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Effect of sulphur nutrient and moisture regimes on economics of wheat (*Triticum aestivum* L.) varieties

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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 2013-14 and 2014-15.The experiment was carried out in split plot design with three replications. with 24 treatment combinations, comprised of four irrigation levels (a) I_1; 0.6 IW/CPE ratio (b) I_2; 0.8 IW/CPE ratio (c) I_3; 1.0 IW/CPE ratio and (c) I_4; 1.2 IW/CPE ratio with two varieties namely PBW 343 and PBW 502 and three sulphur levels (a) Control (b) 20 kg/ha (c) 40 kg/ha. The growth attributes plant hight, no of shoot m^2 and leaf area index was significantly superior 1.2 IW/CPE ratio with PBW 502 variety at all growth stages except 30 days after sowing. PBW-502 (V2) wheat cultivar recorded significantly higher yield of crop over PBW-343 (V1). Moisture regime 1.0 IW/CPE (I3) has been found most suitable for wheat production. The optimum dose of sulphur has been found as 20kg/ha (S2) for wheat production. Wheat cultivar, PBW-502 (V2) recorded the significantly high uptake of NPK and sulphur under 1.0 IW/CPE moisture regime (I3) with 20kg/sulphur dose kg/ha. (S2). Wheat cultivar PBW-502 (V2) accrued the maximum net return with B:C ratio of 2.65 and 2.47 under 1.0 IW/CPE moisture regime (I3) with 20kg/ ha. Sulphur dose (S2) during the year 2013-14 and 2014-15, respectively.

Keywords: Wheat, Sulphur nutrient, IW/CPE ratio, Varieties, Growth, Economics, Yield

Introduction
Wheat (*Triticum aestivum* L.) is the most important crop of the world. It belongs to 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 nations. It ranks first (Anonymous, 2013) [1] in the world among the cereals both in respect of area (225.43 mha) and production (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} (Anonymous, 2013) [1]. In India, about 90% of the total wheat production is contributed by northern states. Among them, Uttar Pradesh ranks first with respect to area (9.734 mha) and production (30.30 mt) but the productivity is much lower (3.113 t ha^{-1}) than Punjab with 4.724 t ha^{-1} (Anonymous, 2013) [1]. Fertility status occupies a predominant place in the growth and development of the plant. An insufficient sulphur supply can affect the yield and quality of wheat as to sulphur is required for protein and enzyme synthesis as well. It is a constituent of the amino acids, methionine and cystein. The maximum plant height, number of shoot m^{-2}, LAI and dry matter accumulation was recorded higher with 20 kg sulphur /ha which, significant difference over control during was recorded by Fazal and Sisodia (1989) [7]; Liu *et al.* (2002) [14]. Grain yield and straw yield was also significantly influenced by this sulphur level. Similar result was found by Chaudhary *et al.* (2003) [5]; Jasim (2011) [8]; Sidudinis and Lazauskas (2012) [18].
Efficient input management along with varietal improvement is the basic aspects that can help in achieving the sufficient production but also enhances the water productivity; it must achieve the water economy such that the demand of climate is balanced by the supply, available to it. Since water is very scare and costly input, so it must be used very judiciously by adopting an appropriate technique i.e. IW/CPE ratio or critical stages. Limon *et al.,* (2000) [13] reported that highest water use efficiency (WUE) 11.3 kg/ha mm and Harveer *et al*. (2013) has reported that the application of irrigation water at IW: CPE 1.2 proved to be optimum for exploiting the full production potential of wheat cultivar PBW-343 and also Ashok Kumar *et al*. (1995) [11] was obserbed that the wheat cultivar. HD 2285 with IW: CPE ratio of 1.2 recorded the highest grain yield of 3.65 t/ha.

Material and methods
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 2013-14 and 2014-15. 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. The treatment was carried out with 24 treatment combination formed with four irrigation levels, two varieties and three sulphur levels, in wheat which were allocated in split plot design with three replications. The four irrigation levels (a) I_1; 0.6 IW/CPE ratio (b) I_2; 0.8 IW/CPE ratio (c) I_3; 1.0 IW/CPE ratio and (c) I_4; 1.2 IW/CPE ratio with two varieties namely PBW 343 and PBW 502 and three sulphur levels (a) Control (b) 20 kg/ha (c) 40 kg/ha.

The seed rate used was 100 kg/ha the crop was fertilised with an uniform dose of 60 kg P_2O_5/ha through single super phosphate, 40 kg K_2O/ha through muriate of potash and half dose of the Nitrogen through urea were applied as a basal dose while the remaining nitrogen was applied in two equal split doses at tillering and panicle initiation stages of crop growth. Irrigation was provided as per irrigation scheduling time. From the individual plot the crop of net plot area was harvested. After air d harvesting and seed were cleaned. The final seed weight was recorded in kg per plot and converted in to t/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

The maximum plant height was recorded with 1.2 IW/CPE with PBW 502 at all growth stages of crop, except 30 DAS, which were significantly superior over to 0.6 and 0.8 IW/CPE ratio. This might be due to start of different treatment at 60 DAS. Increase in plant height at higher level of moisture regime has been positive due to maintenance of constant water supply to the plants, which maintained various metabolic processes. It was observed that 1.2 (I4) moisture regimes showed higher plant height. Minimum plant height was recorded under 0.6 (I1) moisture regimes at 60 DAS and at harvest stages due to poor moisture condition during both the years. Significant reduction in plant height due to decrease in moisture availability was also reported by Yadav and Verma (1991) [20], Bandyopadhyay (1997) [2], Rehman *et al*. (2000) [17] and Saren *et al*. (2004).

Among the different moisture regimes, I4 recorded significantly higher dry matter production over I1, and I2, at 30, 60, 90 and 120 DAS was at par with I3. At 120 DAS 25.49% and 25.30% dry matter increase was recorded in I4 over I1 during the year 2013-14 and 2014-15, respectively.

Varieties differences in plant height and dry matter accumulation (m^{-2}) index were recorded significantly with variety PBW 502 at all the growth stage of crops while differences at 30 DAS were recorded non-significant. Variety PBW 502 recorded highest plant height at harvest which was 7.02 and 8.4% higher as compared to the variety PBW 343 and significantly higher dry matter accumulation at every stages of crop growth as compared to PBW 343. At harvest highest, dry matter production found in PBW 502 was 5.91% and 6.17% higher as compared to the PBW 343 during the year 2013-14 and 2014-15, respectively.

The plant height increased with increasing age of crop and it attained its maximum value at harvest stage. At all the stages of crop growth, plant height was significantly higher in case of S_2 (20 kg/ha) sulphur application with PBW 502 at all growth stages of crop, except 30 days after sowing, The maximum plant height and dry matter accumulationwas recorded higher with 20 kg sulphur /ha, highest dry matter production was registered with 20kg sulphur and it recorded increase by 16.44and 16.57% over control (0 kg) during the year 2013-14 and 2014-15, respectively which was showed significant difference over control during both the year of study. Increase in growth with sulphur fertilization was recorded by Fazal and Sisodia (1989) [7]; Liu *et al.* (2002) [14].

Effect on Yield

Yield attributes which determined yield, is the resultant of the vegetative development of the plant. All the attributes of yield viz., effective tillers, number of grains per spike, and 1000-grain weight (g) were influenced significantly due to different moisture regime. Those were recorded maximum under 1.2 IW/CPE ratio followed by 1.0 IW/CPE. Owing to favourable vegetative growth and development because it received adequate moisture during entire period of growth. Under adequate moisture, the plant height, leaf area index were highest which contributed to highest yield attributes thereby increasing photosynthetic activity of leaves. Besides increased translocation of photosynthates from source to sink under wettest condition through higher uptake of potassium led more yield attributes. Minimum yield attributes were recorded with 0.6 IW/CPE ratio, because plant were unable to extract more water and nutrients under moisture deficit condition which resulted in poor growth and yield attributes during both the years of study. This result is close proximity to those obtained by Khola *et al*. (1989) [10]; Dubey and Sharma (1996) [6]; Bandyopadhyay (1997) [2]; Khatri *et al*. (2001) [9].

Yield is the result of coordinated inter play of growth characters and yield attributes. Grain and straw yield were significantly influenced by the different moisture regimes. Highest grain yield was recorded under moisture regime of 1.2 IW/CPE ratios. This might be due to adequate moisture availability, which contributed to better growth parameters and yield attributes. Productivity of crop collectively determined by vigor of the vegetative growth and yield attributes. Better vegetative growth coupled with higher yield attributes resulted in higher grain and straw yields. Lowest grain yield was recorded under 0.6 IW/CPE due to poor moisture supply during the period of growth. Poor moisture supply during the critical stages reduced the yield attributes and resulted in poor grain and straw yields during 2013-14 and 2014-15. The similar results were reported by Khola *et al*. (1989) [10], Parihar and Tripathi (1990); Patel and Upadhyay (1973); Kumar *et al*. (1994) [12]; Kumar *et al*. (1995) [11]; bandyopadhyay (1997) [2], Khatri *et al*. (2001) [9], Behara *et al* (2002).

Among the cultivars of wheat included in experiment, PBW 502 has been found more promising in comparison to PBW 343 to provide higher yield attributes as well as yield during both of years. PBW 502 recorded significantly higher no of effective tillers m-2 (278 and 283) as compared to PBW 343 (262 and 266), which was as maximum grain yield was recorded with variety PBW 502 (4.72 and 4.80 t/ha). The variation in growth development and yield might also be probably due to their characteristics. Variation in plant growth, development and yield of among varieties might also be probably due to their genetic characters. Similar finding in respect to varieties reported by Brijkishor (1998) [4].

Application of sulphur increased leaf area, tillering and ear number/plant and other yield attributes. The greater dry matter accumulation, number of ear, ear length, number of grains per

ear and 1000 seed weight (yield attributes) were recorded significantly higher with 20 kg S/ha application over the control during both the years. Grain yield and straw yield were also significantly influenced by sulphur levels. Similar results were found by Chaudhary *et al*. (2003) [5]; Jasim (2011) [8]; Siaudinis and Lazauskas (2012) [18].

Effect on Economics

The economics of wheat crop showed that the variety PBW 502 fetched the maximum net return (Rs. 71197 and 73566/ha) with I3 x 40 kg/ha sulphur but B: C ratio was the highest (2.65 and 2.47) under I3 irrigation level (1.0 IW/CPE) with application of sulphur, 20 kg/ha during the year 2013-14 and 2014-15, respectively. The minimum benefit cost ratio (1.57 in 2013-14 and 1.48 in 2014-15) was obtained with variety, PBW 343 under I1 irrigation level (0.6IW/CPE) with sulphur application of 40 kg ha^{-1}. It was due to lowest net returns under this treatment combination. Maximum cost of cultivation was recorded with the moisture regime of 1.2 IW/CPE + S3 40 kg S ha^{-1} with variety PBW 343, while minimum (Rs. 22543 and 24900 ha^{-1}) under treatment combination of 0.6 IW/CPE + control with PBW 343 during both the year of study. Maximum gross return (Rs 98022 and 104495ha^{-1}) was recorded under the treatment combination of 1.2 IW/CPE + PBW 502 with 40 kg S ha^{-1} application. The cost of cultivation was maximum due to more number of irrigation, difference in cost of variety and higher dose of sulphur. Gross return was more due to higher production of grain yield and straw (Roy and Pardhan, 1994).

Highest net return were obtained under 1.0 IW/ CPE ratio+ PBW 502 with 40 kg S and highest B:C (2.65 and 2.47) during both the year of study were recorded under the treatment combination of 1.0 IW/CPE ratio + PBW 502 with 20 kg S ha-1 application. This was due to low cost of irrigation, higher yield and low fertilizer application (Yadav and Verma, 1991) [20].

Table 1: Effect of sulphur nutrient and moisture regimes on growth, yield attributes and yield of wheat varieties

Treatments	Plant height (cm)						Dry matter accumulation (g/m2)						Effective tillers (m^{-2})		Test weight (g)		Grain yield (t/ha)		Straw yield	
	60 DAS		90 DAS		At harvest		60 DAS		90 DAS		120DAS									
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regimes (IW/CPE Ratio)																				
0.6	45.92	46.69	76.36	77.64	73.58	74.82	296.07	301.05	331.78	337.37	592.13	602.10	224.80	228.59	34.46	34.37	3.81	3.87	5.79	5.89
0.8	48.08	48.91	79.94	81.33	77.04	78.38	347.59	353.64	348.90	354.92	695.19	707.28	263.93	268.52	36.69	36.59	4.47	4.55	6.81	6.93
1.0	50.49	51.32	83.96	85.34	80.92	82.24	383.58	389.87	370.11	376.16	767.16	779.74	291.25	296.02	38.93	38.77	4.93	5.02	7.50	7.62
1.2	52.51	53.27	87.32	90.85	84.15	87.56	397.36	403.07	389.73	395.33	794.72	806.13	301.71	306.05	40.84	40.89	5.11	5.19	7.72	7.83
SEm±	0.77	0.79	1.21	1.97	1.17	1.90	5.05	6.23	5.31	6.39	10.10	12.47	3.83	5.26	0.80	0.75	0.65	0.89	0.65	1.01
CD at 5%	2.68	2.72	4.18	6.81	4.03	6.56	17.47	21.57	18.38	22.10	34.94	43.13	13.27	18.19	2.76	2.59	2.25	3.08	2.26	3.49
Variety																				
PBW-343	47.46	48.16	78.92	80.08	76.05	77.17	345.30	350.38	352.50	357.70	690.59	700.76	262.18	266.04	37.17	37.09	4.44	4.51	6.71	6.81
PBW-502	51.04	51.94	84.88	87.50	81.80	84.32	367.00	373.43	367.76	374.19	734.00	746.87	278.66	283.55	38.30	38.22	4.42	4.80	7.19	7.32
SEm±	0.92	0.94	1.19	1.27	1.14	1.23	5.12	5.52	5.22	5.61	10.23	11.03	3.88	4.66	0.57	0.65	0.66	0.79	0.73	1.02
CD at 5%	3.01	3.05	3.86	4.15	3.72	4.00	16.68	17.98	N.S	N.S	33.36	35.97	12.67	15.19	N.S	N.S	2.15	2.58	2.38	3.33
Sulphur level kg/ha																				
0	47.17	47.90	78.43	79.66	75.59	76.77	312.55	317.42	351.84	357.33	625.09	634.83	237.31	241.01	35.98	35.88	40.24	40.87	60.96	61.91
20	50.63	51.51	84.19	87.35	81.13	84.18	374.05	380.50	361.67	367.92	748.09	761.01	289.94	294.45	38.82	38.92	49.17	49.93	74.42	75.58
40	49.96	50.73	83.07	84.36	80.05	81.30	381.86	387.80	366.88	372.58	763.71	775.60	284.01	288.91	38.40	38.16	48.16	48.99	73.38	74.64
S.Em±	0.84	0.86	1.07	1.86	1.03	1.79	4.62	5.78	4.66	5.68	9.24	11.57	3.51	4.56	0.92	0.63	0.59	0.77	0.63	0.92
CD at 5%	2.43	2.47	3.07	5.36	2.96	5.17	13.30	16.66	N.S	N.S	26.60	33.31	10.10	13.13	2.66	1.83	1.71	2.23	1.81	2.65

Table 2: Effect of sulphur nutrient and moisture regimes on economics of wheat varieties

S. No.	Treatment combination	Total cost (ha^{-1})		Gross return (ha^{-1})		Net return (ha^{-1})		B:C (Re^{-1} Invested)	
		2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
1	$I_1 V_1 S_1$	22543	24900	62965	66578	40421	41678	1.79	1.67
2	$I_1 V_1 S_2$	24343	26800	66853	70704	42510	43904	1.75	1.64
3	$I_1 V_1 S_3$	26143	28700	67274	71118	41130	42418	1.57	1.48
4	$I_1 V_2 S_1$	22543	24900	66053	69890	43509	44990	1.93	1.81
5	$I_1 V_2 S_2$	24343	26800	71885	76148	47541	49348	1.95	1.84
6	$I_1 V_2 S_3$	26143	28700	72631	76748	46487	48048	1.78	1.67
7	$I_2 V_1 S_1$	23243	25802	67324	71084	44080	45282	1.90	1.76
8	$I_2 V_1 S_2$	25043	27702	79219	83905	54175	56203	2.16	2.03
9	$I_2 V_1 S_3$	26843	29602	79754	84112	52910	54510	1.97	1.84
10	$I_2 V_2 S_1$	23243	25802	69873	73889	46629	48087	2.01	1.86
11	$I_2 V_2 S_2$	25043	27702	88807	94155	63763	66453	2.55	2.40
12	$I_2 V_2 S_3$	26843	29602	93798	99419	66955	69817	2.49	2.36
13	$I_3 V_1 S_1$	24643	27606	71135	75234	46491	47628	1.89	1.73
14	$I_3 V_1 S_2$	26443	29506	92182	97491	65738	67985	2.49	2.30
15	$I_3 V_1 S_3$	28243	31406	93932	99228	65688	67822	2.33	2.16
16	$I_3 V_2 S_1$	24643	27606	74720	78943	50076	51337	2.03	1.86
17	$I_3 V_2 S_2$	26443	29506	96616	102476	70172	72970	2.65	2.47
18	$I_3 V_2 S_3$	28243	31406	99441	104972	71197	73566	2.52	2.34
19	$I_4 V_1 S_1$	26043	29410	78522	82768	52479	53358	2.02	1.81
20	$I_4 V_1 S_2$	27843	31310	94894	100044	67050	68734	2.41	2.20
21	$I_4 V_1 S_3$	29643	33210	95477	100758	65833	67548	2.22	2.03
22	$I_4 V_2 S_1$	26043	29410	82735	87541	56691	58131	2.18	1.98
23	$I_4 V_2 S_2$	27843	31310	96622	101965	68779	70655	2.47	2.26
24	$I_4 V_2 S_3$	29643	33210	98022	104495	68378	71285	2.31	2.15

Conclusions

Thus, it can be concluded that an appropriate sulphur dose of wheat crop was found to be 20 kg S/ha in 1.0 IW/CPE ratio + PBW-502 treatment combination. The 1.0 IW/CPE ratio was the most suitable moisture regimes for higher productivity of wheat the variety PBW 502 is most suitable for higher productivity of different varieties of wheat. Sowing of wheat crop with 1.0 IW/CPE ratio with the variety PBW 502 may be most economical. An appropriate sulphur dose of wheat crop was found to be 20 kg S/ha. The uptake of NPK and S by wheat crop was found to be higher in 1.0 IW/CPE ratio + PBW-502 with 20 kg S/ha treatment combination. 5.The highest net return of Rs. 71197 and 73566 was computed under treatment combination of I3 + PBW-502 with 20 kg S/ha.

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