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The effect of sowing methods, irrigation scheduling and agrochemicals on growth and yield parameters of wheat under late sown conditions

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Abstract
A field experiment was conducted during *rabi* season of 2017-18 and 2018-19 at the Rajasthan College of Agriculture, Maharana Pratap University of Agricultural & Technology, Udaipur. The aim of this study was to compare line sowing of wheat to Furrow Irrigated Raised Bed (FIRB) and System of Wheat Intensification (SWI) sowing methods in combination of irrigation scheduling and agrochemical applications for growth and yield parameters. The result disclose that sowing methods had notable impact on growth and yield parameters. Higher plant height was recorded with line sowing with 1.0 IW/CPE ratio 1.0 and hydrogel 10 kg ha^{-1} + salicylic acid 200 ppm. Higher flag leaf area was recorded under SWI sowing whereas, maximum total tillers was recorded under line sowing with higher level of irrigation and agrochemical application. The higher grain yield was recorded through FIRB sowing (4682 kg ha^{-1}) followed by line sowing (4421 kg ha^{-1}) and SWI sowing (3929 kg ha^{-1}). Straw yield was recorded notably higher grain yield with line sowing (6961 kg ha^{-1}) over SWI sowing (5573 kg ha^{-1}) and found at par with FIRB sowing (6916 kg ha^{-1}). SWI sowing recorded superior harvest index (41.3%) than line (38.8%) and FIRB sowing (40.3%). It may be assume that FIRB sowing is appropriate method for wheat in late sown conditions for getting higher yield. Irrigation scheduling at IW/CPE ratio 1.0 recorded superior yield and yield components compared to IW/CPE ratio 0.75. Application of hydrogel 10 kg ha^{-1} + salicylic acid 200 ppm observed notable dominant values of grain, straw and biological yield over others and found at par with salicylic acid 200 ppm.

Keywords: Sowing methods, irrigation scheduling, agrochemicals, hydrogel and salicylic acid

Introduction
Wheat is one of the world's three most dominant cereal crops (and it has the extensive dispersal of any cereal. As a contrast to rice, wheat is cultivated in all the countries of the world. Global production of the wheat is, next only to maize and considered as paramount food of the people and feed for animals throughout the world. The highest average productivity of wheat is obtained by UK (7.9 tonnes/ha), followed by 7.8 tonnes in Germany and 7.5 tonnes/ha in France. In India, it was grown on an area of 29.9 M ha, with a production of 107 million metric tons with an average productivity of 3430 kg ha^{-1} (Government of India. 2019-20) [5].

Sowing methods has a notable influence on water, N and P absorption, energy savings and soil compaction (Trodson *et al.* 1989) [15]. Absorption of photo synthetically active radiations has also been observed to be affected by sowing methodsn (Lal *et al.* 1991) [9] and have impact on crop growth and expansion. Foregoing studies indicates that various sowing methods have different response undergoing various experiment conditions. Hassan and Hassan (1994) [6] have divulge that wheat sowing in furrows offer superior grain, straw and biological yield. Fahong *et al.* (2004) [4] reported that bed-planting lodging and some disease incidences, while increased growth and yield parameters of wheat crop. At the same time, in a study at the same region, Özberk *et al.* (2009) [11] stated that planting methods plays a significant role in yield. In India, wheat is sown through broadcasting on a vast area in intensive cropping systems. Broadcasting sowing system not only needed more seed rate but also evaluated with poor yields. Thus assessment of better sowing methods is crucial for succeeding directions. Water is an invaluable input which plays crucial part in assertive production since it is necessary to conserve it through appropriate way of irrigation to maintain high turgidity, nutrient absorption and metabolic process of the plant. High-rise temperature stress is considered as main factor for looming or yield loss for agricultural crops.

The late sowing after 20th November increased temperature reasoned for hastening of flowering and maturity in wheat crop by 30 days in late sowing as compared to normal sowing circumstances. Karim *et al.* (2011) [8] stated that the high application of salicylic acid improve in plant height, number of tillers and shoot dry weight in wheat. Thus present study was regulated to assess the efficacy of various sowing methods, irrigation scheduling and agrochemical application on yield components and yield of wheat of wheat.

Material and Methods

The present field experiment was conducted during *rabi* 2017-18 and 2018-19 seasons at the experimental farm (Agronomy) of Rajasthan College of Agriculture, Maharana Pratap University of Agricultural Technology, Udaipur to estimate the outcome of various sowing methods, irrigation scheduling and agrochemical application on grain yield components and grain yield of wheat. The area is situated at 24˚35' N Latitude, 73˚42' E Longitude with an altitude of 582 m above mean sea level. The area receives 700-900 mm rainfall.

The investigation was carried out split plot design with three replications, using plot size of 5.4 x 4.6 m. All approved agronomic operation were equivalently put in to all of the experimental units. Fertilizer amount of NPK at the rate of 90-35-00 Kg ha^{-1} was put in to all the experiment plots. Wheat variety Raj-4238 was tested, at the rate of 125 kg ha^{-1} seed rate for line, 84 kg ha^{-1} for FIRB and 20 kg ha^{-1} for SWI sowing using following sowing methods, irrigation scheduling and agrochemicals application for assessment.

(A)	Sowing Methods
1.	Conventional (Line sowing) at 20 cm
2.	Furrow Irrigated Raised Bed (FIRB) raised beds (60 cm) altering with furrows (30 cm) prepared and 3 rows of wheat were planted on the bed.
3.	System of wheat intensification (SWI) at Row x Row 20 cm, Plant x Plant 20 cm with 2 seeds $hill^{-1}$
(B)	**Irrigation scheduling (IW/CPE) ratio)**
1.	1.0
2.	0.75
(C)	**Agro-chemicals**
1.	Water spray
2.	Hydrogel 10 kg ha^{-1}
3.	Salicylic acid 200 ppm
4.	Hydrogel 10 kg ha^{-1} + Salicylic acid 200ppm

Note: Hydrogel is non-carcinogenic.
*Hydrogel soil application done at the time of sowing or before irrigation
*Foliar spray of salicylic acid done at 55 and 75 DAS

Results and Discussion

Effect of sowing methods

It is evident (Table 1) that sowing methods significantly influenced growth parameters in wheat crop *viz.*, plant height, flag leaf area and total tillers. Data shows that FIRB and line sowing recorded significantly higher plant height over SWI sowing by 6.7 and 5.1 percent. Higher plant height in FIRB sowing may be due higher growth of individual plant due to less competition. Superior flag leaf area was recorded with SWI sowing over line and FIRB sowing by 12.3 and 4.1 percent at 75 DAS and 9.3 and 2.8 percent, respectively. Further, FIRB sowing also recorded higher flag leaf area over line sowing by 7.9 and 6.3 percent, respectively. Further maximum number of total tillers was recorded superior with line sowing over FIRB and SWI sowing by 4.2 and 28.9 percent, respectively. FIRB sowing also recorded higher number of tillers over SWI sowing by 23.7 percent. This result is supported by the study of Tripathi *et al.* (2002) [14], Alam *et al.* (2007) [1] and Özberk *et al.* (2009) [11].

Data (Table 2) indicates that the maximum grain yield of 4682 kg ha^{-1} was obtained with FIRB sowing which was significantly superior over line sowing (4421 kg ha^{-1}) and SWI (3929 kg ha^{-1}) by 5.0 and 19.1 per cent, respectively. Further, line sowing also gave significantly higher grain yield over SWI by 12.5 per cent. Data revealed that line (6961 kg ha^{-1}) and FIRB (6916 kg ha^{-1}) sowing reported significantly increased straw yield over SWI sowing by 24.9 and 24.1 per cent, respectively. Finding of experiment indicate that FIRB (11598 kg ha^{-1}) and line (11381 kg ha^{-1}) sowing described notable higher biological yield over SWI by 22.1 and 19.78 per cent, respectively. Facts indicates that SWI (41.3%) sowing reported significantly higher harvest index over line and FIRB sowing by 6.5 and 2.5 per cent, respectively, whereas, FIRB sowing also found with same trend over line sowing by 3.9 per cent. Hossain (2006) [7] reported that superior grain yield of wheat crop with FIRB sowing was due to improvement in yield components. They further described that increase in these yield components were due to greater and efficient utilization of, moisture, solar radiation and nutrients available into soil solution. These results are in agreement with Hossain *et al.*, (2006) [7], Alam *et al.* (2007) [1] and Özberk *et al.* (2009) [11].

Table 1: Effect of sowing methods, irrigation scheduling and agrochemicals on growth parameters of wheat under late sown conditions

Treatments	Plant height (cm)	Flag leaf area (cm^2) 75 DAS	Flag leaf area (cm^2) 90 DAS	Total tillers
Sowing methods				
Line	84.5	29.3	36.7	157.2
FIRB	85.8	31.6	39.0	150.9
SWI	80.4	32.9	40.1	122.0
S.Em+	0.77	0.31	0.33	1.11
CD at 5%	2.26	0.91	0.98	3.26
Irrigation schedules				

1.0 IW/CPE	85.3	32.2	40.0	148.5
0.75 IW/CPE	81.8	30.3	37.2	138.2
S.Em+	0.63	0.25	0.27	0.90
CD at 5%	1.84	0.74	0.80	2.66
Agro-chemicals				
Water spray	81.5	28.3	36.3	140.0
Hydrogel 10 kg/ha	82.8	30.1	37.9	142.2
Salicylic Acid 200 ppm	84.3	32.5	39.4	144.1
Hydrogel 10 kg/ha + Salicylic Acid 200 ppm	85.6	34.1	40.7	147.1
S.Em+	0.87	0.34	0.38	1.26
CD at 5%	2.43	0.94	1.06	3.52

Table 2: Effect of sowing methods, irrigation scheduling and agrochemicals on yield attributes and yield under late sown wheat

Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index
Sowing methods				
Line	4421	6961	11381	38.78
FIRB	4682	6916	11598	40.32
SWI	3930	5573	9502	41.31
S.Em+	53.9	76.9	63.3	0.11
CD at 5%	159.1	226.7	186.7	0.34
Irrigation schedules				
1.0 IW/CPE	4578	6693	11271	40.67
0.75 IW/CPE	4110	6274	10384	39.60
S.Em+	44.0	62.8	51.7	0.09
CD at 5%	129.9	185.1	152.4	0.28
Agro-chemicals				
Water spray	4144	6269	10414	39.81
Hydrogel 10 kg/ha	4306	6439	10745	40.11
Salicylic Acid 200 ppm	4395	6527	10922	40.26
Hydrogel 10 kg/ha + Salicylic Acid 200 ppm	4530	6698	11228	40.36
S.Em+	47.2	74.5	118.0	0.13
CD at 5%	132.2	208.7	330.4	0.35

Effect of Irrigation scheduling (IW/CPE ratio)

Data stipulate that irrigation at IW/CPE ratio 1.0 communicate significantly superior plant height, flag leaf area at 75 and 90 DAS and total tillers by 4.3, 6.3, 7.5 and 7.5 percent over IW/CPE ratio 0.75, respectively. Irrigation at IW/CPE ratio 1.0 appear remarkable elevated grain, straw, biological yield and harvest index over IW/CPE ratio 0.75 by 11.4, 6.7, 10.0 and 2.7 per cent, respectively. The superior growth and yield parameters with higher level of irrigation may be due to ambient environment for root and shoot growth and higher availability of soluble nutrients to the plants and sufficient moisture available to the crop in the soil throughout growing period specifically at critical stages of crop. Therefore, it is confirmed that IW/CPE ratio at 1.0 maintained enough soil moisture at growth stages of wheat to maintain the physiological, structural and metabolic requirements of wheat apart from meeting out the required evapo-transpiration demand. These results are in great concurrence with Rehman *et al.* (2000) and Saren *et al.* (2004) [12, 13]. It is well established that any condition of water stress to plants is normally linked with lower growth and yield performance (Mukharjee and Ghosh, 2006) [10].

Effect of agrochemical application

An analysis of data revealed that hydrogel 10 kg/ha + salicylic acid 200 ppm reported remarkably superior number of plant height, flag leaf area at 75 and 90 DAS and total tillers over water spray by 5.0, 20.5, 12.1 and 5.1 percent over hydrogel 10 kg/ha by 3.4, 13.3, 7.4 and 3.5 percent, respectively. Application of salicylic acid 200 ppm also recorded higher growth parameters over water spray *viz.*, plant height, flag leaf area and total tillers. This may due to the reality that hydrogel hold on to high soil moisture result in better soil moisture conditions, minimize the leaching mislaying of nutrients thus, provides the suitable soil environment which increase the crop growth parameters effective tillers, grains ear^{-1} and weight of grains ear^{-1} (Dar and Ram (2017) [3]. These results are in accordance of Karim *et al.*, (2011) [8].

Data shows that hydrogel 10 kg/ha + salicylic acid 200 ppm announced notable higher grain yield over water spray, hydrogel 10 kg/ha and salicylic acid 200 ppm by 9.3, 5.2 and 3.1 per cent, respectively. Further, salicylic acid 200 ppm and hydrogel 10 kg/ha gave significantly higher grain yield over water spray by 6.1 and 3.9 percent, respectively. Data divulge that hydrogel 10 kg/ha + salicylic acid 200 ppm (6698 kg ha^{-1}) was found notable towering straw yield over water and hydrogel 10 kg/ha by 6.8 and 4.0 per cent, respectively. Data indicates that hydrogel 10 kg/ha + salicylic acid 200 ppm was reported superior biological yield over water spray and hydrogel 10 kg/ha by 7.82 and 4.50 per cent, respectively and found at par with salicylic acid 200 ppm which was also found significantly superior over water spray by 4.88 per cent. Data indicates that hydrogel 10 kg/ha + salicylic acid 200 ppm and salicylic acid 200 ppm was outlined giant harvest index by 1.38 and 1.16 per cent, respectively. This could be due to providing sufficient moisture to plants for photosynthesis and respiration activities and might be due to due to higher moisture availability with hydrogel supplication. These results are in harmony of Karim *et al.*, (2011) [8], Chouhan *et al.* (2017) [2] and Dar and Ram (2017) [3].

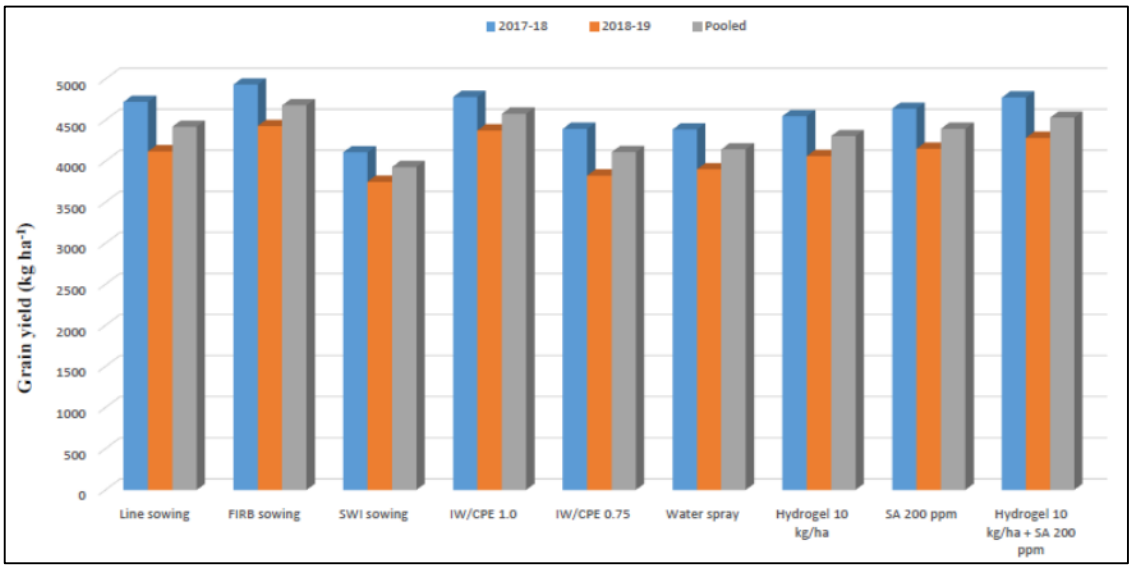

Fig 1: Effect of sowing methods, irrigation schedules and agrochemical application on grain yield of wheat

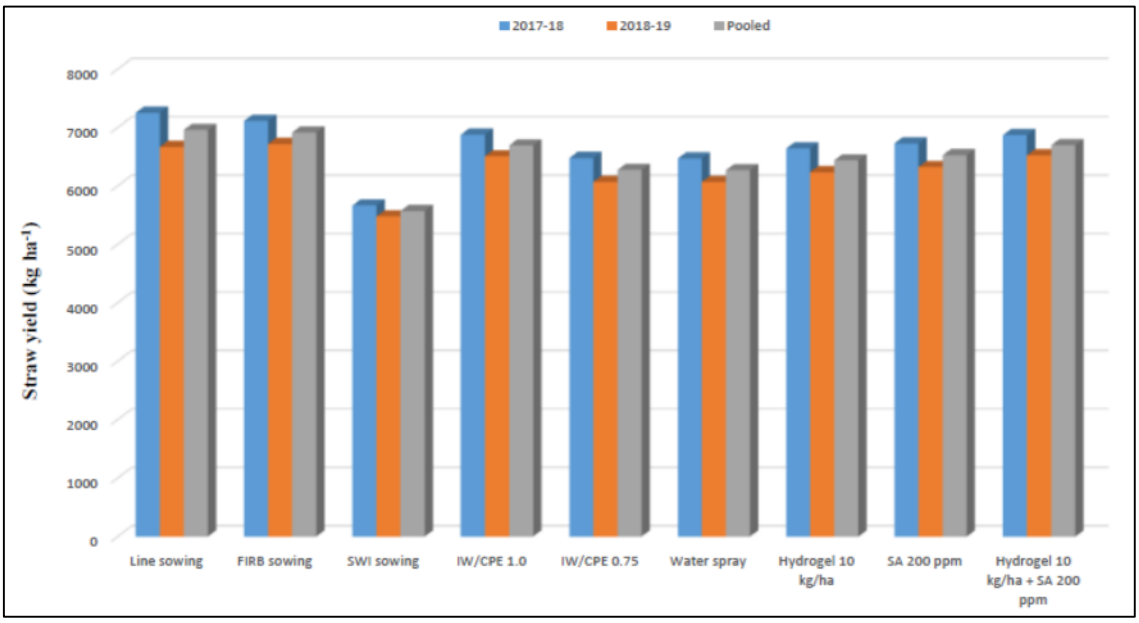

Fig 2: Effect of sowing methods, irrigation schedules and agrochemical application on straw yield of wheat

Conclusion

The current research indicates that improved sowing methods, appropriate irrigation scheduling (IW/CPE ratio) and agrochemical application give superior outcome compared to the traditional sowing methods, faulty irrigation practices and chemical spray to wheat crop. Consequently, FIRB and line sowing is advised for obtaining superior grain yields with maintain soil health and quality under resource sufficient conditions, whereas under limited resource and late sown conditions FIRB sowing with deficit irrigation and agrochemical spray is recommended.

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