

Original Research Article

Impact of Vermi-compost and Hydrogel (Pusa) on Soil Dynamics, Nutrient uptake & Water Productivity through Wheat Crop

Abstract

A field experiment was conducted during winter (*Rabi*) season of 2015-16 and 2016-17 at the Crop Research Centre of the Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India to study the Impact of different irrigation levels and moisture conservation practices on wheat crop. Three irrigation levels were three viz., I₁ (at CRI stage), I₂ (at CRI, Booting and Milking) and I₃ (at CRI, Late tillering, Late jointing, Flowering and Milking stage) and moisture conservation practices (Application of pusa hydrogel @ 5 kg/ha, Vermi-compost @ 1t/ha, pusa hydrogel @ 5 kg/ha+Vermicompost @ 1t/ha and no application) were tested in split plot design (SPD) with three replications. Results revealed that the highest total nitrogen (105.22 and 97.48 kg/ha), phosphorus (23.05 and 20.94 kg/ha) and potassium (141.96 and 138.41kg/ha) uptake was recorded with five irrigations followed by three irrigations during first and second years, respectively. Besides, this treatment also gave highest nutrient uptake by crop along with maintaining the soil fertility and moisture status. Thus, in wheat application of 5 kg pusa hydrogel+1t Vermi-compost/ha with five irrigations (at CRI, Late tillering, Late jointing, Flowering and Milking stage) seems to be best under sandy loam soils of North Western Plain Zones of Western Uttar Pradesh.

Keywords: Soil nutrients, Moisture conservation, Vermicompost, Pusa Hydrogel & Protein.

Introduction

Wheat (*Triticum aestivum L.*) is the most important cereal crop in the world. Wheat covered more land for cultivation as compared to the other crops worldwide than any other; it's

contribution to provide human diet for fulfill the demand of daily required protein and more calories than any other crops. The total area under wheat in the world was 216.64 million hectares with an annual production of 674.88 million tones and an average productivity of 3115 kg ha⁻¹ (FAO- 2015). In India, wheat is second most important food crop, next only to rice, with an area of 29.65 million hectares production of 92.46 million tones and the average productivity of 3118 kg ha⁻¹ (Anonymous, 2015). It occupies 25 per cent of area under food grains and contributes 36 per cent to the total food grain production of the country. Water is an important lifesaving natural resource for the crop. Due to improper irrigation in the country, it is important to increase irrigation efficiency and water productivity of crop and to exploit the existing water potential by reducing the losses of water and also ensuring better atmospheric condition for crop growth. Super absorbent polymer has capability to store extra water in soil that enables crops to utilize the water over an extended period of time. Hydrogel (Super absorbent polymer) is a water retaining, cross-linked hydrophilic, biodegradable amorphous polymer which can absorb and retain water at least 400 times of its original weight and make at least 95 per cent of stored water available for crop absorption (Johnson and Veltkamp, 1985).

Hydrogel is three-dimensional, hydrophilic polymer, loosely cross-linked networks capable of imbibing large amounts of water or biological fluids. These synthetic polymers found in form of crystals and available under several trade names viz., Super Absorbent, Pusa Hydrogel *etcare* collectively called hydrogel. 'Pusa Hydrogel' is a novel semi-synthetic super absorbent polymer developed by the Indian Agricultural Research Institute (IARI) has shown the potential to realize more yield per unit of input. This product displayed a swelling potential of minimum 350 times, often exceeding 500 times its weight in pure water. Notably, its swelling ratio increased with the rise in temperature up to 50 °C without any adverse effect on the polymer

matrix structure. It enhances the crop productivity per unit available water and nutrients, particularly in moisture stress condition. It improves physical properties of soil, seed germination, seedling emergence rate, root growth and density that help plants to prolonged moisture stress (**Ekebafeet et al., 2011**). Hydrogel reduces the leaching of herbicide, fertilizer and requirements of irrigation for crops. Applications of Hydrogel in the soil forms an amorphous gelatinous mass on hydration and is capable of absorption and desorption over long period of time, hence acts as a slow-release source of water in soil. However, Hydrogel particles may be taken as “*miniature water reservoir*” in the soil and water will be removed from these reservoirs upon the root demand through osmotic pressure difference.

Vermi compost (VC) which is produced by the fragmentation of organic wastes by earthworms, contains nutrients in forms that are readily available for plant uptake (**Atiyeh et al., 2002**). There is good evidence that VC application promotes growth of plants and it has been found to have a positive effect on growth and productivity of cereals and legumes. there is an increasing interest in the potential use of VC as soil amendment, where the addition of VC improves the soil physical and chemical properties (Arancon et al., 2006 and Edwards and Burrows, 1988). Integration of organic and inorganic fertilizers is being advocated as one of the strategic solutions to maintain soil fertility and to increase production in Ethiopia and has been highly emphasized for the Growth and Transformation Plan (GTP), in which the Agricultural Growth Program (AGP) is an essential component (**Gezahegn et al., 2014**). This is because the carbon pool of most Ethiopian soils has been depleted due to continuous cultivation and removal of crop residues from crop fields as well as little addition of manures to the land (**Girmay et al., 2008**). In this regard, vermi compost is a potential organic nutrient source which provides additional plant nutrients that are not found in chemical NP fertilizers. **Simsek-Ersahin (2011)**

revealed that vermi compost were effective organic fertilizers and bio-control agents that's improved food quality, increases soil porosity, aeration and water holding capacity and thus increases the surface area, provides strong absorbability and retention of nutrients for a longer period of time. Manure, compost or vermi compost applications increase the contents of organic C, P and N in the soil. The soil pH decreases slightly and the electrical conductivity increases without salinity effect. The information on the above study is meager and fragmented under this region, thus the investigation is planned and executed in western U.P. conditions.

Materials and Methods

The experiment was carried out in pots at Crop Research Centre, Sardar Vallabhbai Patel University of Agriculture and Technology, Meerut (U.P.), having semiarid to sub-tropical climate and geographically situated at a latitude of 29⁰ 40' North, longitude of 77⁰ 42' East with an altitude of 237 meter above mean sea level.

Climate and Weather

The climate of this region is semi-arid and sub-tropical with extreme hot weather in summer and cold in winter season. There is gradual decrease in mean daily temperature in December reaching as low as 3.2 °C and further a gradual increase is registered reaching as high as 45.0 °C in the month of May. Occasionally, frost does occur during the months of December and January. The total annual rainfall of the region is about 665 & 787mm. Winter showers sometimes are accompanied by high wind velocity and hail storms. Mean relative humidity is found to be maximum in August and minimum in May.

The mean data of weekly weather such as rainfall, temperature, wind velocity and relative humidity for the crop period of 2015-16 & 2016-17 was recorded from the Meteorological observatory in the University. However, daily pan evaporation and Sun shine

duration have been collected from Indian Institute of Farming Systems Research (IIFSR), ICAR Modipuram Meerut.

During crop period minimum mean temperature was recorded 4.8°C in the 4th week of January in 2015-16 & 4.3°C in the 2nd week of January in 2016-17. The mean maximum temperature was recorded 40.2°C in the 3rd week of April in 2015-16 and 40.3°C in the 3rd week of April in 2016-17. During crop period minimum mean evaporation was recorded (0.7 mm) in the 4th week of January and maximum (10.6 mm) was recorded in the 4th week of April in 2014-15 and minimum mean evaporation was recorded (1.2 mm) in the 1st week of January and maximum (42.3 mm) was recorded in the 4th week of April in 2016-17. The total rainfall 38.7 and 123.3 mm was received during crop period 2015-16 and 2016-17, respectively. The minimum mean Humidity was recorded 21.4 % in the 4th week of April in 2015-16 and 18.5 % in the 1st week of May in 2016-17. The maximum Humidity mean was recorded 99.2% in the 4th week of January in 2015-16 and 97.7% in the 4th week of April in 2016-17.

Soil of the Experiment Field

The sampling of soil was done to a depth of 0-15 cm from 10 spots before sowing of wheat crop in the research field. The samples collected were mixed homogenously and a composite soil sample was air dried, powdered and allowed to pass through (2 mm) sieve and analysed for physic-chemical properties. The values obtained are given in Table .1. The soil of experimental site was sandy loam in texture, low in nitrogen and OC, medium in available phosphorus, available potassium and alkaline in reaction.

Soil analysis

Soil Moisture Content (%)

Soil samples were drawn with the help of post auger from 0-15 and 15-30 cm of soil depth. In all the treatments, soil samples for moisture determination were collected initially and after harvest of the crop. We adopted gravimetric method for determination of soil moisture content and the average moisture percentage from different soil depths were used to calculate consumptive use of water and moisture productivity during twice the years.

Organic Carbon (%)

OC of the soil was estimated by the procedure given by Walkley and Black (1934) rapid titration method (Jackson, 1973).

Available Nitrogen (kg ha^{-1})

Available N determined by alkaline potassium permanganate method given by Subbiah and Asija (1956). In this method, N in the soil is oxidized with warm alkaline KMnO_4 solution followed by release of ammonia which is distilled and trapped in boric acid mixed indicator solution. The amount of NH_3 trapped is estimated by titrating with standard acid. Soil sample of 5g was taken and transferred to digestion tube. Sample was distilled with 0.32% KMnO_4 and 2.5% NaOH followed by heating of sample by passing steady steam and collection of liberated NH_3 in conical flask containing 20 ml of 2% boric acid with mixed indicator. Colour changed from pink to green. Thereby, distillate was titrated against 0.02 N H_2SO_4 and colour changed to original pink.

Available Phosphorus (kg ha^{-1})

Before estimation of available phosphorus the pH of soil sample was determined using glass electrode pH meter. The pH of soil sample was 7.9 alkaline ranges, so 0.5M NaHCO_3 extractable method was used given by Olsen's *et al.* (1954). 2.5 g of soil sample was weighed and a pinch of activated charcoal was added and mixed with extraction solution (50 ml of 0.5M NaHCO_3 pH 8.5) with continuous shaking the solution for half an hour

followed by filtrate collection (5 ml) in 25 ml volumetric flask. 2-3 drops of p- nitro phenol indicator was added to the filtrate resulting in yellow color development thereby, addition of 5N H₂SO₄ drop by drop, until yellow color disappears to acidify upto pH 5. Thereafter, 4 ml solution of ascorbic acid was added to the flask resulting in blue color development. The intensity of blue color which is proportional to phosphate was read on the spectrophotometer at a wave length of 660 nm. A blank was also prepared with all chemicals and no soil. The concentration of available phosphorus in soil was expressed in kg ha⁻¹.

Available phosphorus (kg ha⁻¹) = ppm of P calculated from standard curve × dilution factor × 2.24.

Available Potassium (kg ha⁻¹)

Available K in the soil extracted by 1N ammonium acetate as an extractant (Hanway & Heidel, 1952) and K in the extract were determined by Flame photometer.

Plant analysis

Preparation of plant sample

Nutrient content was analyzed in crop grains and straw at harvested and estimated separately from the randomly selected plants of each plot. The plant samples for estimating the dry matter production (grain and straw) and nutrient uptake from each plot at harvest were thoroughly washed with distilled water and dried in hot air oven at 65±2°C as dry matter accumulation. Dried samples were powdered in a Willey mill to considerable fineness before storing them in polythene bags for further analysis.

Nutrient content and uptake studies

Nutrient content in wheat (grains & straw) at harvested and estimated separately from the selected plants of each plot. Oven dried plant samples were ground with the help of Willey mill

grinder. Total N, P & K contents were estimated by micro-Kjeldahal, vanadomolybdo phosphoric acid yellow color and flame photometric method, respectively (Jackson, 1973).

The nutrient uptake by grains and straw of wheat was calculated as follows:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{Yield of grains or straw (kg/ha)}}{100}$$

Finally, NPK uptake by grains and straw were added to work out the total N, P and K nutrient uptake by wheat, respectively.

Protein content in grains

Nitrogen content of grains as determined by modified micro-Kjeldahl method was multiplied by 5.73 conservation factor to get total crude protein content (AOAC, 1960).

$$\text{Grains protein content (\%)} = \text{Nitrogen content in grains (\%)} \times 5.73$$

Results and Discussion

Nutrient content and their uptake

Nutrient content and uptake *viz.*, nitrogen content uptake in grains and straw, phosphorous content uptake in grains and straw potassium content uptake in grains and straw as well as their total uptake did reveal significant effect of irrigation level and moisture conservation practices during both of the years. And the interaction between irrigation level and moisture conservation practices was insignificant.

Nitrogen content in grains and straw

Nitrogen content in grains and straw was significantly highest under the crop received 5 irrigations over 1 irrigation, followed by 3 irrigations during both the years. Crop supply by 1 time irrigation was inferior over all other treatments. The mean percent of nitrogen in grains and straw less than 1 irrigation was 1.63 and 0.37 % as against 1.73 and 0.47 %, respectively over 5 irrigations 2015-16 and 2016-17, respectively. Control led to reduction in N content in grains

and straw than rest of the treatments. Though, the effect was significant during both the years. Moreover, Crop fertilized with pusa hydrogel @ 5 kg ha⁻¹ and vermin-compost @ 1 t ha⁻¹ obtained high nitrogen content in crop grains and straw followed by vermin-compost @ 1 t ha⁻¹. However, vermin-compost @10 q ha⁻¹ did also differ significantly over pusa hydrogel @ 5 kg ha⁻¹ and control.

Nitrogen uptake in grains and straw as well as their total uptake

Nitrogen uptake in grain and straw was significantly lowest under the application of 1 irrigation as against 3 and 5 irrigations during both the years (Table 2). Crop received 5-time irrigation was superior over other irrigation levels. Moreover, in total uptake, crop receiving 5 irrigations had removed 4.39% and 3.42% more nitrogen over 3 irrigations, while 19.59% and 16.78% over 1 irrigation during 2015-16 and 2016-17, respectively. Crop grown under pusa hydrogel @ 5 kg ha⁻¹ along with vermi compost @ 1 t ha⁻¹ did show significant increment in nitrogen uptake in grains and straw than rest of the treatments during both the years. Moreover, Crop grown under unfertilized condition had recorded lowest nitrogen uptake in grains and straw. Furthermore, application of pusa hydrogel @ 5 kg ha⁻¹ recorded higher nitrogen uptake in grains and straw against control, whereas lowest over vermi-compost @ 1 t ha⁻¹. However, vermi compost @ 1 t ha⁻¹ did also differ significantly over pusa hydrogel @ 5 kg ha⁻¹ and control. Though, as above control did remain lowest in respect to nitrogen uptake in grains and straw over rest of its counterparts, irrespective of the years. Alike trends were also noted in total N uptake during both the years of experimentation.

Table 1: Nitrogen content uptake by wheat crop as effected by irrigation levels and moisture conservation practices

Treatment	Nitrogen content (%)				Nitrogen uptake (kg ha ⁻¹)					
	Grains		Straw		Grains		Straw		Total	
	015-	016-	015-	016-	015-	016-	015-	016-	015-16	016-17

	16	17	16	17	16	17	16	17		
Irrigation levels										
I ₁ (at CRI stage)	.64	.62	.39	.35	8.02	5.97	9.96	7.50	7.98	3.47
I ₂ (at CRI, Booting and Milking)	.68	.65	.44	.40	5.08	1.86	5.72	2.38	00.79	4.25
I ₃ (at CRI, tillering, jointing, Flowering and Milking stage)	.76	.72	.48	.45	8.68	3.38	6.54	4.09	05.22	7.48
S. Em. ±	.008	.007	.005	.001	.26	.39	.26	.33	.45	.13
C. D. (P=0.05)	.032	.031	.023	.005	.01	.53	.01	.31	.78	.52
Moisture conservation practices										
Co ntrol	.57	.53	.36	.31	2.10	9.15	6.80	5.11	8.90	4.26
Pu sa hydrogel @5 kg ha ⁻¹	.67	.63	.42	.37	6.50	2.57	1.44	9.14	7.94	1.70
Ve rmi compost @ 1 t ha ⁻¹	.75	.71	.47	.43	1.13	7.81	6.32	3.39	07.46	01.20

Pusa hydrogel @ 5 kg ha ⁻¹ + Vermicompost @ 1 t ha ⁻¹	.81	.78	.51	.48	5.97	2.09	1.70	7.66	17.68	09.75
S.E.M. ±	.006	.005	.005	.003	.21	.37	.33	.32	.34	.40
C.D. (P=0.05)	.020	.019	.014	.008	.62	.09	.98	.94	.02	.18

Phosphorous content in grains and straw

Application of 5 irrigations significantly resulted into maximum phosphorous content in grains (0.35 and 0.33 %) as against all other treatments during 2015-16 and 2016-17, respectively (Table 2). Whereas, crop receiving 1 irrigation at CRI had recorded maximum phosphorous content in straw (0.22 %) during 2015-16 only, while supplying of 1 and 3 irrigations had obtained maximum and alike phosphorous content in straw (0.20 %) during 2016-17 as against 5 irrigations. Though, the differences among them were significant during both the years. Control did measure least phosphorous content in grain (0.30 and 0.28 %) and straw (0.17 and 0.15 %) during both the years. Though, the effect was significant than rest of the treatments. Moreover, Crop fertilized with pusa hydrogel @ 5 kg ha⁻¹ and vermi compost @ 1 t ha⁻¹ did obtain maximum phosphorous content in grain and straw followed by vermi compost @ 1 t ha⁻¹. However, pusa hydrogel @ 5 kg ha⁻¹ did record significantly maximum phosphorous content in grain and straw over control, while remained lower over vermi compost @ 1 t ha⁻¹.

Phosphorous uptake in grain and straw as well as their total uptake

Phosphorous uptake in grains and straw was significantly lowest under the application of 1 irrigation as against 3 irrigation and 5 irrigations during both the year (Table No:2). Crop receiving 5-time irrigation was superior over other irrigation levels during both the years. Moreover, in total uptake, crop receiving 1 irrigation had removed 4.39% and 0.43 % lowest phosphorous over 3 irrigations, while 14.05% and 11.91% over 5 irrigations during 2015-16 and 2016-17, respectively. Integrated incorporation of pusa hydrogel @ 5 kg ha⁻¹ and vermi compost @ 1 t ha⁻¹ did show significant increment in phosphorous uptake in grains and straw than rest of the treatments during both the years. Moreover, Crop grown under unfertilized condition had recorded lowest phosphorous uptake in grains and straw. Furthermore, application of pusa hydrogel @ 5 kg ha⁻¹ did record higher phosphorous uptake in grains and straw against control, whereas lowest over vermi compost @ 1 t ha⁻¹. However, vermi compost @ 1 t ha⁻¹ did also differ significantly over pusa hydrogel @ 5 kg ha⁻¹ and control. Though, control did remain inferior in respect to phosphorous uptake in grains and straw over rest of its counterparts, irrespective of the years. Similar trends were noted in total phosphorous uptake during both the years.

Table2: Phosphorus content and uptake by wheat as influenced by irrigation levels and moisture conservation practices

Treatment	Tr	P content (%)				P uptake (kg ha ⁻¹)					
		Grains		Straw		Grains		Straw		Total	
		015-16	016-17	015-16	016-17	015-16	016-17	015-16	016-17	015-16	016-17
Irrigation levels											
I ₁ (at CRI stage)		.32	.31	.19	.17	2.17	1.47	.04	.24	0.21	8.71
I ₂											

(at CRI, Booting and Milking)	.33	.32	.21	.19	3.18	2.82	.62	.62	2.08	0.85
I ₃ (at CRI, Late tillering, Late jointing, Flowering and Milking stage)	.35	.33	.22	.20	4.43	3.22	.90	.11	3.05	0.94
S. Em. ±	.001	.002	.002	.001	.18	.08	.06	.05	.21	.10
C. D. (P=0.05)	.006	.009	.007	.006	.72	.31	.23	.23	.81	.39
Moisture conservation practices										
Co ntrol	.30	.28	.17	.15	.98	.85	.69	.82	5.66	4.67
Pus a hydrogel @ 5 kg ha ⁻¹	.31	.30	.19	.17	2.72	2.02	.10	.23	0.82	9.25
Ver mi compost @ 1 t ha ⁻¹	.34	.33	.22	.20	3.46	2.66	.74	.88	2.21	0.55
Pus a hydrogel										

@5 kg ha ⁻¹ Ver mi compost @1 t ha ⁻¹	.38	.36	.25	.23	6.87	5.49	1.55	0.68	8.42	6.18
S. Em. ±	.002	.002	.001	.002	.19	.19	.25	.24	.38	.38
C. D. (P=0.05)	.005	.006	.005	.005	.57	.58	.75	.72	.14	.13

(Table No:2)

Potassium content in grains and straw

The content of K in grains and straw was significantly highest under the crop received 5 irrigations over 1 irrigation, followed by 3 irrigations during both the year (Table 3). Crop supply by 1 time irrigation was inferior over all other treatments. The mean percent of potassium content in grains and straw under the 5 irrigation was 0.45 and 1.70 % as against 0.39 and 1.41 %, respectively over the 1 irrigation during both the year. Control did let to reduction in potassium content in grains and straw than other treatments. Though, the effect was significant during both the years. Moreover, Crop fertilized with pusa hydrogel @ 5 kg ha⁻¹ and vermi compost @ 1 t ha⁻¹ did obtain maximum potassium content in grains and straw followed by vermi compost @ 10 q ha⁻¹. However, vermi compost @ 1 t ha⁻¹ did also differ significantly over pusa hydrogel @ 5 kg ha⁻¹ and control, while recorded maximum potassium content in grains and straw as against both moisture conservation practices.

Potassium uptake in grains and straw as well as their total uptake

Potassium uptake in grains and straw was significantly lowest under the application of 1 irrigation as against 3 and 5 irrigations during both the year. Crop supply by 5-time irrigation

was significantly recorded highest potassium uptake in grains and straw over other irrigation levels (Table No:3). Moreover, in total uptake, crop receiving 5 irrigations had removed 6.03% and 6.36 % more potassium over 3 irrigations, while 9.38% and 9.24 % over 1 irrigation during 2015-16 and 2016-17, respectively. crop grown under pusa hydrogel @ 5 kg ha⁻¹ along with vermi compost @ 1 t ha⁻¹ did show significant increment in potassium uptake in grains and straw than rest of the treatments during both the years. Moreover, Crop grown under unfertilized condition had recorded lowest potassium uptake in grains and straw. Furthermore, application of pusa hydrogel @ 5 kg ha⁻¹ did record higher potassium uptake in grains and straw against control, whereas lowest over vermi compost @ 1 t ha⁻¹. Though, as above control did remain lowest in respect to potassium uptake in grains and straw over rest of its counterparts, irrespective of the years. Alike trends were also noted in the total nitrogen uptake during both years of experiments.

Table3: Potassium content and uptake by wheat crop effected by irrigation levels and moisture conservation practices

Treatment	Potassium content (%)				Potassium uptake (kg ha ⁻¹)					
	Grains		Straw		Grains		Straw		Total	
	015-16	016-17	015-16	016-17	015-16	016-17	015-16	016-17	015-16	016-17
Irrigation levels										
I ₁ (at CRI stage)	.40	.38	.49	.42	7.33	6.23	12.44	10.47	29.78	26.70
I ₂ (at CRI, Booting and)	.43	.41	.60	.55	8.82	7.97	15.06	12.16	33.88	30.13

Milking)										
I ₃ (at CRI, tillering, jointing, Flowering and Milking stage)	.46	.44	.74	.66	1.64	0.34	20.32	18.07	41.96	38.41
S. Em. ±	001	002	007	008	08	08	15	16	08	18
C. D. (P=0.05)	006	009	027	033	33	32	56	62	31	70
Moisture conservation practices										
Co ntrol	.39	.38	.47	.41	5.76	4.71	09.81	08.03	25.58	22.74
Pus a hydrogel @ 5 kg ha ⁻¹	.41	.39	.53	.48	7.84	6.96	14.56	12.54	32.40	29.50
Ver mi compost @ 1 t ha ⁻¹	.44	.42	.66	.59	0.66	8.89	17.94	15.34	38.61	34.23
Pus a hydrogel @ 5 kg ha ⁻¹ + Ver mi compost @ 1 t ha ⁻¹	.47	.45	.77	.69	2.80	2.17	21.44	18.34	44.24	40.52

S.										
Em. ±	.002	.002	.007	.008	.19	.15	.16	.19	.24	.24
C.										
D.	.005	.006	.021	.024	.56	.44	.48	.56	.71	.72
(P=0.05)										

(Table No:3)

NPK contents and their uptake by crop

Implement of different irrigation levels treatments increased N, P and K content and their uptake and total uptake by wheat grain and straw significantly over control during both years with few exceptions. Among different irrigation levels treatments, highest value for NPK content and uptake was recorded with 05 irrigation levels. An increment of 7.32 and 6.17, 9.38 and 6.45 and 15.00 and 15.78% in N, P and K content in grain and 23.08 and 28.57, 15.78 and 17.64 and 16.77 and 16.90% in straw was recorded with 5 irrigation levels over 1 irrigation levels during 2015-16 and 2016-17 respectively. NPK contents increase might be due to the solubilization effect of organic manures on native nutrients solubilization and releasing of nutrients for a longer duration might be the reason for greater availability. Arancon *et al.* (2004) reported that organic sources had a longer and greater efficiency as compared to inorganic source that might be responsible for higher uptake by building material. Application different irrigation levels treatments increased significantly the uptake of NPK in grain and straw over 1 irrigation levels. The uptake of these nutrients was more in 2015-16 as compared to 2016-17 because the yield was more during the first year of experiment. Among irrigation levels treatments 5 irrigation levels and 1 irrigation levels recorded maximum and minimum NPK uptake, respectively. Application different moisture conservation treatments increased nitrogen, phosphorus and potassium content and their uptake and total uptake by wheat grain and straw

significantly over control during both years with few exceptions. Among different moisture conservation treatments, highest value for NPK content and uptake was recorded with Pusa hydrogel @5 kg ha⁻¹+ Vermi-compost @1 t ha⁻¹. An increment of 15.28 and 16.34, 26.66 and 28.57 and 20.51 and 18.42 per cent in N, P and K content in grain and 41.66 and 54.84, 47.06 and 53.33 and 20.41 and 19.86 per cent in straw was recorded with Pusa hydrogel @5 kg ha⁻¹+ Vermi compost @1 t ha⁻¹ over control plot during 2015-16 and 2016-17, respectively. Application of different irrigation levels treatments increased nitrogen, phosphorus and potassium content and their uptake and total uptake by wheat grain and straw significantly over control during both years with few exceptions. Among different moisture conservation treatments, highest value for NPK content and uptake was recorded with 05 irrigation levels. An increment of 15.67 and 11.23, 18.57 and 15.25 and 24.87 and 25.32 per cent in N, P and K uptake in grain and 32.96 and 37.65, 10.70 and 12.02 and 7.00 and 6.88 per cent in straw was recorded with 05 irrigation levels over 01 irrigation levels during 2015-16 and 2016-17 respectively. Application different moisture conservation treatments increased nitrogen, phosphorus and potassium content and their uptake and total uptake by wheat grain and straw significantly over control during both years with few exceptions. Among different moisture conservation treatments, highest value for NPK content and uptake was recorded with Pusa hydrogel @5 kg ha⁻¹+ Vermi compost @1 t ha⁻¹. An increment of 65.00 and 67.01, 69.04 and 57.26 and 44.67 and 50.71 per cent in N, P and K uptake in grain and 88.69 and 83.06, 102.98 and 121.57 and 10.59 and 9.54 per cent in straw was recorded with Pusa hydrogel @5 kg ha⁻¹+ Vermi compost @1 t ha⁻¹ followed by Vermi compost @1 t ha⁻¹ over control during 2015-16 and 2016-17, respectively. higher uptake of nutrients by the crop under the influence of moisture conservation treatments was due to the fact that moisture conservation treatments controlled the

moisture conservation effectively and consequently made more nutrient available to wheat resulting in enhanced nutrient concentration and yield and thereby higher uptake of nutrients. Similar findings have been reported by Nehra *et al.* (2000), Akhteret *al.* (2004) and Yadav *et al.* (2010). higher NPK uptake by crop in Pusa hydrogel @5 kg ha⁻¹+ Vermi compost @1 t ha⁻¹ has also been reported by El-Hady and Abosedera(2006).

Protein content in grains

Protein content exhibited significantly with irrigation levels and moisture conservation practices during both the years (Table 4). Moreover, the interaction between irrigation level and moisture conservation practices was non-significant. Significantly maximum protein content was recorded with the application of 5 irrigations as compared with rest of the treatments. Moreover, 3 irrigations did also differ over 1 irrigation. Though, least protein content was noted with 1 irrigation. The mean protein content in 5 irrigations was 10.72 and 10.18 % r against 9.91 and 9.41 % under 1 irrigation during 2015-16 and 2016-17, respectively. among the different moisture conservation practice, combine application of pusa hydrogel @ 5 kg ha⁻¹ and vermi compost @ 1 t ha⁻¹ did recorded maximum protein content which was significantly differ over rest of the treatments, irrespective of the years. Though, application of pusa hydrogel @ 5 kg ha⁻¹ did significantly result higher protein content over control while lower as againstvermi compost @ 1 t ha⁻¹ during both the years. moreover,significantly lowest protein content (9.20 and 8.74 %) was recorded under the control during 2015-16 and 2016-17, respectively.

Table4: Protein content of wheat grains as influenced by irrigation levels and moisture conservation practices

Treatment	Protein content (%)	
	2015-16	2016-17
Irrigation levels		
I ₁ (at CRI stage)	9.91	9.41
I ₂ (at CRI, Booting and Milking)	10.24	9.73

I ₃ (at CRI, Late tillering, Late jointing, Flowering and Milking stage)	10.72	10.18
S. Em. \pm	0.07	0.06
C.D. (P=0.05)	0.26	0.25
Moisture conservation practices		
Control	9.20	8.74
Pusa hydrogel @5 kg ha ⁻¹	9.90	9.40
Vermi compost @ 1 t ha ⁻¹	10.72	10.18
Pusa hydrogel @5 kg ha ⁻¹ + Vermi compost @1 t ha ⁻¹	11.35	10.78
S. Em. \pm	0.05	0.04
C.D. (P=0.05)	0.14	0.13

(Table 4)

Soil studies

Soil available nutrients

Soil available nutrients (nitrogen, phosphorous and potassium) and organic carbon did reveal significant effect of irrigation level and moisture conservation practices during both the years (Table5) Moreover, the interaction between irrigation level and moisture conservation practices was insignificant. Further, slight variations were noted in soil available nutrients at harvest as against initial nutrients during both the years.

Available nitrogen

Available nitrogen was increases with broadening irrigation level where crop receiving five times irrigation did showed its superiority to record maximum available nitrogen as compared to three irrigation and 1 irrigation. The increment under 5 irrigations was to the tune of was 7.3 % (2015-16) and 7.7 % (2016-17) as against one irrigation. Though, one irrigation did showed inferiority over other treatments to record least grains yield, irrespective of the years. Crop grown without fertilization did obtain lowest available nitrogen of 212.22 kg ha⁻¹ (2015-16)

and 214.34 kg ha⁻¹ (2016-17) as compared with all other treatments. Although, incorporation of pusa hydrogel @ 5 kg ha⁻¹ along with vermi compost @ 1 t ha⁻¹ was significantly recorded highest available nitrogen over its individual component, irrespective of the years. Though, application of pusa hydrogel @ 5 kg ha⁻¹ did significantly result higher available nitrogen over control while lower as against vermi compost @ 1 t ha⁻¹ during both the years.

Available phosphorous

Significantly application of 1 irrigation did record 8.8 and 6.8 % lower available phosphorous as against crop received 5 irrigations during 2015-16 and 2016-17, respectively. The next in order was 3-time irrigation which was significantly higher over 1 time irrigation and minimum over 5-time irrigation, irrespective of the years. Crop fertilized with pusa hydrogel @ 5 kg ha⁻¹ and vermi-compost @ 1 t ha⁻¹ obtained 14.61 kg ha⁻¹ (2015-16) and 15.05 kg ha⁻¹ (2016-17) available phosphorous which was significantly higher than other treatments. Although, incorporation of pusa hydrogel @ 5 kg ha⁻¹ did superior than over control and inferior over vermi-compost @ 1 t ha⁻¹ in order to recorded available phosphorous. Moreover, control did remain inferior over rest of its counterparts during both the years.

Available potassium

Irrigation level did also result significant difference among them during both the year. However, considerable improvement was noted in available potassium with the increasing irrigation frequency. Though, application of 5-time irrigation in wheat significantly recorded maximum available potassium (177.18 and 179.10 kg ha⁻¹), while lowest available potassium (165.84 and 167.12 kg ha⁻¹) was found under the crop received 1 irrigation as compared with other irrigation levels during 2015-16 and 2016-17, respectively. Crop grown without pusa hydrogel @ 5 kg ha⁻¹ and vermi compost @ 1 t ha⁻¹ (control) did significantly obtain lower

available potassium as compared with all other treatments. Moreover, combine application of pusa hydrogel @ 5 kg ha⁻¹ alongwith vermi compost @ 1 t ha⁻¹ had recorded significantly highest available potassium as compared with control, pusa hydrogel @ 5 kg ha⁻¹ and vermi compost @ 1 t ha⁻¹, irrespective of the years.

Organic carbon

Application of 5 irrigations brought significant improvement in organic carbon over 3 and 1 irrigation during twice the years. Moreover, lowest organic carbon noted under crop obtained only irrigation at CRI stage, irrespective of the years. Crop receiving pusa hydrogel @ 5 kg ha⁻¹ + vermi compost @ 1 t ha⁻¹ had significantly maximum organic carbon as compared to the other treatments irrespective of the years. However, application of vermi compost @ 1 t ha⁻¹ did also significantly result higher organic carbon as against pusa hydrogel @ 5 kg ha⁻¹ and control during twice the years.

Table5: Available N, P, K and organic carbon content of the soil as influenced irrigation levels and moisture conservation practices at harvesting time

Treatment	N (kg ha ⁻¹)		P (kg ha ⁻¹)		K (kg ha ⁻¹)		OC (%)	
	015-16	016-17	015-16	016-17	015-16	016-17	015-16	016-17
Irrigation levels								
I ₁ (at CRI stage)	13.4	15.6	2.8	3.1	65.8	67.1	.46	.48
I ₂ (at CRI, Booting and Milking)	22.3	24.5	3.0	3.9	71.3	74.3	.47	.49
I ₃ (at CRI, Late tillering, Late jointing, Flowering and Milking stage)	29.9	32.2	4.0	4.1	77.2	79.1	.48	.50
S. Em. ±	.3	.2	.19	.08	.2	.2	.003	.003
C.D. (P=0.05)	.9	.0	.74	.31	.6	.6	.008	.007
Moisture conservation practices								
Control	12.2	14.3	2.0	2.3	67.3	68.9	.46	.46
Pusa hydrogel @ 5 kg ha ⁻¹	19.4	21.6	2.9	3.4	70.2	72.6	.47	.47

Vermi compost @ 1 t ha ⁻¹	2	2	1	1	1	1	1	0	0
	25.0	27.2	3.6	4.0	72.7	74.8	.48	.48	
Pusa hydrogel @ 5 kg ha ⁻¹ + Vermi compost @ 1 t ha ⁻¹	2	2	1	1	1	1	0	0	
	31.0	33.3	4.6	5.1	75.5	77.8	.49	.51	
S. Em. ±	0	0	0	0	0	0	0	0	
	.5	.5	.15	.12	.2	.2	.003	.003	
C.D. (P=0.05)	1	1	0	0	0	0	0	0	
	.5	.4	.43	.35	.7	.6	.008	.008	
Initial value	2	2	1	1	1	1	0	0	
	22.0	24.6	4.2	4.6	72.1	75.3	.48	.49	

(Table:5)

Soil moisture content studies

The effect of moisture conservation under different irrigation schedule on average profile, soil moisture content in wheat during 2015-16 and 2016-17. In general, the profile moisture content was the highest at the time of sowing (21%) and it was lowest at the time of crop maturity in all the treatments during both 2015-16 and 2016-17, successive increase in irrigation levels has been increased moisture content at harvest, being the highest at five irrigation levels, 17.3 and 17.3%, respectively. Though, the respective mean values were 15.7 and 15.1%. Similarly, combined application of 5 kg Pusa hydrogel + 1 t vermi-compost ha⁻¹ stored the highest moisture content of 16.1 and 14.4% during 2015-16 and 2016-17, respectively. The next in the order were VC @ 1 t ha⁻¹ and Pusa hydrogel @ 5 kg ha⁻¹ of treatments.

Table6: Impact of irrigation levels and moisture conservation practices on soil at the harvesting and water productivity (kg m⁻³) of wheat:

Water productivity						
Treatments	Soil moisture content (%)		Total water applied (cm)		Water productivity (kg grain m ⁻³)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation levels						

I ₁ (at CRI stage)	14.3	12.0	10.48	10.25	2.60	2.58
I ₂ (at CRI, Booting and Milking)	15.4	16.0	34.21	33.45	1.25	1.23
I ₃ (at CRI, Late tillering, jointing, Flowering and Milking stage)	17.3	17.3	44.28	43.58	1.04	1.03
Mean	15.7	15.1	29.65	29.10	1.63	1.61
Moisture conservation practices						
Control	13.8	13.3	18.63	17.95	1.65	1.57
Pusa hydrogel @5 kg ha ⁻¹	14.2	13.5	32.56	31.29	1.30	1.32
Vermi compost @ 1 t ha ⁻¹	15.6	14.0	35.69	34.69	1.25	1.24
Pusa hydrogel @5 kg ha ⁻¹ + Vermi compost @1 t ha ⁻¹	16.1	14.4	38.56	37.54	1.22	1.20
Mean	14.9	13.8	31.36	30.37	1.36	1.33

Water productivity

The crop water productivity during 2015-16 was slightly higher than 2016-17 (Table6). The crop water use increased under plots where more irrigation scheduling was adopted during twice of the year of experimentation. The crop water use increased markedly in five irrigation levels than three irrigation levels and one irrigation levels during twice of the year of study. Water productivity varied inversely with irrigation levels. Maximum water productivity was recorded under one irrigation levels followed by three irrigation levels and five irrigation levels during both the years. Although mean water productivity during 2015-16 and 2016-17 was 1.63 and 1.61 kg grains/m³, respectively. Among moisture conservation practices, water productivity varied from 1.22 to 1.33 and 1.20 to 1.32 kg grams/m³, being highest under treatment receiving Pusa hydrogel @ 5 kg ha⁻¹ during first and second years, respectively.

Table7: Effect of irrigation levels and moisture conservation practices on soil moisture content at harvest and water productivity (kg m⁻³) of wheat

Water productivity			
Treatments	Soil moisture content (%)	Total water applied (cm)	Water productivity (kg grain m ⁻³)

	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation levels						
I ₁ (at CRI stage)	14.3	12.0	10.48	10.25	2.60	2.58
I ₂ (at CRI, Booting and Milking)	15.4	16.0	34.21	33.45	1.25	1.23
I ₃ (at CRI, Late tillering, Late jointing, Flowering and Milking stage)	17.3	17.3	44.28	43.58	1.04	1.03
Mean	15.7	15.1	29.65	29.10	1.63	1.61
Moisture conservation practices						
Control	13.8	13.3	18.63	17.95	1.65	1.57
Pusa hydrogel @5 kg ha ⁻¹	14.2	13.5	32.56	31.29	1.30	1.32
Vermi compost @ 1 t ha ⁻¹	15.6	14.0	35.69	34.69	1.25	1.24
Pusa hydrogel @5 kg ha ⁻¹ + Vermi compost @1 t ha ⁻¹	16.1	14.4	38.56	37.54	1.22	1.20
Mean	14.9	13.8	31.36	30.37	1.36	1.33

(Table:7)

Impact of Available NPK and Organic Carbon in Soil

Alliance of organic manures and chemical fertilizers generally affects physical, chemical and biological properties of soil. During this study available N, P and K organic carbon were measuring during 2015-16 and 2016-17 after harvesting of crop from various treatments during twice years. Provided N, P and K increased in soil with the application of different irrigation levels treatments during twice years.

All various treatments maximum value for available N, P and K in soils was recorded with five irrigation levels during the years of study. The application of manures have been reported not only to improve the nutrient content in the soil but also helps to bringing native irrigation into the available forms thus increasing the available nutrient contents in the soil. Moreover, organic manures create better environment for biological activity in the soil which

results into more fixation of N and more solubilizing effect on other fixed form of irrigation. In the present study N, P and K content in the soil after harvesting were 7.73 and 7.70, 9.64 and 7.25 and 6.87 and 7.18 percent higher than five irrigation levels during 2015-16 and 2016-17, respectively. Increase in nutrients in soil by the application of organic manures was also reported by Ahmadabadiet *al.* (2011) and Islamet *al.* (2011).

Maximum carbon content was recorded in five irrigation levels (0.485 and 0.502) followed by three irrigation levels during twice the years which was significantly higher than one irrigation levels. Studies conducted by various workers have established the fact of maintenance of soil fertility in terms to improved organic content and available nutrients in soil through the applications of organic manures in combination with chemical fertilizers in different ratio (Gupta and Seth, 1996 and Bulluck *et al.* (2002).

Table 8 : Impact of different irrigation levels and moisture conservation practices at various stages of crop growth grains, straw and biological yield (q ha⁻¹) and harvest index of wheat

Treatment	Grain		Yields (q ha ⁻¹)				Harvest index (%)	
			Straw		Biological Yield			
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation levels								
I ₁	2	2	5	5	7	7	3	3
(at CRI stage)	7.25	6.58	1.74	0.37	8.99	6.95	8.46	8.48
I ₂	4	4	5	5	1	9	4	4
(at CRI, Booting and Milking)	2.75	1.63	7.72	6.21	00.48	7.84	2.54	2.55
I ₃	4	4	7	7	1	1	4	4

(at	CRI,	6.01	5.02	3.62	2.02	19.62	17.03	4.43	4.44
Late									
tillering,									
jointing,									
Flowering									
and									
Milking									
stage)									
S		0	0	0	0	0	1	0	0
Em ±		.30	.47	.59	.68	.87	.12	.12	.18
C.D		1	1	2	2	3	4	0	0
. (P=0.05)		.28	.82	.32	.67	.62	.58	.45	.59
Moisture conservation practices									
Con		3	2	5	5	8	8	4	4
trol		0.71	8.12	6.11	5.01	6.82	3.13	1.50	1.43
Pus		4	4	5	5	1	9	4	4
a hydro gel		2.30	1.42	9.53	8.35	01.83	9.77	1.54	1.51
@5 kg ha ⁻¹									
Ver		4	4	6	6	1	1	4	4
mi compost		4.46	3.17	2.47	0.68	06.93	03.85	1.57	1.56
@ 1 t ha ⁻¹									
Pus		4	4	6	6	1	1	4	4
a hydro gel		6.97	5.62	5.98	4.09	12.95	09.71	1.58	1.57
@5 kg ha ⁻¹									
¹⁺									
Ver									
mi compost									
@1 t ha ⁻¹									
S		0	0	1	1	2	2	0	0
Em ±		.88	.68	.47	.52	.48	.52	.27	.12
C.D		2	3	4	4	7	7	N	N
. (P=0.05)		.97	.00	.38	.50	.46	.60	S	S

Different moisture conservation treatments had significant effect on the available NPK status of soil during twice the years of investigation. This might be due to more removal of nutrients by the crop under integration of Pusa hydrogel @5 kg ha⁻¹+ vermi compost @1 t ha⁻¹. Organic carbon was significantly highest in the treatment receiving Pusa hydrogel @5 kg ha⁻¹+ Vermicompost @1 t ha⁻¹ followed by Vermicompost @1 t ha⁻¹ which was significantly higher to Pusa hydrogel @5 kg ha⁻¹+ Vermicompost @1 t ha⁻¹. These results are closely related to the findings of Arguello *et al.* (2006) which observed that soil nutrient status was unaffected by various cultural and chemical moisture conservation treatments. On the contrary, Mahmood *et al.* (2004) reported that increase in the fertility levels and conservation of moisture by either mechanical or chemical method increased the available NPK status of soil after crop harvest.

Conclusion

After doing two years of study and research it can be concluded that the increased irrigation levels enhanced the growth, yield attributing characters, yield and productivity of wheat crop significantly, being highest with adoption of five irrigations (at CRI, Late tillering, jointing, Flowering and Milking stage). All the moisture conservation practices and applications of pusa hydrogel @ 5 kg/ha+Vermicompost @ 1 t/ha performed best with highest yield and quality. Thus, in wheat application of 5 kg pusa hydrogel+1 t/ha vermi-compost with five irrigations (at CRI, Late tillering, jointing, Flowering and Milking stage) seems to be best under the sandy loam soil of North Western Plain Zones of Western Uttar Pradesh.

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