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Effect of nutrient management and moisture regime on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract
The field experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during *Rabi* season of 2014-15 and 2015-16. Comprised whitsixteen treatments combination formed Viz; four moisture regime, and four nutrient management which were allocated in split plot design with three replications. The four moisture regime I_1; 0.6 IW/CPE ratio I_2; 0.8 IW/CPE ratio I_3; 1.0 IW/CPE ratio and I_4; 1.2 IW/CPE ratio were as main plot and four nutrient management 100% RDF through inorganic fertilizers (120:60:40 kg NPK ha^{-1}), 75% NPK+ 25% N through FYM (90:45:30 kg NPK ha^{-1}). 50% NPK+ 50% N through FYM (60:30:20 kg NPK ha^{-1}) (d) 25% NPK+75% N through FYM (30:15:10 kg NPK ha^{-1}) were kept as sub plots. The growth attributes *viz*; number of shoots, plant height, dry matter accumulation and yield attributing characters *viz*, number of grains $spike^{-1}$, number of spike m^2, length of spike, test weight, grain and straw yield, harvest index, nutrients uptake by crop was significantly increased 75% RDF (90:45:30 kg NPK/ha +25% N through FYM along withI4; 1.2 IW/CPE ratio moisture regimewhich was at par with 100% RDF(120:60:40 kg NPK/ha)along with I4; 1.2 IW/CPE ratio moisture regimeand significantly higher over rest of the treatment as well as economics of various treatments were recorded. Moisture regime of 1.0 IW/CPE ratio (5-6irrigations) was found suitable for achieving higher yield of wheat with 75% RDF (90:45:30 kg NPK/ha +25% N through FYM followed by 100% RDF (120:60:40 kg NPK/ha) was found suitable higher growth and yield of wheat crop. On the basis of results obtained, application of 75% RDF (90:45:30 kg NPK/ha +25% N through FYM, nutrient supply system and I4; 1.2 IW/CPE ratio moisture regimefound to be more suitable for higher yield of wheat variety Malviya 234.

Keywords: Wheat; Moisture regime; Nutrient; Varieties; Growth; Economics; Yield

Introduction
Wheat (Triticumaestivum L.) is a staple food of the world and falls under Poaceae family. It is primarily grown in temperate regions and also at higher altitude under tropical climatic areas in winter season. It is the single most important cereal crop that has been considered as integral component of the food security system of the several nationsWheat is the single, most important cereal crop that has been considered as integral component of the food security system of the several nations. It ranks first in the world among the cereals both in area with 225.43 mha and production with 708.0 mt. In India, total area under wheat is 29.90 mha with the production and productivity of 93.90 mt and 3.14 t ha-1 respectively (Anonymous, 2014).
The normal time for sowing of dwarf wheat in irrigated tracts starts in the beginning of November. Medium to long duration varieties taking 135-145 days to mature should be sown in the first fortnight of November while, short duration varieties (120-125 days) may be sown in the second fortnight of November.The productivity of wheat in eastern U.P. is very low (25 q ha-1) and it might be due to adoption of cereal-cereal (Rice-Wheat) cropping system, poor management in balanced fertilization, etc. Increasing level of production can be achieved by increasing level of fertilizer, but continuous use of chemical fertilizers alone may lead diminishable yield even with the recommended dose of fertilizer application. Besides chemical fertilizer alone may also lead to same detrimental effect on physical and chemical properties of soil and may not be so remunerable unless the fertility of soil is maintained at sustainable level by application of organic manures. Therefore to maintain fertility and productivity of soil at sustainable level for long duration, there is a need to adopt the concept of integrated nutrient management. Organic manures such as farmyard manure are to be considered and integral component and may help to recover soil health in cropping system (Ranwa and Singh, 1999) as they improve soil fertility and physical properties. Organic matters in soil improve physical
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condition of soil for better performance of microorganism and physical status at soil (Kumar and Tripathi, 1990).

Irrigation water is a major constraint for assumed crop production. Evapo-transpiration by a full crop cover is closely associated with the evaporation from an open pan. At present irrigation is very costly input so will be used very judiciously. Parihar *et al*. (2003) suggested a relatively more practical meteorological approach of IW/CPE, the ratio between a fixed amount of irrigation water (IW) and Cumulative Pan Evaporation, as a basis for irrigation scheduling to crops. IW/CPE approach merits special consideration on account of its simplicity of operation. IW/CPE is taken for applying water to wheat and for comparative study treatments at critical growth stages, Patel and Upadhya, (1993) reported that the higher grain yield with IW: CPE ratio 1.2 of 6cm irrigation, resulted in improved yield attributes, viz. effective tiller per meter row length, spikelets per spike, number of grains per spike, grain weight per spike and 1000-grain weight.

Material and Methods

A field experiment was conducted at Main Research Farm, Department of Agronomy of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) India. The farm is located 42 km away from Faizabad city on Faizabad- Raebareily road at 26.47˚ N latitude and 82.12˚ E longitude and about 113 metres above the mean sea level. Sixteen treatments comprised of four levels of moisture regime (a) I1; 0.6 IW/CPE ratio (b) I2; 0.8 IW/CPE ratio (c) I3; 1.0 IW/CPE ratio and (c) I4; 1.2 IW/CPE ratio and four levels of fertilizers ((a) 100% RDF through inorganic fertilizers (120:60:40 kg NPK ha-1) (b) 75% NPK+ 25% N through FYM (90:45:30 kg NPK ha-1) (c) 50% NPK+ 50% N through FYM (60:30:20 kg NPK ha-1) (d) 25% NPK+75% N through FYM (30:15:10 kg NPK ha-1) were tested in a split plot design with three replications. The wheat variety Malviya 234 was sown in 20 cm row to row distance on 16 Nov., during both years. Fertilization was doneby using inorganic fertilizers and FYM as per treatments (level of inorganic fertilizers; 100%, 75%, 50% and 25%) and was added at time of sowing while full dose N was applied as basal and rest half nitrogen was top dressed in two splits after first irrigation and second 45 DAS were done as when required during 2014-15 and 2015-16.Whereas first irrigation of all treatments done at CRI stage (21DAS) after that as per IW/CPE ratio treatments. From the individual plot the crop of net plot area was harvested for taking observation. The final seed weight was recorded in kg per plot and converted into q/ha.

Results and Discussion

The data pertaining to different moisture regimes and varieties, plant growth and yield given in Table 1 reveal that the growth and yield of wheat was affected by moisture regimes.

Effect on crop growth

Data on progressive plant height at the successive stages of crop growth as influenced by various nutrient supply system and moisture have been summarized in Table-4.1. In general, plant height increased successfully up to 90 DAS stage. There after the rate of increased in plant height was nominal at harvest stage of the crop. It is evident from the data that the effect of nutrient supply system was not visible at 30 DAS stage, after this, it exhibited significant effect on plant height. At 60, 90 DAS stage and at harvest stage.At all the stages of growth, the tallest plants were recorded with an irrigation practice of I_4 (IW/CPE of 1.2) which was at par with I_3 (IW/CPE of 1.0) and the shortest plants with I_1 (IW/CPE of 0.6) and I2 (0.8 IW/CPE ratio)The higher plant height were counted it could be attributed to the fact that due to proper combinations of inorganic and organic source of nutrient in F_2 (75% NPK+ 25% N through FYM) would certainly increased the amount of availability to the individual plant and hence resulted in taller plants while the plants were shortest stature with F4 (25% NPK+ 75% N through FYM). These findings were in close conformity with those of Zhong *et al.* (2015), Mohsin *et al.* (2014), Singh *et al.* (2012), Naser *et al.* (2000), Khola *et al.* (1989).

The highest number of shoots of wheat was recorded with the highest level of irrigation tried i.e., I4 (IW/CPE ratio of 1.2) which was at par with I3 and I2 (IW/CPE ratio of 1.0 and 0.8) while significantly superior to that of I1 (IW/CPE ratio 0.6) Number of shoots of wheat increased with increase in frequency of irrigation. Number of wheat shoots was more under F2 (75% NPK+ 25% N through FYM) management practices, it increased linearly with the better management strategy, Translocation of food materials from source (leaf) to sink (reproductive parts) was more with F2 (75% NPK+ 25% N through FYM) management practices. Higher moisture percentage in soil leads to better root growth so that plant can take more nutrients from deeper layers of layer soil. Various researchers reported that continuous availability of water improve the plant tillering in wheat Mohsin *et al.* (2014), Singh *et al.* (2012) and established the need of higher irrigation for better plant tillering Zhong *et al.* (2015), Mohsin *et al.* (2014), Singh *et al.* (2012), Naser *et al.* (2000), Khola *et al.* (1989).

Leaf area index (LAI) of wheat increased progressively with the advance in the age of the crop up to 60 DAS, beyond which it was found declined towards harvest. At all the stages of growth, irrigation at IW/CPE ratio of 1.2 resulted in the higher LAI which was at par with IW/CPE ratio of 1.0. This might be due to the beneficial effect of adequate soil moisture in maintaining the cell turgidity, cell division and cell elongation, thus producing more leaf area, the highest LAI of wheat was recorded with F2 (75% NPK+ 25% N through FYM), while the lowest LAI was associated with F4. Increase in LAI was due to increased nutrient management which accommodates more number of plants per unit area thereby increased the functional leaves which in turn enhanced the LAI. The results were in close conformity with those of Mohsin *et al.* (2014), Singh *et al.* (2012).

Higher dry matter production was due more plant height and increased LAI together produced higher dry matter production. Dry matter production of wheat tended to increase progressively with advance in the age of the crop. The total dry matter production of I_3 (1.2 IW/CPE Ratio) was higher with the crop nutrient level of F_2 (75% NPK+ 25% N through FYM) which was at par with F1 and significant over with F3 and F4 which resulted in the lowest dry matter accumulation. These findings were in agreement with Zhong *et al.* (2015), Mohsin *et al.* (2014), Singh *et al.* (2012), Naser *et al.* (2000), Khola *et al.* (1989).

Effect on yield and yield attributing parameter

The yield attributes character like number of spike, length of spike and number of grain per spike was recorded with the highest level of irrigation tried i.e, IW/CPE ratio of 1.2 (I4) which was at par with IW/CPE ratio of 1.0 while significantly higher than with IW/CPE ratio of 0.6 (I1) and 0.8 IW/CPE

ratio, among the nutrient management tried, the yield attributes was recorded with F_2 (75% NPK+ 25% N through FYM), which was at par with F1. This might be due to better growth of individual plant in F_2 and F_1 which resulted in utilization of accumulated photosynthates and influenced the growth and development of yield attributes. This might be due to more vigorous and luxuriant vegetative growth, which in turn favoured a better partitioning of, assimilates from source to sink. Similar results were obtained by Pal *et al.* (2001), Singh *et al.* (2007), Das and Guha (1998) and Khiriya and Singh (2003).

Higher thousand grain weight was recorded with IW/CPE ratio of 1.2 (I4) which was at par with IW/CPE ratio of 1.0and 0.8 IW/CPE ratio (I2) while significantly higher than IW/CPE ratio of 0.6 (I1) and 0.8 ratio, which has resulted in lower grain weight.

With F_2 (75% NPK+ 25% N through FYM) as regards the nutrient management practices, the higher no of grain per spike of wheat was recorded with the nutrient management of F_2 which was at par with F1.This was followed by F3, which was comparable with lowest no of grain per spike F_4.which produced the lowest hundred seed weight. Better growth of individual plant in F_2 result in better utilization of accumulated photosynthates which influenced the growth and development of yield attributes. This finding was in conformity with the work of Pal *et al.* (2001), Singh *et al.* (2007), Pradhan *et al.* (2013), and Khiriya and Singh (2003).

The higher seed yield was recorded with the highest level of irrigation tried i.e, IW/CPE ratio of 1.2 (I4), which was however comparable with 0.8 IW/CPE ratio (I3) and 0.6(I1), which has resulted in lower seed yield. Higher seed yield due to irrigation might be accounted to their favourable influence on the crop growth and yield attributes. As regards the nutrient management practices, highest seed yield was recorded with a nutrient management of F2, which was at par with F1 followed by F3 and F4with significant difference between them, which produced the lowest seed yield. The same was obvious through the findings of Pal *et al.* (2001), Saren *et al.* (2004),Singh *et al.* (2007), Pradhan *et al.* (2013), Kakar *et al.* (2015), Zagonel *et al*. (2002) Talashikar *et al.* (1999).

Among the irrigation levels tried, IW/CPE ratio of 1.2 (I_4) recorded the higher straw yield which was however, comparable with 0.8 IW/CPE ratio (I_3). The lowest straw yield was recorded with IW/CPE ratio of 0.6(I_1). Increased straw yield might be due to better vegetative growth and higher dry matter production. Higher straw yield was recorded with F_2, which was at par with F_1. F_3 and F_4 produced the lowest straw yield. This is due to increased number of plants per unit area and increased growth of plants i.e, plant height, leaf area, dry matter production in F_2. Similar results were obtained by Pal *et al.* (2001), Zagonel *et al*. (2002) Talashikar *et al.* (1999).

Conclusions

Nutrient management system with 100% RDF (120:60:40 kg NPK/ha followed by 75% RDF (90:45:30 kg NPK/ha +25% N through FYM) was found suitable higher growth and yield of wheat crop. Moisture regime of 1.0 IW/CPE ratio (5-6irrigations) was found suitable for achieving higher yield of wheat. Interaction between moisture regime and nutrient management was found significant on dry accumulated 90 at DAS,120DAS, at harvest; No. of spikes ; grain yield ; straw yield ; nutrient uptake(NPK) and water use efficiency during both the year of investigation.

Table 1: Growth parameter as influenced by Moisture regime and Nutrients supply system on wheat crop.

Treatment	Plant height (cm)				Number of shoots (m^{-2})				Leaf area index			Dry matter accumulation (g m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	At harvest
Nutrients supply system															
F_1	23.73	49.75	79.95	80.75	220.53	320.75	392.00	370.50	1.07	3.18	4.10	67.92	458.02	767.20	971.85
F_2	25.50	53.49	86.02	86.87	244.85	330.13	421.50	398.47	1.15	3.42	4.40	73.08	492.50	825.00	1045.02
F_3	26.00	54.62	87.70	88.58	251.50	346.55	429.57	406.33	1.18	3.49	4.49	74.50	502.38	841.48	1065.90
F_4	26.73	56.20	90.30	91.18	261.95	383.15	442.57	418.37	1.21	3.59	4.62	76.75	517.13	866.23	1097.25
SEm±	0.67	1.04	2.27	2.28	6.90	11.20	10.60	10.31	0.02	0.07	0.10	1.87	11.06	21.152	22.49
C.D. (P=0.05)	1.97	3.05	6.68	6.69	20.46	32.85	31.09	30.24	0.07	0.21	0.32	5.48	32.44	62.03	65.97
Seed rate (kg ha^{-1})															
S_1	24.20	50.85	81.68	82.50	220.53	314.75	400.43	378.50	1.10	3.25	4.18	69.44	467.89	783.71	992.75
S_2	25.78	54.05	86.86	87.74	44.85	329.20	425.70	402.40	1.17	3.45	4.45	73.75	497.43	833.24	1055.48
S_3	26.50	55.64	89.44	90.30	251.50	383.50	438.38	414.35	1.20	3.56	4.58	76.00	512.21	857.99	1086.79
SEm±	0.58	0.90	1.97	1.97	12.08	9.70	9.18	8.93	0.02	0.06	0.09	1.62	9.58	18.31	19.48
C.D.(P=0.05)	1.71	2.64	5.78	5.79	5.44	128.45	26.92	26.19	0.06	0.18	0.27	4.75	28.098	53.72	57.13

(Note: I_1:6 cm irrigation at 0.6 IW/CPE;**I_2:**6 cm irrigation at 0.8 IW/CPE; **I_3:**6 cm irrigation at 1.0 IW/CPE; **I_4:**6 cm irrigation at 1.2 IW/CPE); (**F_1**: 100% RDF through inorganic fertilizers (120:60:40 kg NPK ha^{-1}); **F_2**: 75% NPK+ 25% N through FYM (90:45:30 kg NPK ha^{-1}); **F_3**: 50% NPK+ 50% N through FYM (60:30:20 kg NPK ha^{-1}); **F_4**: 25% NPK+ 75% N through FYM (30:15:10 kg NPK ha^{-1})

Table 2: Yield and yield attributing parameter as influenced by Moisture regime and Nutrients supply system on wheat crop.

Treatment	Number of spike/m^2	Length of spike (cm)	Grain spike^{-1}	Grain yield (q/ha)	Straw yield (q/ha)	Test weight (g)
Nutrients supply system						
F_1	279.95	7.92	35.53	29.95	39.75	36.17
F_2	301.02	8.52	30.22	32.22	41.27	36.93
F_3	307.03	8.67	38.97	32.85	41.19	37.20
F_4	316.05	8.93	40.12	33.81	42.84	37.50
SEm±	7.78	0.19	1.07	0.68	4.11	0.92
C.D. (P=0.05)	22.83	0.56	3.14	2.00	1.06	NS
Seed rate (kg ha^{-1})						
S_1	285.96	8.09	36.29	30.95	39.63	36.65
S_2	304.01	8.59	38.59	32.54	41.90	37.15
S_3	313.06	8.85	39.75	33.49	42.26	37.05
SEm±	6.74	0.16	0.92	0.59	0.92	0.80
C.D. (P=0.05)	19.77	0.48	2.72	1.73	2.71	NS

(Note: I_1:6 cm irrigation at 0.6 IW/CPE;**I_2:**6 cm irrigation at 0.8 IW/CPE; **I_3:**6 cm irrigation at 1.0 IW/CPE; **I_4:**6 cm irrigation at 1.2 IW/CPE); (**F_1**: 100% RDF through inorganic fertilizers (120:60:40 kg NPK ha^{-1}); **F_2**: 75% NPK+ 25% N through FYM (90:45:30 kg NPK ha^{-1}); **F_3**: 50% NPK+ 50% N through FYM (60:30:20 kg NPK ha^{-1}); **F_4**: 25% NPK+ 75% N through FYM (30:15:10 kg NPK ha^{-1})

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