Biological Forum – An International Journal **15(7): 106-110(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Influence of Resource Conservation Practices on Economics of Wheat (*Triticum aestivum* L.) under Limited Irrigated Condition

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(Received: 25 April 2023; Revised: 04 May 2023; Accepted: 20 May 2023; Published: 05 July 2023)
(Published by Research Trend)

ABSTRACT: A field experiment was carried out at Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.) during *Rabi* season of 2020-21 and 2021-22 to study the "Influence of moisture conserving polymer and integrated nutrient management on productivity of wheat (*Triticum aestivum* L.) under limited irrigated condition". The experiment comprised of twenty four treatment combinations and conducted in split plot design and replicated three times. Experiment consisted of three irrigation schedules *viz*., One irrigation, Two irrigations, and Three irrigations in main plots, two moisture conservation practices *viz*., Pusa Hydrogel 5 kg ha^{-1} and Paddy straw mulch 5 t ha^{-1} in sub plots and four nutrient management *viz*. 100% RDF, 100% RDF + Azotobacter, 75% RDF + Azotobacter + FYM 5 t ha^{-1} and 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1} were kept in sub-sub plots. On pooled basis of two years experimentation results indicated that significantly higher grain and straw and biological yield were recorded in the three irrigations. Among, the moisture conservation practices significantly higher yield was recorded with the application of Pusa Hydrogel 5 kg ha^{-1} than paddy straw mulch 5 t ha^{-1}. However, in the integrated nutrient management same parameters as above significantly higher were recorded with the integration of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1} which was followed by 75% RDF + Azotobacter + FYM 5 t ha^{-1}. Higher net return and benefit cost (B:C) ratio were recorded in the combination of three irrigations, Pusa hydrogel 5 kg ha^{-1} and 100% RDF + Azotobacter treatments.

Key words: Irrigation, Pusa hydrogel, Mulch, Azotobacter, FYM and Wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a king of cereal crop has major contribution in food security at national and international levels. It rank first in the world among the all cereals in respect of area 222.21 million hectare and production 779.03 million metric tonne during the year 2021-22 (USDA, 2022). Besides staple food for human beings, wheat straw also serves as an important dry matter source of feed for animals (Sarwar *et al.*, 2006). In India it is second important staple food crop after rice. India is the second largest wheat producing country after China. In India total area under wheat is 31.61 million hectares, with the production of 109.59 million tonnes during the year 2020-21 (DES, DAC&FW, 2022). Among the different states of India, Uttar Pradesh ranks first in area and total production of wheat, while Punjab ranks first in productivity. In Uttar Pradesh, wheat area were 9.85 million hectares that is 31.16 % of total wheat growing area of India and 35.50 million tonnes production with the productivity of 3604 kg ha^{-1} during the year of 2020-21 (Agricultural statistics at a glance 2021).

Moisture conservation practices are utmost requirement for increasing water use efficiency. Moisture conservation through mulch helps to mitigate the drought stress, increase water productivity and reduce the soil degradation, resulting in enhancing the productivity of crops. Polymers are also important source of soil moisture conservation in agriculture as hydrogel. Pusa hydrogel is an insoluble, cross-linked three-dimensional hydrogel which absorbs water more than 400 times of its weight and gradually releases it and also improves soil hydro-physical properties such as porosity, aggregate stability and hydraulic conductivity (Dabhi *et al.*, 2013). In this context 'Pusa hydrogel', a novel semi-synthetic super absorbent polymer has shown potential to realize higher crop yield with limited water. A significant improvement in yield and water use efficiency in most of the test crops was reported by application of Pusa hydrogel (Anupama and Parmar 2012).

Integrated nutrient management (INM) is one of the agronomic practices aiming at the usage of the harmonious properties of both sources by making a combination that can be used for decreasing the enormous use of chemical fertilizers and accreting a balance between fertilizer inputs and crop nutrient requirement options. Integrated nutrient management (INM) or integrated plant nutrient supply system (IPNS) is an approach, which adopts plant nutrition to a specific farming system and particular yield targets, the resource base, the available plant nutrient source and socio-economic background (Dudal and Roy 1995). Organic manures, which were perhaps the main sources of plant nutrients in traditional agriculture, receive less emphasis with the advent of high analysis inorganic fertilizers. Among the organic sources of nutrients, FYM (farmyard manure) is the most commonly and easily available source in India. The application of FYM improves the soil's organic matter and physical–chemical and biological properties, resulting in the restoration of soil fertility. Biofertilizers emerged as one of the integral component of integrated nutrient management. These are cost effective, eco-friendly and renewable source of plant nutrition. Azotobacter sp. has been observed to augment plant growth and yield by production of IAA, fixation of atmospheric nitrogen, antibiotic production. Zinc deficiency in humans is directly associated with the minimum uptake of zinc in the plants that are consumed as food by humans. Plants generally require zinc in small quantities. In different soils, it can range from the lowest values of 10 ppm to a maximum of 1000 ppm. Zinc is a major requirement for optimum plant development and maturity because of its role in the formation of structural components and growth hormones.

Keeping this in view, the present field experiment was conducted to find out the "Influence of moisture conserving polymer and integrated nutrient management on productivity of wheat (*Triticum aestivum* L.) under limited irrigated condition".

MATERIALS AND METHODS

The field experiment was carried out during *Rabi* season of 2020-21 and 2021-22 at Students' Instructional Farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.) which is situated in the alluvial tract of Indo-Gangetic plain in central part of Uttar Pradesh between $25^0$26' to $26^0$58' North latitude, $79^0$31' to $31^0$34' East longitude and on the altitude of 125.9 meters. The average annual rainfall of this zone was 850-900 mm of which about 90% of annual rainfall of region is received during later half of June to September with erratic distribution over time and space. The experiment comprised of twenty four treatment combinations and conducted in split-split plot design and replicated three time. Experiment consisted of three irrigation schedules *viz*. one irrigation at CRI stage, two irrigations at CRI and late jointing stage, and three irrigations at CRI, booting and milking stage, in main plots, two moisture conservation practices *viz*. Pusa hydrogel 5 kg ha^{-1} and paddy straw mulch 5 t ha^{-1} in sub plots and four nutrient management *viz*. 100% RDF, 100% RDF + Azotobacter, 75% RDF + Azotobacter + FYM 5 t ha^{-1} and 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1} were kept in sub-sub plots.

The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 7.69, Organic carbon 0.30 per cent, with available nitrogen 185.40 kg ha^{-1}, available phosphorus 15.52 kg ha^{-1}, available potassium was 172.12 kg ha^{-1}.

The field preparation included one deep ploughing and two cross harrowing and planking. The wheat variety K 1317 was sown first December with a recommended seed rate of 100 kg ha^{-1}. The recommended dose of nitrogen, phosphorus, potash and zinc was 120-60-40 and 20 kg ha^{-1} was applied through urea, diammonium phosphate, muriate of potash and zinc sulphate, respectively. However, biofertilizer (Azotobacter) was applied as seed inoculation. During both the seasons 50 per cent of nitrogen and whole quantity of P_2O_5, K_2O and zinc were applied at sowing time, while remaining dose of nitrogen was applied after first irrigation as per treatment. Paddy straw mulch was applied at 20 days after sowing and Pusa hydrogel was applied with seed in furrows at the time of sowing.

The biological yield was recorded after sun drying and expressed as kg ha^{-1}, after threshing of bundles from each plot, grain was cleaned. The grain yield was expressed in kg ha^{-1} and straw yield obtained by subtracting the grain yield from biological yield for individual plots, were expressed as kg ha^{-1}.

The net return was calculated by deducting the total cost of cultivation from gross return and the benefit cost ratio (B:C ratio) was calculated by dividing the net return with the total cost of cultivation of respective treatments.

RESULTS AND DISCUSSION

A. Yield characters

The irrigation schedules had significant influence on yield wheat crop (Table 1). Significantly, higher grain (3816.56 kg ha^{-1}), straw (4493.44 kg ha^{-1}), and biological yield (8310 kg ha^{-1}) were recorded with the application of three irrigations, which were enhanced grain 24.13 and 13.68%, straw yield 25.26 and 14.23% and biological yield 24.74 and 13.98% by over the one and two irrigations, respectively. Whereas, lower grain (2895.50 kg ha^{-1}), straw (3358.38 kg ha^{-1}), and biological yield (6253.88 kg ha^{-1}) were recorded with the application of one irrigation, on pooled basis. The higher yield of crop with three irrigation attributed might be due to adequate soil moisture for metabolic reaction within the plant which improve photosynthates accumulation, resulted better growth and development. Whereas, reduces uptake of nutrient by the soil and moisture stress decrease in translocation of photosynthates resulted in sink size (Rahim *et al*., 2010; Wairagade *et al*., 2020; Kumar and Singh 2020; Tyagi *et al*., 2022).

In moisture conservation practices, significantly higher grain (3383 kg ha^{-1}), straw (3957.46 kg ha^{-1}), and biological yield (7340.46 kg ha^{-1}) were recorded with the application of Pusa hydrogel, which were enhanced grain, straw yield and biological yield 2.80% by over the paddy straw mulch (Table 1). The increases in the growth and yield attributes of the plant under adequate soil moisture and nutrient availability supply by Pusa hydrogel resulted higher yield Roy *et al*. (2019); Kumar and Singh (2020).

Among the integrated nutrient management practices, Significantly, higher grain (3440.83 kg ha^{-1}), straw (4025.17 kg ha^{-1}), and biological yield (7466 kg ha^{-1}) were recorded with the integration of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1}, which were enhanced grain yield by 6.26, 3.89 and 2.09% and straw yield by 6.25, 3.90 and 2.09% and biological yield by 6.25, 3.90 and 2.10% over 100% RDF, 100% RDF + Azotobacter and 75% RDF + Azotobacter + FYM 5 t ha^{-1} treatment, respectively. Whereas, minimum grain (3225.58 kg ha^{-1}), straw (3773.50 kg ha^{-1}), and biological yield (6999.08 kg ha^{-1}) were recorded with the application of 100% RDF, on pooled basis. This might be due to additional of farm yard manure improved the soil health (physical, chemical and biological condition) and supply of essential nutrients during all stages, Azotobacter enhanced growth of the plant by production of auxin hormone and fixation of atmospheric nitrogen in the soil while, zinc play key role in biosynthesis of the indole acetic acid (IAA) phytohormone and initiation of primordia for reproductive parts and a result of favourable influence of Zn on metabolic activities within the plant Keram *et al*. (2012); Lal Bahadur *et al*. (2013); Bhatt *et al*. (2017); Firdous *et al*. (2018).

B. Farm profitability

Among the irrigation schedules, the maximum values for cost of cultivation (₹ 55639.50 ha^{-1}), gross return (₹ 106498.70 ha^{-1}), net return (₹ 50859.19 ha^{-1}) and B:C ratio (₹ 0.923) was recorded with the three irrigation at critical growth stages. Whereas, minimum cost of cultivation (₹ 52583.50 ha^{-1}), gross return (₹ 80455.36 ha^{-1}), net return (₹ 27871.86 ha^{-1}) and B:C ratio (₹ 0.538) were recorded with one irrigation at CRI stage (Table 2). The application of three irrigations increased cost of cultivation by 5.49 and 2.74%, gross return by 24.45 and 13.84%, net return by 45.19 and 25.96% and benefit cost ratio by 41.71 and 23.83% over the one and two irrigations, respectively (Kaur *et al*., 2018; Wairagade *et al*., 2020; Tyagi *et al*., 2022).

In moisture conservation practices, the higher gross return (₹ 94227.79 ha^{-1}), net return (₹ 43182.29 ha^{-1}) and B:C ratio (0.844) were recorded with the application of Pusa hydrogel 5 kg ha^{-1} except cost of cultivation (₹ 57177.50 ha^{-1}) recorded in paddy straw mulch (Table 2). The application of Pusa hydrogel increased gross return by 2.81%, net return 20.32% and benefit cost ratio by 29.02% over the paddy straw mulch 5 t ha^{-1}. Whereas, cost of cultivation 12.01% was enhanced by paddy straw mulch Singh *et al*. (2018).

Among integrated nutrient management practices, maximum cost of cultivation (₹ 56970.50 ha^{-1}) and gross return (₹ 95839.55 ha^{-1}) were recorded with the integration of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$. Whereas, maximum net return (₹ 40163.20 ha^{-1}) and B:C ratio (0.777) were recorded in 100% RDF + Azotobacter treatment (Table 2). The application of 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ increased cost of cultivation by 9.17, 8.82 and 2.07%, gross return by 6.25, 3.89 and 2.09% over the 100% RDF, 100% RDF + Azotobacter and 75% RDF + Azotobacter + FYM 5 t ha^{-1}. However, maximum net return by 5.27, 5.13 and 3.22% was increased by 100% RDF + Azotobacter over the 75% RDF + Azotobacter + FYM 5 t ha^{-1}, 100% RDF (N 120, P 60, K 40 kg ha^{-1}) and 75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$, respectively.

Table 1 : Influence of irrigation schedules, moisture conservation and integrated nutrient management practices on yield.

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Biological yield (kg ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Irrigation scheduling									
One irrigation at CRI stage	2852.50	2938.50	2895.50	3308.38	3408.38	3358.38	6160.88	6346.88	6253.88
Two irrigations at CRI and Late jointing stage	3249.00	3340.00	3294.50	3800.88	3907.38	3854.13	7049.88	7247.38	7148.63
Three irrigations at CRI, Booting and Milking stage	3756.00	3877.13	3816.56	4431.63	4555.25	4493.44	8187.63	8432.38	8310.00
S.Em. ±	28.65	35.80	10.76	26.40	22.82	8.65	27.95	54.19	23.33
CD at 5%	111.84	139.77	42.01	103.08	89.10	33.76	109.12	211.59	91.09
Moisture conservation practices									
Pusa Hydrogel 5 kg ha^{-1}	3332.50	3433.50	3383.00	3901.50	4013.42	3957.46	7234.00	7446.92	7340.46
Paddy straw mulch 5 t ha^{-1}	3239.17	3336.92	3288.04	3792.42	3900.58	3846.50	7031.58	7237.50	7134.54
S.Em.±	16.70	18.95	14.69	31.06	21.61	13.11	27.98	36.31	16.09
CD at 5%	57.64	65.38	50.71	107.20	74.59	45.23	96.55	125.30	55.52
Nutrient Management									
100% RDF (N 120, P 60, K 40 kg ha^{-1})	3178.33	3272.83	3225.58	3721.17	3825.83	3773.50	6899.50	7098.67	6999.08
100% RDF + Azotobacter	3258.33	3355.33	3306.83	3814.67	3922.00	3868.33	7073.00	7277.33	7175.17
75% RDF + Azotobacter + FYM 5 t ha^{-1}	3318.33	3419.33	3368.83	3885.00	3996.83	3940.92	7203.33	7416.17	7309.75
75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1}	3388.33	3493.33	3440.83	3967.00	4083.33	4025.17	7355.33	7576.67	7466.00
S.Em. ±	27.91	34.72	16.04	33.05	38.85	20.26	64.50	67.12	43.57
CD at 5%	80.07	99.60	46.01	94.80	111.45	58.11	185.05	192.56	124.98

Table 2 : Influence of irrigation schedules, moisture conservation and integrated nutrient management practices on farm profitability.

Treatments	Cost of cultivation (Rs. ha^{-1})			Gross return (Rs. ha^{-1})			Net return (Rs. ha^{-1})			Benefit cost ratio		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Irrigation scheduling												
One irrigation at CRI stage	52377	52790	52583.5	77841.31	83069.40	80455.36	25464.31	30279.40	27871.86	0.494	0.582	0.538
Two irrigations at CRI and Late jointing stage	53905	54318	54111.5	88873.44	94652.63	91763.04	34968.44	40334.63	37651.54	0.657	0.751	0.703
Three irrigations at CRI, Booting and Milking stage	55433	55846	55639.5	102986.6	110010.9	106498.7	47553.56	54164.82	50859.19	0.867	0.979	0.923
Moisture conservation practices												
Pusa Hydrogel 5 kg ha^{-1}	50839	51252	51045.5	91176.64	97278.96	94227.79	40337.63	46026.95	43182.29	0.792	0.895	0.844
Paddy straw mulch 5 t ha^{-1}	56971	57384	57177.5	88624.25	94542.96	91583.62	31653.25	37158.96	34406.11	0.553	0.646	0.599
Nutrient Management												
100% RDF (N 120, P 60, K 40 kg ha^{-1})	51541	51944	51742.5	86959.67	92728.44	89844.05	35418.67	40784.42	38101.55	0.691	0.789	0.740
100% RDF + Azotobacter	51741	52144	51942.5	89147.42	95063.97	92105.71	37406.42	42919.96	40163.20	0.727	0.827	0.777
75% RDF + Azotobacter + FYM 5 t ha^{-1}	55589	55992	55790.5	90789.59	96877.41	93833.52	35200.58	40885.40	38042.99	0.637	0.733	0.684
75% RDF + Azotobacter + FYM 5 t ha^{-1} + $ZnSO_4$ 20 kg ha^{-1}	56749	57192	56970.5	92705.09	98974.02	95839.55	35956.08	41782	38869.04	0.636	0.733	0.685

CONCLUSIONS

The results of this experiment demonstrated that cultivation of wheat with the application of three irrigations, Pusa hydrogel and integration of 100% RDF + Azotobacter result revealed significant improvement into yield and profitability of crop than other treatments. In limited irrigation condition, wheat growers can get higher income with the application of three irrigations, Pusa hydrogel 5 kg ha^{-1} and 100% RDF + Azotobacter treatment combination.

Acknowledgement. We are thankful to the Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) for providing all necessary facilities during the research work.
Conflict of interest. None.

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How to cite this article: Kamal Tiwari, Sanjeev Kumar, Ashish Kumar Srivastava, Shailendra Singh, Ram Niwas, Anushi and Jitendra Kumar (2023). Influence of Resource Conservation Practices on Economics of Wheat (*Triticum aestivum* L.) under Limited Irrigated Condition. *Biological Forum – An International Journal*, *15*(7): 106-110.