efficiency depend upon the grain yield & total quantity of water used (during the entire crop period). The data pertaining to water use efficiency is presented in Table-1. Water use efficiency was influenced by various level of irrigation and integrated nutrient management.

An examination of data indicates that water use efficiency decreased markedly with increasing level of irrigation. The maximum water use efficiency (177.56 and 129.48 kg/ha-cm) was obtained under 0.8 IW/CPE treatments which was significantly superior over 1.0 IW/CPE and 1.2 IW/CPE during both the year.

Integrated nutrient management had marked impact on the water use efficiency. The maximum water use efficiency was (149.54 and 118.26 kg/ha-cm) noticed under 100 per cent RDF through inorganic fertilizer with 25% N through bio compost which was at par with 100 per cent RDF through inorganic fertilizer with 25% N through FYM, but significantly superior over 125 per cent RDF through inorganic fertilizer, 75 per cent RDF through inorganic fertilizer with 25% N through bio compost, 75 per cent RDF through inorganic fertilizer with 25% N through FYM, 100 per cent RDF through inorganic fertilizer. The lowest water use efficiency was recorded (138.91 and 109.90 kg/ha-cm) under 100% RDF through inorganic fertilizer during 2013-14 and 2014-15, respectively.

The interaction effect of different levels of irrigation and integrated nutrient management on water use efficiency (kg/ha-cm) was found significant during both the years.

Water use efficiency (WUE) was markedly influenced by different level of irrigation. The highest water use efficiency 177.56 kg/ha-cm and 129.48 kg/ha-cm was recorded under irrigation at 0.8 IW/CPE ratio was significantly over irrigation at 1.0 IW/CPE ratio and irrigation at 1.2 IW/CPE ratio during both the year. This might be due to the fact that lower level of irrigation, plant yielded more per unit of water consumed. These findings are in agreement with those of Rathore and Patel (1991), Maurya and Singh (2008).

Highest water use efficiency was found under 100% RDF through chemical fertilizer along with 25% N through bio-compost and lowest with application of 100% RDF through inorganic fertilizer during both the years. The water use efficiency (WUE) increasing with increase level of nutrients. Nutrients applied through chemicals fertilizers along with organic favoured the growth of plants as they consumed more amount of water for their metabolic process and transpiration more value due to maximum water availability plant growth which led to higher WUE. The increase in WUE under higher integrated nutrient availability and maximum water holding capacity was mainly due to proportionately higher increase in grain yield than consumption of water supported by Bhat *et al.* (2006).

Interaction effect of different levels of irrigation and integrated nutrient management on water use efficiency (kg/ha-cm)

The interaction effect of irrigation level and integrated nutrient management practices significantly influenced the water use efficiency during both the years. Increase in level of irrigation with increase in level of integrated nutrient management, influenced the water use efficiency (Table-3). Irrigation at 0.8 IW/CPE with 100 per cent RDF through inorganic fertilizer with 25% N through biocompost recorded maximum water use efficiency which was at par with 0.8 IW/CPE with 100 per cent RDF through inorganic fertilizer with 25% N through FYM during both the year, but significantly higher over rest of the treatment combination. The maximum water use efficiency (kg/ha-cm) was noted 184.69 and 134.68 kg/ha-cm under 0.8 IW/CPE with 100 per cent RDF through inorganic fertilizer with 25% N through biocompost and lowest water use efficiency (kg/ha-cm) was noted 102.08 and 94.94 kg/ha-cm with 0.8 IW/CPE with 100% RDF during both the year.

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