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Effect of hydrogel with and without vermicompost on yield and yield attributes of Okra (*Abelmoschus esculentus*) in acid alfisol of Ranchi

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Abstract
Background: Hydrogel is a biodegradable super absorbent polymer that can hold 400-1500 g of water per gram of dry hydrogel. It may have a higher potential for storing water available for plant growth and production. The addition of hydrogel polymer can increase soil water retention capacity by 50-70% with proper amendment with various dosages of soil to hydrogel ratio. Due to the water resource crisis, water-saving agriculture is essential for sustainable development. Hydrogel polymer improves water penetration rate; hydrogel polymer has been used as water-retaining material in the arid and semiarid region under the limitation of supplementary irrigation sources and salinity conditions, Hydrogel is used to increase a water reservoir near the root system, increase the field capacity of different soils. In view of the potential of hydrogels to absorb and retain more soil moisture to sustain the crop, the experiment was conducted to see the potential of Pusa Hydrogel and SPG hydrogel in Ranchi condition.
Methods: The experiment was conducted during Rabi 2020 at Agrotechnology Park, Birsa Agricultural University, Ranchi to investigate the effect of hydrogel with and without vermicompost on yield and yield attributes of Okra (*Abelmoschus esculentus*) in acid alfisol. The experiment was laid out in a randomized block design with three replications along with fourteen treatments. Treatments included three concentrations of Pusa and SPG 1818 Hydrogel (5g, 10g, and 20 g each) mixed with 2 kg of vermicompost.
Result: The application of 20 kg of SPG 1818 hydrogel + 2 kg of vermicompost was recorded significantly higher plant height (97.2cm), branches per plant (2.5), pods per plant (2.29), leaves per plant (18.3), total pods per plot (540.3), root length (30.4 cm), root weight (41.5g), shoot weight (142.1g), and yield (77.4 q ha^{-1}) as compared to other treatments.

Keywords: Okra, hydrogel, growth parameters, yield

Introduction
Agriculture is subject to abiotic stresses (drought, salinity, and temperature), which are expected to get worse due to land degradation, urbanization, and climate change. The majority of India's land area is in arid and semi-arid regions. Water for irrigation is becoming scarce, and the world is looking for water-efficient agriculture. Food security is being threatened by rising food demand and dwindling water resources Kreye *et al*., (2009) [6]. As a result, proper management practices should be implemented to conserve moisture and increase the soil's water-holding capacity. For various reasons, including undulating soil, low water holding capacity, meager irrigation potential (10-12 percent only), and erratic monsoon behavior, agriculture in Jharkhand is rainfed with a mono-cropping system. The okra [*Abelmoschus esculentus* (L.) Moench] is a major vegetable crop grown worldwide in tropical, subtropical, and mild temperate regions. The world's largest growing belt includes temperate Asia, Southern Europe, Northern Africa, the United States, and the tropics. Okra is a member of the Malvaceae family. It is one of the most important vegetable crops grown during the summer and rainy seasons. Okra is a hot-weather crop that adapts well to the hot, humid climate. Frost, low temperatures, waterlogging, and drought are all threats. Jharkhand has 32540 ha of okra cultivation, with a total production of 447600 metric tones. Hydrogel (super absorbent polymer) is a water-retaining, cross-linked hydrophilic, biodegradable amorphous polymer which can absorb and retain water at least 400-1500 times of its original weight and make at least 95 percent of stored water available for crop absorption. Pusa Hydrogel and SPG 1818 hydrogel are indigenous products developed by IARI New Delhi to increase crop productivity per unit of available water and nutrients,

particularly in moisture-stressed agriculture. Hydrogels potentially influence soil permeability, density, structure, evaporation, and infiltration rates of water through soils. Particularly, the hydrogels increase the water holding capacity of the soil, reduce irrigation frequency, reduce fertilizer leaching, reduce compaction tendency of soil, reduce soil erosion and water runoff and increase the soil aeration and microbial activity. Eduardo *et al*., (2004) [4], Waleed Fouad Abobatta, (2019) [10] and Narjary *et al*., (2013) [8].

Materials and Methods

A field experiment was conducted at the Agrotechnology Park, Birsa Agricultural University Ranchi during the Rabi season 2020 for okra cultivation which is geographically located at 23°17'N latitude, 83°17' E longitude and at an altitude of 625 meters above MSL. It comes under a semi-arid and subtropical climate. The experimental field was sandy loam in texture with 55.6% sand, 35% salt, and 9.4% clay. The surface soil of the field was acidic with the medium in organic carbon 0.85%, available N 465 kg-ha^{-1}, available P_2O_5 28.72 kg-ha^{-1}, and available K_2O 238.5 kg-ha^{-1}.Besides bulk densities of the soil were 1.49 and 1.59 g-cm^{-3} in 0-15 and 15-30 cm depth. A statistically designed field experiment was laid out in uniformly sized plots in Randomized block design with fourteen treatments and three replications. Three concentrations of Pusa and SPG 1818 hydrogel (5kg, 10kg, and 20 kg) were used with and without vermicompost. The fertilizers were applied in the proportions of 100:50:50 NPK kg ha^{-1} in the form of urea, SSP, and MOP, respectively. The row to row and plant to plant spacing for okra was maintained at 25X40 cm respectively. The sowing of okra was done in the 2nd week of February in the year 2020. The details ofthe experiment is given below:

Experimental details

Crop: Okra
Varieties: Samrat (F1) hybrid
Design: RBD
Season: Summer season crop
Spacing: 25 cmX40 cm
Plot size: 3mX 3m

Method of recording observations

Observations were recorded on various growth and yield parameters such as plant height (cm), number of branches per plant, number of leaves, and number of pods at 20-days intervals. At harvest, total pods per plant, root length (cm), root weight (g), shoot weight, and yield per hectare were recorded. The data was statistically analyzed using Fisher's analysis of variance, as described by Gomez and Gomez (1984). The critical difference (CD) values are given at a 5% significance level where the F test was significant

Treatment details per plot

T1	Pusa hydrogel (5kg)	T8	T1+ Vermicompost (2Kg)
T2	Pusa hydrogel (10kg)	T9	T2+ Vermicompost (2Kg)
T3	Pusa hydrogel (20kg)	T10	T3+ Vermicompost (2Kg)
T4	SPG-1818 hydrogel (5kg)	T11	T4+ Vermicompost (2Kg)
T5	SPG-1818 hydrogel (10kg)	T12	T5+ Vermicompost (2Kg)
T6	SPG-1818 hydrogel (20k g)	T13	T6+ Vermicompost (2Kg)
T7	Control (No gel)	T14	T7+ Vermicompost (2Kg)

Result and Discussion

Plant height (cm)

The data pertaining to the effect of hydrogel with and without vermicompost on the plant height of okra are represented in Table 1. The effect of different hydrogel levels with and without vermicompost on plant height was also significant at all stages of plant growth. Plant height increased as the concentration of hydrogel increased. At 40, 60, 80, 100 and 120 DAS, T13 had the highest plant height (18.3, 30.5,50.5,88.5 & 97.2cm, respectively), and T7 had the lowest plant height (7.3,9.7, 28.0,55.0 and 61.7 cm, respectively) (20 kg of SPG-1818 hydrogel with vermicompost @ 2 kg-ha^{-1}) (without hydrogel and no vermicompost). At harvest, T13 (20 kg of SPG-1818 hydrogel with vermicompost @ 2 kg-ha^{-1}) had the highest plant height (97.2 cm), which was followed by T6 (96.7 cm) (20 kg of SPG-1818 hydrogel), and T7 had the lowest plant height (61.7 cm) (without hydrogel). Plant height increased significantly as the hydrogel content increased. Water availability and indirect nutrients provided by super absorbent polymer have been reported to increase the activity of cell division, cell expansion, and cell elongation, ultimately leading to an increase in plant height. Al-Harbi *et al*., (1999) [1] reported similar results in cucumber Kumaran *et al*., (2008) [7] in tomato Sivapalan S, (2001) [9] in soybean.

Table 1: Effect of hydrogel with and without vermicompost on plant height (cm) in Okra Crop.

Treatment	Plant height (cm)				
	40 DAS	60 DAS	80 DAS	100 DAS	Maturity
T1	9.3	13.7	32.0	63.0	70.0
T2	9.7	16.7	36.0	64.3	73.7
T3	12.0	19.3	37.7	70.0	81.0
T4	13.0	22.0	39.3	71.7	84.7
T5	16.0	26.3	41.7	81.3	88.7
T6	17.8	30.0	50.0	88.0	96.7
T7	7.3	9.7	28.0	55.0	61.7
T8	9.6	14.0	32.3	63.0	70.3
T9	10.1	17.1	36.4	64.7	74.1
T10	12.5	19.8	38.2	70.5	81.5
T11	13.3	22.3	39.6	72.0	85.0
T12	16.4	26.7	42.1	81.7	89.1
T13	18.3	30.5	50.5	88.5	97.2
T14	7.5	9.9	28.2	55.2	61.9
SEm±	1.2	1.8	1.7	2.5	3.5
CDat 5%	3.5	5.4	5.1	7.2	10.1

T1: Pusa hydrogel (5kg)	T6: SPG1818 hydrogel (20kg)	T11: SPG 1818 hydrogel (5kg) + V.C
T2: Pusa hydrogel (10kg)	T7: Control	T12: SPG 1818 hydrogel (10kg) + V.C
T3: Pusa hydrogel (20kg)	T8: Pusa hydrogel (5kg) + V.C	T13: SPG 1818 hydrogel (20kg) + V.C
T4: SPG 1818 hydrogel (5kg)	T9: Pusa hydrogel (10kg) + V.C	T14: Control+ V.C
T5: SPG1818 hydrogel(10kg)	T10: Pusa hydrogel (20kg) + V.C	

Number of branches

The data pertaining to the effect of hydrogel with and without vermicompost on the branches per plant of okra are represented in Table 2. At all stages of plant growth, the number of branches increased or decreased significantly in response to different hydrogel concentrations with or without vermicompost. The number of branches per plant at all growth stages was found to be significantly different among the other hydrogel treatments, with the highest average number of branches per plant (2.5) recorded in T13 (20 kg of SPG-1818 hydrogel with vermicompost @ 2 kg-ha^{-1}), which was on par with T12 (2.2) (10 kg of SPG-1818 hydrogel with vermicompost @ 2 kg-ha^{-1}). The lowest minimum number of branches per plant (1.2) was observed in T7. The highest average (without hydrogel). Increasing the concentration of hydrogel caused a significant increase in the number of branches produced per plant, which may have been caused by a considerable amount of water in the hydrogel structure and subsequent absorption of this water into the soil around plant roots, which increased the soil's water holding capacity and served to provide a buffer against product loss between two irrigations Woodhouse & Johnson MS, (1991) [11]. Similar results have been found by Kumar *et al*., (2018) in the ginger crop.

Table 2: Yield and yield attributes as influenced by the application of Pusa and SPG-1818 hydrogel with and without vermicompost in Okra crop.

Treatment	No. of branches	No. of leaves	No. of pods	Total pods/plot	Root length (cm)	Root weight (g)	Shoot weight (g)	Yield(q/ha)
T1	1.4	10.6	1.04	354.7	22.9	22.0	54.3	51.2
T2	1.5	12.2	1.17	365.0	24.3	23.3	61.7	55.3
T3	1.5	12.8	1.42	389.0	24.7	25.5	66.3	58.8
T4	1.6	13.1	1.46	432.3	25.6	26.9	75.8	61.8
T5	1.8	14.0	1.54	451.3	26.8	30.4	83.1	63.9
T6	2.0	15.6	1.79	503.3	29.7	34.3	102.0	74.6
T7	1.2	8.8	0.75	315.7	20.5	18.9	47.4	42.6
T8	1.6	11.3	1.09	386.3	23.2	22.9	57.0	52.3
T9	1.9	12.5	1.24	405.7	24.5	26.2	65.0	57.4
T10	2.0	13.4	1.61	417.0	25.3	28.8	71.6	59.0
T11	1.9	14.7	1.76	440.3	27.1	32.2	82.3	64.9
T12	2.2	16.5	1.94	461.7	28.7	36.2	98.1	68.9
T13	2.5	18.3	2.29	540.3	30.4	41.5	142.1	77.4
T14	1.3	10.0	0.95	348.7	21.4	19.3	54.4	47.9
SEM±	0.1	0.5	0.13	25.3	0.9	1.7	8.1	4.9
CD at 5%	0.3	1.5	0.37	74.0	2.7	4.9	23.7	14.2
CV	7.5	6.6	15.46	10.6	6.3	10.5	18.5	14.1

Number of leaves

The data pertaining to the effect of hydrogel with and without vermicompost on the leaves per plant of okra are represented in Table 2. The number of leaves per plant at all growth stages was found to be significantly different among the different hydrogel treatments, with the highest average number of leaves per plant (18.3) recorded in T13 (20 kg of SPG-1818 hydrogel with vermicompost @ 2 kg-ha^{-1}), which was on par with T12 (16.5) (5 kg of SPG-1818 hydrogel with vermicompost @ 2 kg-ha^{-1}). The lowest minimum number of leaves per plant (8.8) was recorded in T7 (without hydrogel). Similar results have been reported by Chaithra GM and Sridhara S, (2018) [2] in the maize crop.

Number of pods

The data pertaining to the effect of hydrogel with and without vermicompost on the pods per plant of okra are represented in Table 2. The number of pods per plant at all growth stages was significantly different among the different hydrogel treatments. The highest average number of pods per plant (2.29) was recorded in T13 (20 kg of SPG-1818 hydrogel with vermicompost@ 2 kg-ha^{-1}). The lowest minimum number of pods per plant (0.8) was recorded in T7 (without hydrogel).

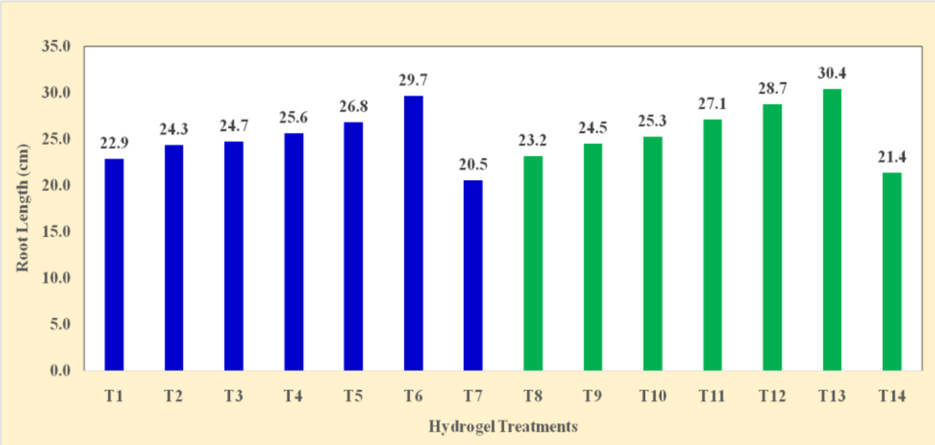
Total pods per plot

The data pertaining to the effect of hydrogel with and without vermicompost on the total pods per plant of okra are represented in Table 2. Pods per plot were significantly influenced by hydrogel levels, with the highest dose of SPG-1818 hydrogel (i.e., 20 kg of SPG1818 hydrogel with vermicompost) T13 producing the highest total pods per plot (504.3), followed by T12 (461.7) (10 kg of SPG1818 hydrogel with vermicompost) respectively. The lowest pods per plot were observed in T7 i.e., control (315.7).

Root length and root weight

The data pertaining to the effect of hydrogel with and without vermicompost on the root length (cm) and root weight (g) of okra are represented in Table 2 and Fig.1. Root length (cm) was found to be significantly influenced by hydrogel levels, with the highest dose of SPG-1818 hydrogel, i.e., 20 kg of SPG1818 hydrogel with vermicompost (T13), resulting in the longest root length (30.4 cm), which was followed by T6 (29.7 cm) (20 kg of SPG1818 hydrogel). In contrast, the minimum root length (cm) was observed in the control (20.5

cm). Likewise, there was a significant effect of SPG-1818 hydrogel concentrations on root weight (g), with the application of a higher dose of SPG-1818 hydrogel, precisely 20 kg of SPG-1818 hydrogel with vermicompost (T13), producing the highest root weight (41.5 g) followed by T12 (36.2 g) and T6 (34.3 g) (20 kg of SPG-1818 hydrogel). The lowest root weight was found in the control (i.e., no hydrogel was used) (18.9 g).

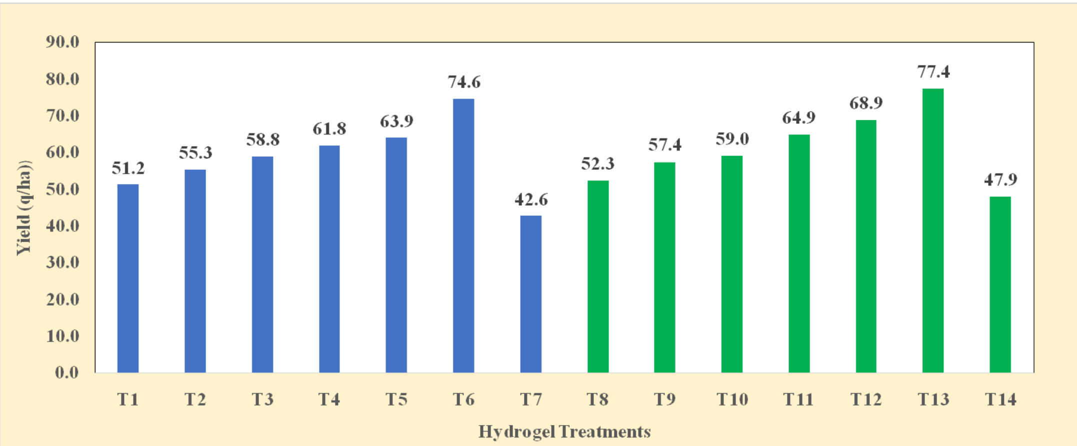


T1: Pusa hydrogel (5kg)	T6: SPG1818 hydrogel (20kg)	T11:SPG 1818 hydrogel (5kg) + V.C
T2: Pusa hydrogel (10kg)	T7: Control	T12:SPG 1818 hydrogel (10kg) + V.C
T3: Pusa hydrogel (20kg)	T8: Pusa hydrogel (5kg) + V.C	T13:SPG 1818 hydrogel (20kg) + V.C
T4: SPG 1818 hydrogel (5kg)	T9: Pusa hydrogel (10kg) + V.C	T14: Control+ V.C
T5: SPG1818 hydrogel(10kg)	T10: Pusa hydrogel (20kg) + V.C	

Fig1: Effect of hydrogel with and without vermicompost on root length of okra.

Shoot weight (g)
The data pertaining to the effect of hydrogel with and without vermicompost on the shoot weight (g) of okra are represented in Table 2.It was observed that hydrogel levels had a significant impact on shoot weight (g), with the application of a higher dose of SPG-1818 hydrogel, namely 20 kg of SPG-1818 hydrogel with vermicompost (T13), resulting in the highest shoot weight (142.1 g), which was followed by T6 (102.0 g) and T12 (98.1 g) (20 kg of SPG-1818 hydrogel with vermicompost). The lowest shoot weight was recorded in the control (47.4 g).

Yield (q/ha)
The data pertaining to the effect of hydrogel with and without vermicompost on the yield (q ha^{-1}) of okra are represented in Table 2 & Fig. 2. Significant differences in yield (q-ha^{-1}) were observed when different levels of hydrogel were used.
The highest yield (77.4 q ha^{-1}) was obtained by using the highest dose of SPG1818 (20 g with 2kg vermicompost, T13) followed by 74.6 q ha^{-1} under the treatment T6 (20 kg of SPG 1818). The lowest yield (42.6 q ha^{-1}) was recorded in the control (T7). Similar results have been reported by Dawlatzai *et al*., (2017) [3] in the coleus crop and Firouzeh Yazdani *et al*., (2007) [5] soybean.



T1: Pusa hydrogel (5kg)	T6: SPG1818 hydrogel (20kg)	T11:SPG 1818 hydrogel (5kg) + V.C
T2: Pusa hydrogel (10kg)	T7: Control	T12:SPG 1818 hydrogel (10kg) + V.C
T3: Pusa hydrogel (20kg)	T8: Pusa hydrogel (5kg) + V.C	T13:SPG 1818 hydrogel (20kg) + V.C
T4: SPG 1818 hydrogel (5kg)	T9: Pusa hydrogel (10kg) + V.C	T14: Control+ V.C
T5: SPG1818 hydrogel(10kg)	T10: Pusa hydrogel (20kg) + V.C	

Fig2: Effect of hydrogel with and without vermicompost on yield of okra.

Conclusion

Application of both (Pusa and SPG 1818) hydrogel had a significant positive effect on all morphological parameters of the okra plant. Among all the treatments, T13 (20 kg of SPG 1818 hydrogel with the addition of vermicompost) showed significantly better plant growth as compared to the other treatments.

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