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

Abstract

A field experiment was conducted duringwinter (*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 ofdifferentirrigation levels and moisture conservation practices on wheat crop.Threeirrigation levels were three viz., I_1 (at CRI stage), I_2 (at CRI, Booting and Milking) and I_3 (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 fiveirrigations seems to more effective in thesandy 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 compare to the other crops worldwide than any other; its 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 thesecond 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 ofthearea 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 ensuring better atmospheric condition for crop growth. Super absorbent polymer has capability to store extra water inthe soil that enables crops to utilize the water over an extended period. 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 etc., are collectively called hydrogel. 'Pusa Hydrogel'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 $^{\circ}$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 **(Ekebafee*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 absorbing and desorption overa long period, 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 pressuredifference.

Vermi-compost (VC) is produced by the fragmentation of organic wastes by earthworms, itcontains 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). 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, VC is a potential organic nutrient source, which provides additional plant nutrients that are not found in chemical NP fertilizers**. Simsek-Ersahin (2011)** revealed that VCwas effective organic fertilizers and bio-control agents that isimproved 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 VC 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 Uttarpradesh conditions.

Materials and Methods

The experiment was carried out in pots at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), geographically situated at a latitude of 29^0 40′ North, longitude of 77^0 42′ East with an altitude of 237 meters above mean sea level.

Climate and Weather

The climate of this region is semi-arid, sub-tropical with extreme hot weather in summer and cold in thewinter season. There isa 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 Precipitations 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 onweekly 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 thecrop development period, theminimum mean temperature was recorded 4.8°C in the 4th week of January in 2015-16 and 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 in the

3rd week of April in 2016-17(40.3°C).Aminimum mean evaporation was recorded (0.7 mm) in the 4th week of January and maximum (10.6 mm) was recorded on 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 on the 4th week of April in 2016-17. The total rainfall 38.7 and 123.3 mm was received duringthecrop 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 physic-chemical properties. The values obtained are shown 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 thegravimetric method for determination of soil moisture content and the average moisture percentage from different soil depths were used to calculatethe 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.

Available Nitrogen (kg ha^{-1})

Available N determined by alkaline potassium permanganate method given by Subbiah and Asija (1956).In this method, OMin the soil is oxidized witha 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. A soil sample of 5g was taken and transferred to digestion tube. The sample was distilled with 0.32% KMnO4 and 2.5% NaOH followed by heating of sample by passing steady steam and collection of liberated NH_3 ina 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 thecolour changed to original pink.

Available Phosphorus (kg ha^{-1})

Before estimation of available phosphorous the pH of soil sample was determined usingtheglass electrode pH meter. The pH of soil sample was 7.9alkaline ranges, so 0.5M $NaHCO_3$ extractable method was used given by Olsen's *et al.* (1954). 2.5 g of soil sample were weighed and a pinch of activated charcoal was added and mixed with anextraction solution (50 ml of 0.5M $NaHCO_3$ pH 8.5) with continuous shaking the solution for half an hour followed by afiltrate collection (5 ml) in 25 ml volumetric flask. 2-3 drops of p- Nitro phenol indicator was added to the filtrate resulting in yellow thecolor development thereby, addition of 5N H_2SO_4 drop by drop, until yellowthe 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 thesoil was expressed in kg ha^{-1}.

Available phosphorus ($kgha^{-1}$) = ppm of P calculated from standard curve × dilution factor×2.24.

Available Potassium (kg ha^{-1})

Available K in the soil extracted by 1Nammoniumacetate as an extract ant (Hanway & Heidel, 1952)and K in theextractwere 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 $65\underline{+}2^0$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 harvestand estimated separately from the selected plants of each plot. Oven dried plant samples were ground with the help of theWilly mill grinder. Total N, P & K contents were estimated by micro-Kjeldahl, vanadomolybdophosphoric acid yellow color and flame photometric method, respectively (Jackson, 1973).

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

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

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).

Grain protein content (%) = Nitrogen content in grains (%)×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 reveala significant effect of irrigation level and moisture conservation practices during both of the years.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 higher under the crop received five irrigations over one irrigation, followed by three irrigations during both the years. Crop supply by one 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. Controllead to reduction in N content in grains and straw than therest of the treatments. However, the effect was significantly 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-

Treatment	Nitrogen content (%)	Nitrogen uptake (kg ha^{-1})

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 one irrigation as against three and five irrigations during both the years (Table 1). 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 ashow significant increment in nitrogen uptake in grains and straw than therest 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 therest 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 affected by irrigation levels and moisture conservation practices

	Grains		Straw		Grains		Straw		Total	
	2015-16	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
Irrigation levels										
I_1 (at CRI stage)	1.64	1.62	0.39	0.35	68.02	65.97	19.96	17.50	87.98	83.47
I_2 (at CRI, Booting and Milking)	1.68	1.65	0.44	0.40	75.08	71.86	25.72	22.38	100.79	94.25
I_3 (at CRI, tillering, jointing, Flowering and Milking stage)	1.76	1.72	0.48	0.45	78.68	73.38	26.54	24.09	105.22	97.48
S. Em. ±	0.008	0.007	0.005	0.001	0.26	0.39	0.26	0.33	0.45	0.13
C.D. (P=0.05)	0.032	0.031	0.023	0.005	1.01	1.53	1.01	1.31	1.78	0.52
Moisture conservation practices										
Control	1.57	1.53	0.36	0.31	52.10	49.15	16.80	15.11	68.90	64.26
Pusa hydrogel @5 kg ha^{-1}	1.67	1.63	0.42	0.37	76.50	72.57	21.44	19.14	97.94	91.70
Vermi-compost @ 1 t ha^{-1}	1.75	1.71	0.47	0.43	81.13	77.81	26.32	23.39	107.46	101.20
Pusa hydrogel @5 kg ha^{-1}+Vermi-compost @1 t ha^{-1}	1.81	1.78	0.51	0.48	85.97	82.09	31.70	27.66	117.68	109.75
S. Em. ±	0.006	0.005	0.005	0.003	0.21	0.37	0.33	0.32	0.34	0.40
C.D. (P=0.05)	0.020	0.019	0.014	0.008	0.62	1.09	0.98	0.94	1.02	1.18

(Table No:1)

Phosphorous content in grains and straw

Application of fiveirrigations significantly resulted in maximum phosphorous content in grains (0.35 and 0.33 %) as against all other treatments during 2015-16 and 2016-17, respectively (Table2). 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. However, the differences among them were significantly during both the years. Control did measure least phosphorous content in grain (0.30 and 0.28 %) and straw (017 and 0.15 %) during both the years. Though, the effect was moresignificant than therest 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 remaining lower over vermi-compost @ 1 t ha^{-1}.

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

Phosphorus uptake in grains and straw was significantly lowest under the application of oneirrigation as against three irrigation and five irrigations during both the year(Table 2). Crop receiving 5-time irrigation was superior over other irrigation levels during both years. Moreover, in total uptake, crop receiving oneirrigation 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 a significant increment in phosphorous uptake in grains and straw than therest 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 pusahydrogel @ 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. However, control did remain inferior in respect to phosphorous uptake in grains and straw overtherest 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	P content (%)				P uptake (kg ha^{-1})					
	Grains		Straw		Grains		Straw		Total	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation levels										
I_1 (at CRI stage)	0.32	0.31	0.19	0.17	12.17	11.47	8.04	7.24	20.21	18.71
I_2 (at CRI, Booting and Milking)	0.33	0.32	0.21	0.19	13.18	12.82	8.62	7.62	22.08	20.85
I_3 (at CRI, Late tillering, Late jointing, Flowering and Milking stage)	0.35	0.33	0.22	0.20	14.43	13.22	8.90	8.11	23.05	20.94
S. Em. ±	0.001	0.002	0.002	0.001	0.18	0.08	0.06	0.05	0.21	0.10
C.D. (P=0.05)	0.006	0.009	0.007	0.006	0.72	0.31	0.23	0.23	0.81	0.39
Moisture conservation practices										
Co ntrol	0.30	0.28	0.17	0.15	9.98	9.85	5.69	4.82	15.66	14.67
Pusa hydrogel @5 kg ha^{-1}	0.31	0.30	0.19	0.17	12.72	12.02	8.10	7.23	20.82	19.25
Vermi-compost @ 1 t ha^{-1}	0.34	0.33	0.22	0.20	13.46	12.66	8.74	7.88	22.21	20.55

Pusa hydrogel @5 kg ha^{-1}+ Vermi-compost @1 t ha^{-1}	0.38	0.36	0.25	0.23	16.87	15.49	11.55	10.68	28.42	26.18
S. Em. ±	0.002	0.002	0.001	0.002	0.19	0.19	0.25	0.24	0.38	0.38
C.D. (P=0.05)	0.005	0.006	0.005	0.005	0.57	0.58	0.75	0.72	1.14	1.13

(Table No:2)

Potassium content in grains and straw

The content of K in grains and straw was significantly highest under the crop received five irrigations over one irrigation, followed bythree irrigations during both the year (Table 3). Crop supply by one 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 theone irrigation during both the years. Control did let toa reduction in potassium content in grains and straw than other treatments. Though, the effect was significantly 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 one irrigation as against three and five irrigations during both the years. Crop supply by 5-time irrigation was significantly recorded highest potassium uptake in grains and straw over other irrigation levels (Table3). Moreover, in total uptake, crop receiving five irrigations had removed

6.03% and 6.36 % more potassium over three irrigations, while 9.38% and 9.24 % over oneirrigation during 2015-16 and 2016-17, respectively.Crop grown under pusa hydrogel @ 5 kg ha^{-1} along with vermi-compost @ 1 t ha^{-1} dida 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 therest 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 affected by irrigation levels and moisture conservation practices

Treatment	**Potassium content (%)**				**Potassium uptake (kg ha^{-1})**					
	Grains		**Straw**		**Grains**		**Straw**		**Total**	
	2015-16	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
Irrigation levels										
I_1 (at CRI stage)	0.40	0.38	1.49	1.42	17.33	16.23	112.44	110.47	129.78	126.70
I_2 (at CRI, Booting and Milking)	0.43	0.41	1.60	1.55	18.82	17.97	115.06	112.16	133.88	130.13
I_3 (at CRI, tillering, jointing, Flowering and Milking stage)	0.46	0.44	1.74	1.66	21.64	20.34	120.32	118.07	141.96	138.41
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										
Control	0.39	0.38	1.47	1.41	15.76	14.71	109.81	108.03	125.58	122.74
Pusa hydrogel @5	0.41	0.39	1.53	1.48	17.84	16.96	114.56	112.54	132.40	129.50

kg ha^{-1}										
Vermi-compost @ 1 t ha^{-1}	0.44	0.42	1.66	1.59	20.66	18.89	117.94	115.34	138.61	134.23
Pusa hydrogel @5 kg ha^{-1}+ Vermi-compost @1 t ha^{-1}	0.47	0.45	1.77	1.69	22.80	22.17	121.44	118.34	144.24	140.52
S. Em. ±	0.002	0.002	0.007	0.008	0.19	0.15	0.16	0.19	0.24	0.24
C.D.(P=0.05)	0.005	0.006	0.021	0.024	0.56	0.44	0.48	0.56	0.71	0.72

(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 level treatments, thehighest 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%on 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.TheNPK contents increase might be due to the solubilizationeffect 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 of building material. Application different irrigation leveltreatments increased significantly the uptake of NPK in grain and straw over one 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 theexperiment. Among irrigation levels treatments five irrigation levels and one irrigation level 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 level 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 were recorded with fiveirrigation levels over1-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 were 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 mode 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), Akhter*et 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 five irrigations as compared withthe rest of the treatments. Moreover, three irrigations did also differ over one irrigation. Though, least protein content was noted with 1 irrigation. The mean protein content in five irrigations was 10.72 and 10.18 % + against 9.91 and 9.41 % under one 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 therest of the treatments, irrespective of the years. However, 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 lower 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. ±	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. ±	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 asignificant 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 increased with broadeningtheirrigation level where crop receiving five times irrigation did show its superiority to record maximum available nitrogen as compared to three irrigation and one irrigation. The increment under five irrigations was to the tune of was 7.3 % (2015-16) and 7.7 % (2016-17) as against one irrigation. However, one irrigation did showed inferiority over other treatments to record least grain 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 @ one t ha^{-1} was significantly recorded highest available nitrogen over its individual component, irrespective of the years. However, 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 one irrigation did record 8.8 and 6.8 % lower available phosphorous as against crop received five 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 @ one 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 @ one t ha^{-1} in order to recorded available phosphorous. Moreover, control did remain inferior over therest of its counterparts during both the years.

Available potassium

Irrigation level has alsoresultsignificant 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 five irrigations brought significant improvement in organic carbon over three and one 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 (%)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation levels								
I_1 (at CRI stage)	213.4	215.6	12.8	13.1	165.8	167.1	0.46	0.48
I_2 (at CRI, Booting and Milking)	222.3	224.5	13.0	13.9	171.3	174.3	0.47	0.49
I_3 (at CRI, Late tillering, Late jointing, Flowering and Milking stage)	229.9	232.2	14.0	14.1	177.2	179.1	0.48	0.50
S. Em. ±	0.3	0.2	0.19	0.08	0.2	0.2	0.003	0.003
C.D. (P=0.05)	0.9	1.0	0.74	0.31	0.6	0.6	0.008	0.007

Moisture conservation practices								
Control	212.2	214.3	12.0	12.3	167.3	168.9	0.46	0.46
Pusa hydrogel @5 kg ha^{-1}	219.4	221.6	12.9	13.4	170.2	172.6	0.47	0.47
Vermi-compost @ 1 t ha^{-1}	225.0	227.2	13.6	14.0	172.7	174.8	0.48	0.48
Pusa hydrogel @5 kg ha^{-1}+ Vermi-compost @1 t ha^{-1}	231.0	233.3	14.6	15.1	175.5	177.8	0.49	0.51
S. Em. ±	0.5	0.5	0.15	0.12	0.2	0.2	0.003	0.003
C.D. (P=0.05)	1.5	1.4	0.43	0.35	0.7	0.6	0.008	0.008
Initial value	**222.0**	**224.6**	**14.2**	**14.6**	**172.1**	**175.3**	**0.48**	**0.49**

(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). However, 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 was 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 andwater 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 in the year of experimentation. The crop water use increased markedly in five irrigation levels than three irrigation levels and one irrigation levelsduring 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/m^3, respectively. Among moisture conservation practices, water productivity varied from 1.22 to 1.33 and 1.20 to 1.32 kg grams/m^3, being highest under treatment ofPusa 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 measured 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 level 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 has been reported not only to improve the nutrient content in the soil but also helps tobring native irrigation into the available forms thus increasing the available nutrient contents in the soil. Moreover, organic manures crate better environment for biological activity in the soil, which results into more fixation of N and more solubilizing effect on another 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 Ahmadabadi*et al.* (2011) and Islam*et 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 were significantly higher than one irrigation levels. Studies conducted by various workers have established the fact of maintenance of soil fertility in terms of improved organic content and available nutrients inthesoil through the applications of organic manures in combination with chemical fertilizers in different ratio (Gupta and Seth, 1996 and Bulluck *et al.* (2002).

Table8: 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	Yields (q ha^{-1})						Harvest index (%)	
	Grain		Straw		Biological Yield			
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation levels								
I_1 (at CRI stage)	27.25	26.58	51.74	50.37	78.99	76.95	38.46	38.48
I_2 (at CRI, Booting and Milking)	42.75	41.63	57.72	56.21	100.48	97.84	42.54	42.55
I_3 (at CRI, Late tillering, jointing, Flowering and Milking stage)	46.01	45.02	73.62	72.02	119.62	117.03	44.43	44.44
S Em ±	0.30	0.47	0.59	0.68	0.87	1.12	0.12	0.18

C.D. (P=0.05)	1.28	1.82	2.32	2.67	3.62	4.58	0.45	0.59
Moisture conservation practices								
Control	30.71	28.12	56.11	55.01	86.82	83.13	41.50	41.43
Pusa hydro gel @5 kg ha^{-1}	42.30	41.42	59.53	58.35	101.83	99.77	41.54	41.51
Vermi-compost @ 1 t ha^{-1}	44.46	43.17	62.47	60.68	106.93	103.85	41.57	41.56
Pusa hydro gel @5 kg ha^{-1}+ Vermi-compost @1 t ha^{-1}	46.97	45.62	65.98	64.09	112.95	109.71	41.58	41.57
S Em ±	0.88	0.68	1.47	1.52	2.48	2.52	0.27	0.12
C.D.(P=0.05)	2.97	3.00	4.38	4.50	7.46	7.60	NS	NS

Different moisture conservation treatments had asignificant 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 undertheintegration of Pusa hydrogel @5 kg ha^{-1}+ vermi-compost @1 t ha^{-1}. Organic carbon was significantly higher in the treatment receiving Pusa hydrogel @5 kg ha^{-1}+ Vermi-compost @1 t ha^{-1}followed by Vermi-compost @1 t ha^{-1}which was significantly higher to Pusa hydrogel @5 kg ha^{-1}+ Vermi-compost @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 an 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 doingtwo 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 theadoption 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+Vermi-compost @ 1 t/haperformedbest with thehighest 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 best under the sandy loam soil of North Western Plain Zones of Western Uttar Pradesh.

Acknowledgements

The support received from the department of Agronomy of Sardar Vallabhbhai Patel university agriculture and technology Meerut U.P. India, is thankfully acknowledged.

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