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ENHANCING GRAIN AND FODDER PRODUCTIVITY OF WHEAT WITH POLYMERS UNDER DIFFERENT IRRIGATION LEVELS

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SUMMARY

Wheat is the second most dominant food grain crop in India and third most important cereal fodder crop. It also has a high scope for sustainable improvement in fodder production with management of deficit irrigation in semi-arid areas by the use of polymers which may be natural or synthetic depending on the source. Hydrogels are also known as super absorbent polymers and are used in agriculture for more than forty years. Gond katira is a natural one and is also known as herbal hydrogel or "*Tragacanth katira*". It is obtained from the gum of the shrubs of *Astragalus gummifer* or *Astragalum microcephalus* type plants. It contains a 60-70 percent water swellable fraction named bassorin or tragacanth acid along with tragacanthin which is a water soluble fraction. Synthetic hydrogels are quite popular in the market and have more absorbing capacity compared to natural hydrogels and can work for about five years in the soil. Thus, hydrogel application in areas with deficit irrigation shows a wide scope for grain and straw yield improvement. The present study was planned to study the performance of polymers under various irrigation regimes in improving the growth of fodder wheat.

Key words: Wheat, straw yield, Gond katira, hydrogel, SPAD and irrigation

India is an agriculture-based country having the highest livestock population (520 million herds) in the world which is nearly about 15 percent of the world's livestock. In milk production also, India holds first rank by producing 22 percent of worldwide milk production (Singh, 2020). The area under fodder crops in India is still only two percent of the world's geographical area under fodder crops (Shah et al., 2011a), which is quite very low looking the fodder demands. Presently, India is facing a net deficit of 35.6 percent green fodder, 10.9 percent dry crop residues, and 44 percent feed (Vision, 2013). This fodder deficit can be reduced in two ways: either by increasing area under fodder crops or improving productivity of fodder and forage crops. Since, the maximum area of cultivated land is under rice and wheat cultivation, which are the major food crops, it is not possible to accommodate forage crops by risking the food security of the country. So, the only option left with us is to enhance the forage and fodder yield by sustainable management practices without harming the environment as well as health of livestock. Wheat is grown in such a large area in our country, also it has a high potential to produce more grain yield along with considerable fodder production. Wheat is ranked third among cereals used for cattle feeding (FAO, 2011). Many parts of wheat such as wheat grain, bran, forage, and straw are used for cattle feeding. Wheat fodder can be fed directly to animals without fermentation or after farming and nutrient enriching. Wheat fodder is highly nutritious containing about 4.2 percent crude protein, 41.5 percent crude fibre of the dry matter, 4.8 (g/kg DM) calcium, 0.7 (g/kg DM) phosphorus, and 11.2 (g/kg DM) potassium with 45.2 per cent energy digestibility, ruminants. Climate change has altered the rainfall distribution in India over time and space along with increased temperature. Increased intensity of rainfall and long dry spells between two rains severely affects the productivity of crops. However, wheat is mainly grown in irrigated areas but salinity and heavy metal-contaminated groundwater make the farmer dependent on the canal water for irrigation purpose. Timely availability of the water became then crucial and slight water stress along with heat stress could severely hamper the wheat productivity. In this context, hydrogels present a very wide scope for mitigating moisture stress and improving water productivity. Hydrogels can be synthetic polymers such as Pusa hydrogel and natural like *Tragacanth katira* (herbal hydrogel). Hydrogels are hydrophilic cross-linked polymers and are capable of holding about 400 times water of its weight by hydrogen bonding (Kalhapure *et al*., 2016). Hydrogel application @ 5 kg ha^{-1} improved grain yield, straw yield, and water use efficiency in wheat grown in sandy loam soil. Many findings suggested the beneficial effect of hydrogels on crop growth and soil properties (Roy *et al*., 2019). Lather *et al.* (2015) in a study conducted at CCS HAU, Hisar reported the yield improvement in wheat yield with the use of herbal hydrogel (gond-katira) @ 100 g kg^{-1} seed by hydro-priming cum seed pelleting techniques when irrigation at critical CRI (crown root initiation) stage *i.e*., 21 DAS (days after sowing) was delayed to 35 and 45 DAS compared to their respective controls when no hydrogel was applied and irrigation was delayed. Keeping the facts stated above in mind, the present study was planned to study the effect of polymers under different irrigation levels on growth and grain and fodder yield of wheat crop.

MATERIALS AND METHODS

The research was conducted in *Rabi*, 2018-19 at CCS Haryana Agricultural University, Hisar located at 29°10' N latitude and 75°46' E longitude and has an elevation of 215.2 m above mean sea level. It is situated in semi-arid and subtropical monsoonal climatic tracts. The location experiences dryness, extreme temperature, and scanty rainfall and cool winters. The soils are very deep and sandy loam in texture and contain some amount of calcium carbonate in their profile. The weather data observed over the crop season as depicted in Fig. 1 was collected from the meteorological observatory of CCS HAU, Hisar. The investigation was carried out on the WH-1105 variety of wheat sown on November 5, 2018, and harvested on April 20, 2019. The experiment was laid out in a split-plot design with four irrigation levels in the main plot and three polymer treatments in the subplot and replicated thrice owing to a total of thirty-six plots. The main plot treatments were no irrigation (I_1), one irrigation at CRI (I_2), two irrigation at CRI and booting (I_3), and three irrigation at CRI, booting and milking stage (I_3). The polymer treatments of the subplot include control (P_1), gond-katira @ 5 kg $ha^{-1,}$ and Pusa hydrogel @ 2.5 kg ha^{-1}. The experimental soil had the following properties sampled and analyzed before sowing- pH 7.8, electrical conductivity 0.25 (dS/m), organic carbon 0.50 percent, available nitrogen 182 (kg/ha), available phosphorus 17 (kg/ha) and available potassium 265 (kg/ha). Nitrogen (Nessler's reagent method, Lindner, 1944), phosphorus (Vanadomolybdo-phosphoric acid yellow color method, Jackson, 1973), and potassium (Flame photometer method, Richards, 1954) were analyzed using these methods given in parenthesis. The crop was grown with a recommended package of practice by CCS HAU for wheat. Di-ammonium phosphate was line sown before sowing to fulfill nitrogen and phosphorus requirements. The remaining half dose of nitrogen was top dressed with Urea at first irrigation. Potassium was given through muriate of potash. Plant height was recorded at 30 DAS and harvest with a meter rod from the base of the plant to the highest tip. A number of tillers were recorded at 30 DAS and then effective tillers at harvest to observe the mortality and sterility in plants. Chlorophyll content was recorded using a SPAD chlorophyll meter at the anthesis stage. Plants were sun-dried after harvest and biological yield was recorded before threshing. Grain yield was recorded after sun-drying grains until 14 percent moisture was attained. Statistical analysis was done using OPSTAT software and the data were analyzed at both 1 and 5 percent level of significance. "F" (variance test) was used to evaluate the significance of different treatment effects. Critical difference (C.D.) was used to evaluate the significant difference between the means of the two treatments, which was worked out by the formula given below:

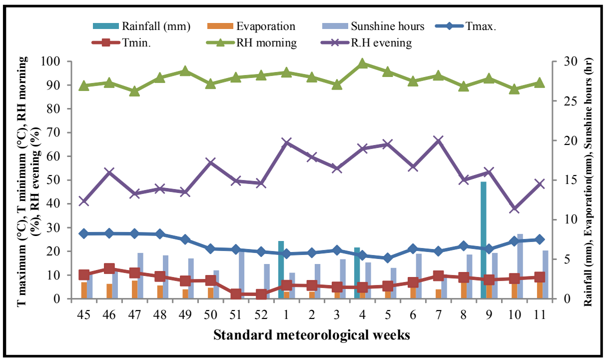

Fig. 1. Weekly meteorological data of crop season.

$$C.D. = (\sqrt{2 \times EMS/n}) \times t \text{ value at } 5\%$$

Where,

C.D. = critical difference
EMS = error mean sum of square
n = number of observations
t = value of t-distribution at a 5 percent level of significance and error degree of freedom.

RESULTS AND DISCUSSIONS

Effect of irrigation levels: A healthy plant with good growth ultimately results in higher biomass production giving high grain as well as biological yield output. Both irrigation levels as well as polymers have shown significant effects on plant height at 30 DAS and at harvest as given in Table 1. At 30 DAS, the treatment having three irrigation was significant over control, while at maturity treatment with two irrigation and three irrigation, both were effective over control improving plant height by 2.52 and 4.03 percent respectively. Increased moisture availability leads to better nutrient use efficiency and improves plant height by increasing cell division and cell elongation rates. The results observed were in close proximity to the findings of Shirazi *et al.* (2014) and Sharma *et al.* (2020). Tillers per meter row length at 30 DAS and at harvest with one irrigation, two irrigation, and three irrigation, all were observed significantly superior over control (no irrigation) as shown in Table 1. An ample amount of moisture at the early vegetative stage helped the plant in high tillering and irrigation at the booting and milking stage avoided mortality as well as resulted in spike formation on the highest number of tillers as depicted by the significantly higher number of tillers with three irrigation compared to one irrigation. The findings were supported by the observations of Islam *et al.* (2018) and Kumar *et al.* (2022). Irrigation levels showed no significant effect on the chlorophyll content in leaves. Barutcular *et al.* (2016) also reported similar results. Grain and biological yield are the direct depiction of plant growth in terms of plant height, dry matter, and effective tillers. Grain yield and biological yield were observed significantly superior with three irrigation compared to control, one irrigation, and two irrigation (Table 1). Three irrigation improved the grain yield by 33.73, 17.11, and 11.89 percent and biological yield by 24.53, 18.49, and 14.46 percent over control, one and two irrigation, respectively. The results were in accordance with Singh *et al.* (2011), Shah *et al.* (2016), Kumar *et al.* (2019), and Yadav *et al.* (2020). The effect of irrigation levels on N, P_2O_5, and K_2O content in soil is given in Fig. 2.

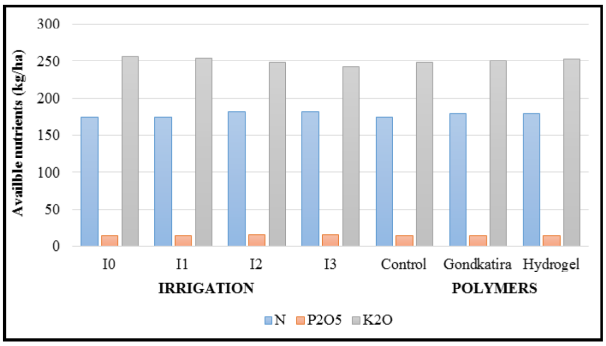

Fig. 2. Effect of irrigation levels and polymers on nutrient content in soil.

Effect of polymers: Both gond-katira, as well as hydrogel, were observed significantly effective in improving plant height and tillers at 30 DAS and at harvest (Table 1). However, a higher increment was observed with hydrogel by its high water-absorbing capacity as compared to the control. Hydrogel and gond katira increased plant height at harvest by 5.31 and 4.49 percent compared to control. The increment in effective tillers with hydrogel and gond katira application was 26.96 and 6.2 percent. Hydrogel also recorded 15.47 percent significantly higher effective tiller than gond katira. The results were observed in line with the findings of Kumar *et al.* (2019), Tyagi *et*

TABLE 1

Effect of irrigation and polymers on plant height, tillers, chlorophyll content, grain, fodder and biological yield

Treatments	Plant height at 30 DAS (cm)	Plant height at harvest (cm)	Tiller/mrl (30 DAS)	Effective tiller/mrl at harvest	SPAD	Grain yield (kg/ha)	Fodder yield (kg/ha)	Biological yield (kg/ha)
Irrigation								
I_0	34.8	99.1	20.04	63.9	44.2	3136	13052	16188
I_1	36.1	100.3	21.19	69.1	42.6	3581	13433	17014
I_2	37.4	101.6	21.56	70.7	44.4	3748	13865	17613
I_3	40.5	103.1	22.2	76.5	46.9	4194	15966	20160
C. D. (P=0.05)	3.0	1.5	0.72	5.1	NS	505	-	1507
Polymers								
Control	34.6	97.8	20.25	62.3	43.6	3563	12582	16145
Gondkatira	37.9	102.2	21.43	68.5	44.1	3604	14265	17869
Hydrogel	39.0	103.0	22.04	79.1	45.9	3827	15391	19218
C. D. (P=0.05)	3.0	0.9	1.06	3.2	NS	260	-	450

al. (2015), and Dar and Ram (2016). Effect of polymers was observed non-significant for the SPAD chlorophyll value. Grain yield was significantly improved by 7.40 percent over control with the application of hydrogel (Table 1). However, no significant effect of gond-katira was observed on the effect of grain yield. Kumar and Singh (2020) reported similar results for gond-katira. The effect was due to increased moisture availability and nutrient uptake along with moisture as a result of water holding and slow release properties of hydrogel (Han *et al*., 2013). Application of hydrogel improved biological yield by 19.03 and 7.54 percent respectively over control and gond katira. The effect of gond katira was also observed significant and increased biological yield by 10.67 percent. The results were observed similar for grain and biological yield for the effect of hydrogel with the findings of Mahla and Wanjari (2017), Meena *et al.* (2020), and Bana *et al*. (2018). The effect of polymers on nutrient content (N, P_2O_5 and K_2O) is given in Fig. 2.

CONCLUSION

From the study, it can be concluded that irrigation at critical stages along with the application of polymers is beneficial in improving the grain as well as fodder production. One can opt for hydrogel or gond katira based on the resources available to them. It can be suggested as a better tool to gain fodder advantage under a prevalent cropping system without compromising the grain production along with increased water use efficiency.

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