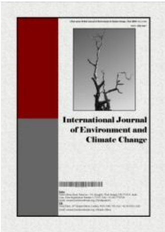

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Effect of Different Levels of Pusa Hydrogel on Soil Moisture Retention in Different Soil of Ranchi Region under Polyhouse Condition

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The pot experiment was conducted under polyhouse conditions during 2019 in Kharif season (August- December) in the Department of Agrometeorology and Environmental Science, Birsa Agricultural University, Ranchi, Jharkhand, India using Factorial Complete Randomized Design. The treatments consists three levels of Pusa hydrogel (5 g, 10 g, and 20 g) with three replications in upland, upper medium land and lower medium land soil. This study was carried out with specific objectives of the influence of Pusa hydrogel-induced varying soil moistures on the performance of the okra crop. Results revealed that the treatment T3 (20 g of Pusa hydrogel) recorded significantly high soil moisture content compared to all other treatments. It recorded the highest average soil moisture content (25.1% in upland,26.8% in upper midland, and 27.5% in lower midland soil) while the control i.e. without hydrogel (T7) recorded the least soil moisture content as 14.96% in upland, 15.55%. in upper midland and 15.57% in lower midland soil.

Keywords: Pusa hydrogel; upland soil; soil moisture.

1. INTRODUCTION

Irrigation water is increasingly scarce, and the globe is looking for agriculture that uses minimal water. Food security is being challenged by rising food consumption and diminishing water supplies. Kreye et al. [1]. So, under such areas, effective management techniques should be

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done to save moisture and boost the soil's water-holding ability. Agriculture in Jharkhand is rainfed with a mono-cropping system for so many reasons, such as undulating soil, low soil water holding capacity, meager irrigation potential (10-12 percent only, and erratic monsoon behavior. Regarding temperature and humidity, Jharkhand's climate is amicable and suitable for vegetable production. As a cash crop, it is cultivable in Jharkhand is very remunerative for farmers. Still, its cultivation is limited to small areas where guaranteed irrigation is available. Due to upland and medium soils' insufficient water retention capacity (hardly 20-22 percent at field capacity). Since the possibility of improving the irrigation, the potential is far away, and soil treatment with some moisture absorbent material would increase the water-retentive capacity much more often, requiring less frequent irrigation of vegetable crops. Therefore, more and more areas would be included in the cultivation of vegetables, including using precise vegetable farming practices.

Okra (*Abelmoschus esculentus* (L.) Moench) is a popular edible vegetable crop grown in tropical, subtropical, and mild temperate zones. The world's largest growing belt comprises temperate Asia, Southern Europe, Northern Africa, the United States, and the tropics. Okra belongs to 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 and acclimatizes well in the hot, humid climate. It is susceptible to frost, low temperatures, waterlogging, and drought. Dhaliwal, [2].

Pusa hydrogel is a semi-synthetic super absorbent polymer that has been developed by the Indian Agriculture Research Institute. It sticks to the roots of the trees and when the soil moisture falls as the temperature rises, the gel sheds water to nourish the crop Sindhu, [3] and it is developed to enhance the crop productivity per unit of available water and nutrients, particularly in moisture stress agriculture. Dar et al., [4] & Narjary et al., [5] Hydrogels may exhibit drastic volume changes in response to specific external stimuli, such as the temperature, solvent quality, pH, electric field, etc. Tanaka, (1978). It reduces the leaching of herbicides and fertilizers, improves the physical properties of soils. It reduces the irrigation and fertigation requirements of crops [6]. Hydrogel has been used to reduce runoff and increase infiltration rates in field agriculture in addition to increasing water holding capacity for agricultural applications [7]. This function is particularly important in dry seasons, as the hydrogel will hold soil moisture in water-limited areas and feed the necessary water into the root system of the plant [8].

2. MATERIAL AND METHODS

The pot experiment was conducted under polyhouse conditions during 2019 in Kharif season (August- December) in the Department of Agrometeorology and Environmental Science, Birsa Agricultural University, Ranchi which is geographically located at 23°17' N latitude,83°17' E longitude and at an altitude of 625 metres above MSL. It comes under a semi-arid and subtropical climate. The experiment was laid out in the factorial complete randomized design with 3 treatments of Pusa Hydrogel levels (5g, 10g, and 20 g) and 3 replications in various types of soils viz, upland, Upper medium land, and Lower medium land soils.

Table 1. Physio-chemical properties of the soil

A.Physical Properties						
Particulars	**Upland**		**Upper midland**		**Lower midland**	
Sand (%)	72.8		62.8		60.8	
Silt (%)	7.2		16.2		11.2	
Clay (%)	20		21		28	
Texture	Sandy clay loam		Sandy clay loam		Sandy clay loam	
	0-15 cm	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
Bulk density ($g\text{-}cm^{-3}$)	1.53	1.55	1.57	1.73	1.54	1.58
B. Chemical properties						
Ph	5.3		5.5		6.6	
Organic Carbon (%)	0.325		0.525		0.525	
N (kg ha^{-1})	285.4		357.5		470.4	
P_2O_5 (kg ha^{-1})	12.3		33.3		40.0	
K2O (kg ha^{-1})	164.96		207.21		227.36	

Chart 1. Treatment Details per pot

Pusa Hydrogel	Soil
T1-Pusa Hydrogel (5g)	S1- Upland Soil
T2-Pusa Hydrogel (10g)	S2- Upper midland soil
T3-Pusa Hydrogel (20g)	S3-Lower midland soil

The fertilizers were applied as per the recommended dose of the crop in the proportion of 100:50:50 NPK kg ha^{-1}. It was applied in the form of urea, SSP, and MOP respectively i.e., 2g of urea, 4g of SSP, and 3 g of potash were applied in all pots before sowing. The Okra Samrat F1 hybrid is a used. It is a tall vigorous plant. It is an excellent fruit quality with an attractive dark green thick pentagonal shape. It is good fruit weight length is 14-16 cm. It gives a high yield. The soil moisture regimes were monitored at a regular interval of 3 days from sowing to maturity. For this, soil samples from moisture content were taken at the mid-point of the pot and it was determined by using a digital soil moisture meter.

3. RESULTS AND DISCUSSION

Effect of Pusa Hydrogel applications on Soil moisture retention at different stages of crop in different soils.

3.1 Upland Soil

Soil moisture contents at different days after sowing (DAS) were monitored regularly at 3 days intervals through soil moisture probe in all the treatments and replications. The average soil moisture contents of Pusa Hydrogel treated pots, having upland soil (T1-T3) along with control pot (T7) have been depicted through Fig. 1 (Table 2).

Three days after irrigation followed by sowing of Okra, the average soil moisture content in T1 (5 g gel/pot), T2 (10 g gel/pot), T3 (20 g gel/pot) and T7 (no gel-control) were 21, 26.1, 27.5 and 28.7 percent, respectively. The Field Capacity (FC) and Wilting Point (WP) of untreated soil was on an average 22% and 10% respectively. However, the field capacity of gel treated soils increased to slightly over untreated soil (T7-control),4.1% in T1,5.5% in T2 and 6.7% treatments as observed at 3rd days of water application. The very 1st observation of soil moisture after 3 DAS reveals that the water holding capacity of gel treated soils increased considerably, maximum in T3 followed by T2 and T1.

The soil moisture content in all treatments depleted gradually till 24th DAS. The moisture content, in T7 (control), depleted to 11% which was 50% of Field Capacity (FC 22%), the adopted criteria for irrigation. This criteria, for watering, was followed only in case of the moisture contents of control (T7) pots. Hence, all the pots were watered though the treated pots still had good amounts of moisture. The soil moisture depletion between 3 DAS and 24 DAS was very steep in case of T7 where as the depletion was gradual and steady in gel treated pots. During this period, the highest soil moisture was maintained in T3 pot (20 g gel/pot) which depleted from 28.7% (3 DAS) to 24.1 % (24 DAS). It was followed by T2 and T1, depleting from 27.5% to 22.9% and 26.1% to 22 5 %, respectively. On 24th DAS all the pots were watered which brought the soil moisture contents at the maximum as recorded in next reading (27th DAS) where in T7 reached to 19.7% only whereas the soil moisture contents in T1, T2 and T3 reached to 24.5, 25.6 and 26.7 percents, respectively. The trend of moisture depletion after watering was maintained more or less in same order till 78th DAS when the last watering was done. After 78th DAS no watering was done as the crop didn't need watering as well as it was to be seen that to what extent gel treated and untreated soils retain moisture. It could be visualized from the figure that till the last watering on 78th DAS there was a gap of 7-11% moisture between control (T7) and the best performing treatment (T3) through, almost uniformly till 78th DAS. However, after 78th DAS (last watering) the gap between untreated control (T7) and treated (T1-T3) ones widened markedly. From 81st DAS to 105th DAS moisture content in T7 depleted from 18.4% to 8.1% (below the wilting point) whereas in treated pots it depleted from 22.5% to 19.3% (T1), 25.5% to 20.4% (T2) and from 25.6% to 21.6% (T3). Its an amazing observation that in case of no watering gel treated soils maintained very good soil moisture status, much above field capacity till 105th DAS and would have not depleted to WP for many more days, had the observations continued. On the other hand, untreated soils (T7) exhibited very sharp soil moisture depletion and approached up on 93rd DAS and depleted to much below WP on

105th DAS. Here it is assumed that Okra crop growing in gel treated soils would have required much less frequent watering as compared to untreated soils. Similar results have been reported by Abedi et.al., [9] and Pragnya et.al.,[10]. Advantage of gel incorporation seems to be very high as it imparts moisture support to the crop for longer period requiring less frequent watering/irrigation. However, the advantage of higher levels of gel incorporation seems to be very limited as the difference in moisture content between different levels, 5 g gel/pot(T1), 10 g gel/pot(T2) and 20 g gel/pot (T3) is of around 1% only. Though the higher levels of Pusa Hydrogel incorporation have exhibited higher soil moisture retention even the lowest level of 5 g gel/pot (T1) which corresponds to 6 kg/ha would be sufficient for comfortable cultivation of Okra and such other vegetables in moisture scarce situations. In view of the high cost of Hydrogels opting for the lowest level (5 g gel/pot or 6kg/ha) would reduce the cost of cultivation as compared to higher levels.

It can now be inferred those different levels of Pusa Hydrogel incorporation increased the ability of soil to hold and retain more moisture with steady and gradual release of soil moisture as compared to untreated soils.

3.2 Upper Medium land Soil

The average soil moisture contents of Pusa Hydrogel treated pots, having upper medium land soil (T1S2-T3S2) along with control pot (T7S2) have been depicted through Fig. 2 (Table 2).

The trends of soil moisture variations in upper medium land soil, in response to different levels of Pusa Hydrogel incorporation, was observed to be similar to that of upland soil but the extent of soil moisture retention in this soil was little higher than upland soil which would be attributed to higher soil moisture retention ability of upper medium land soil as compared to upland soil. The average soil moisture content in T1 (5 g gel/pot), T2 (10 g gel/pot), T3 (20 g gel/pot) and T7 (no gel-control) were 27.6, 28.7, 29.1 and 21.6 percent, respectively on 3rd day after irrigation followed by sowing of Okra,. Field capacity of gel treated soils increased over untreated soil (T7-control), 5.6% in T1, 6.7% in T2 and 7.1% in T3 treatments as observed after 3 days of water application. The very 1st observation of soil moisture after 3 DAS reveals that the water holding capacity of gel treated soils increased considerably, maximum in T3 followed by T2 and T1. In upper medium land soil too, the soil moisture content in all treatments depleted gradually till 27th DAS. The moisture content, in T7 (control), depleted to 11.1% which was 50% of Field Capacity. At this point all the pots were watered though the treated pots still had good amounts of moisture. The soil moisture depletion between 3 DAS and 27 DAS was very steep in case of T7 where as the depletion was gradual and steady in gel treated pots. During this period, the highest soil moisture was maintained in T3 pot (20 g gel/pot) which depleted from 29.1% (3 DAS) to 25,2 % (27 DAS). It was followed by T2 and T1, depleting from 28.7% to 24.1% and 27.6% to 23.6 %, respectively. As all the pots were watered on 27th DAS (3 days later than watering in upland soil) the soil moisture contents increased to the maximum as recorded in next reading (30th DAS) where in T7 reached to 21% only whereas the soil moisture contents in T1, T2 and T3 reached to 26.7, 27.6 and 28.7 percents, respectively. The trend of moisture depletion after watering was maintained more or less in same order till 81st DAS when the last watering was done. After 81st DAS no watering was done as the crop didn't need watering as well as it was to be seen that to what extent gel treated and untreated soils retain moisture. In upper medium land soil, till the last watering on 81st DAS there was an average gap of 11.5% moisture between control (T7) and the best performing treatment (T3), almost uniformly till 81st DAS. However, after 81st DAS (last watering) the gap between untreated control (T7) and treated (T1-T3) ones widened markedly. From 84th DAS to 105th DAS moisture content in T7 depleted from 19.5% to 8.7% (below the wilting point) whereas in treated pots it depleted from 25.5% to 21.6% (T1), 26.7% to 22.7% (T2) and from 27.8% to 23.5% (T3). It is again observed that in case of no watering, gel treated soils maintained very good soil moisture status, much above field capacity till 105th DAS and would have not depleted to WP for many more days, had the observations continued. On the other hand, untreated soils (T7) exhibited very sharp soil moisture depletion which depleted to below WP on 99th DAS itself and depleted further to much below WP on 105th DAS. Here too, it is assumed that Okra crop growing in gel treated soils of upper medium land would have required much less frequent watering as compared to untreated soils. In upper medium land the highest average soil moisture retention of 26.8% was found in case of the treatment T3 with 72.4 % advantage over control (T7). This was followed by T2 and T1 having retained 25.9 and 24.7 percent soil moisture with 66.4% and 58.6% advantages, respectively over control (T7). Similar results has been reported by Rehman et.al. [11]. Impact of incorporation of Pusa Hydrogel in upper midland too has been observed even higher than upland soil. It imparted moisture support to the crop for longer period requiring less frequent watering/irrigation. However, the advantage of higher levels of gel incorporation seems to be limited as the difference in moisture content between different levels, 5 g gel/pot(T1), 10 g gel/pot(T2) and 20 g gel/pot (T3) is of around 1-2% only. Though the higher levels of Pusa Hydrogel incorporation have exhibited higher soil moisture retention even the lowest level of 5 g gel/pot (T1) would be sufficient for comfortable cultivation of Okra and such other vegetables in moisture scarce situations. In view of the high cost of Hydrogels opting for the lowest level (5 g gel/pot) would reduce the cost of cultivation as compared to higher levels.

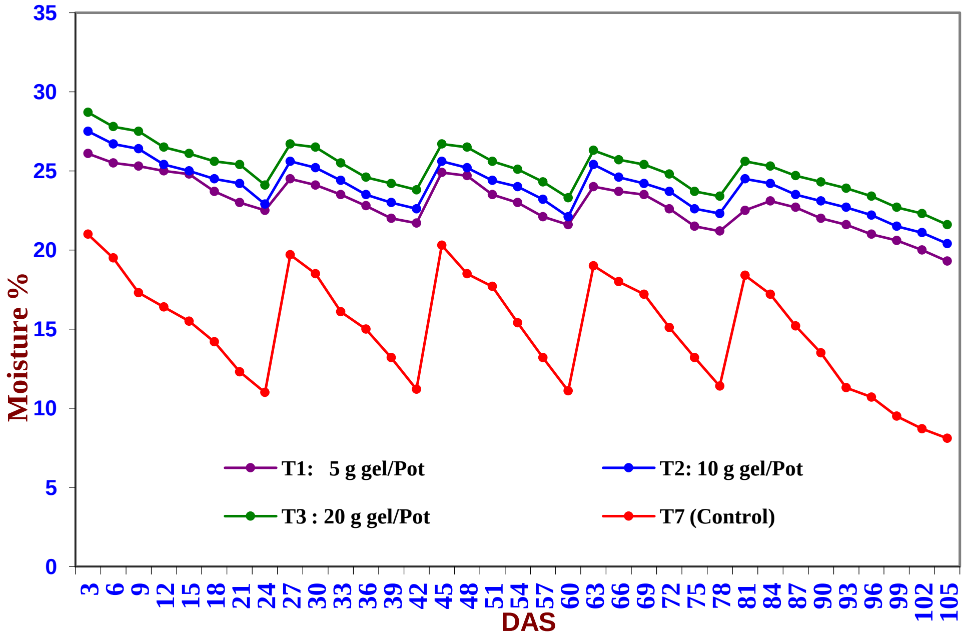

Fig. 1. Effect of different levels of Pusa Hydrogel on soil moisture retention in Upland Soil

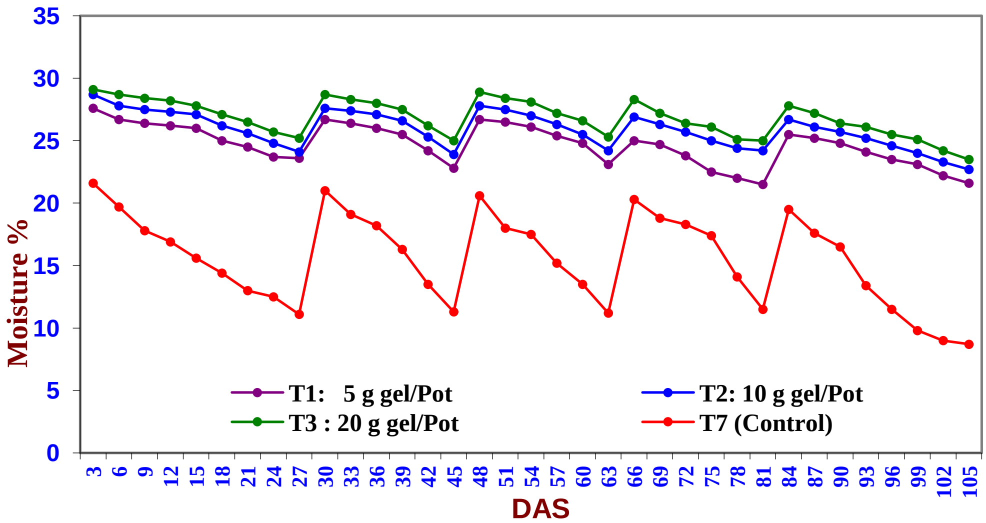

Fig. 2. Effect of diferent levels of Pusa Hydrogel on soil moisture retention in upper medium land Soil

Table 2. Effect of Pusa Hydrogel on soil moisture retention in different soil

Tr	Soil moisture			Tr	Soil moisture		
	DAS Average	**Percent above control**	**Percent over control**		**DAS Average**	**Percent above control**	**% over control**
Pusa Hydrogel							
T1S1	22.96	8.00	53.5	T1S1	23.0	8.0	53.5
T1S2	24.67	9.11	58.6	T2S1	23.9	9.0	59.9
T1S3	25.59	10.02	64.3	T3S1	25.1	10.1	67.6
T1 Soil Av	**24.41**	**9.05**	**58.9**	**S1 Tav**	**24.0**	**9.0**	**60.3**
T2S1	23.93	8.97	59.9	T1S2	24.7	9.1	58.6
T2S2	25.89	10.33	66.4	T2S2	25.9	10.3	66.4
T2S3	26.67	11.09	71.2	T3S2	26.8	11.3	72.4
T2 Soil Av	**25.49**	**10.14**	**66.0**	**S2 Tav**	**25.8**	**10.2**	**65.8**
T3S1	25.07	10.11	67.6	T1S3	25.6	10.0	64.3
T3S2	26.82	11.27	72.4	T2S3	26.7	11.1	71.2
T3S3	27.53	11.95	76.7	T3S3	27.5	12.0	76.7
T3 Soil Av	**26.47**	**11.12**	**72.4**	**S3 Tav**	**26.6**	**11.0**	**70.8**
Control (No Gel)							
T7S1	14.96						
T7S2	15.55						
T7S3	15.57						
T7 Soil Av	**15.36**						

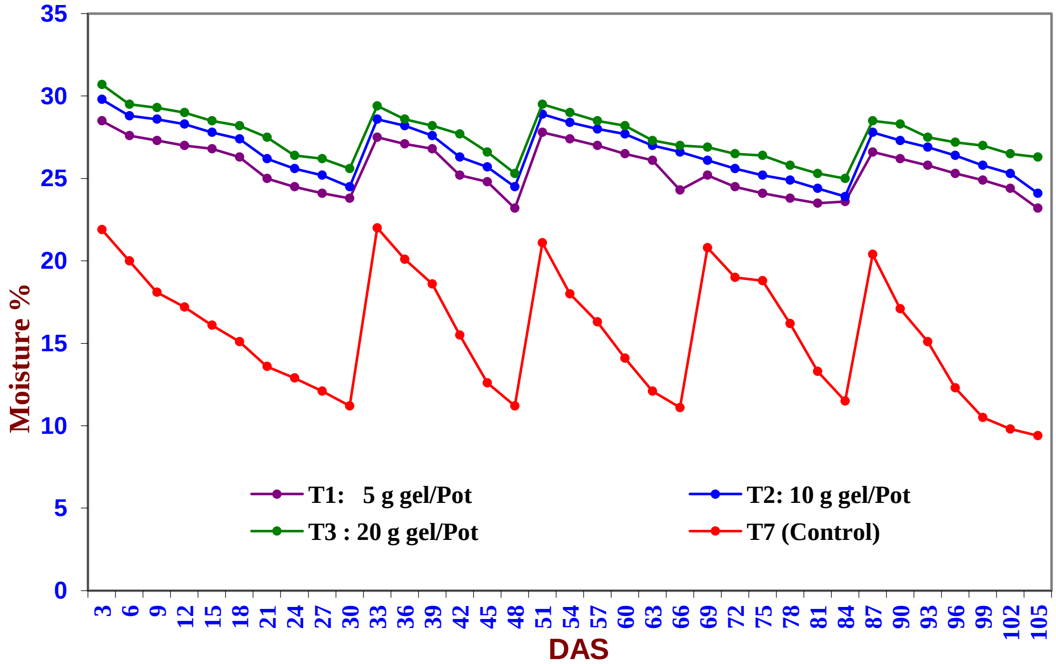

Fig. 3. Effect of diferent levels of Pusa Hydrogel on soil moisture retention in lower medium land Soil

3.3 Lower Medium land Soil

The average soil moisture contents of Pusa Hydrogel treated pots, having lower medium land soil (T1S3-T3S3) along with control pot (T7S3) have been depicted through Fig. 3 (Table 2).

In lower medium land soil also, the trends of soil moisture variations, in response to different levels of Pusa Hydrogel incorporation, was observed to be almost similar to those of upland and upper medium land soil but the extent of soil moisture retention in this soil was even higher than upper medium land soil which would be attributed to higher soil moisture retention ability of lower medium land soil as compared to upper medium land and upland soils. Soil moisture content in T1 (5 g gel/pot), T2 (10 g gel/pot), T3 (20 g gel/pot) and T7 (no gel-control) on an averages, were 28.5, 29.8, 30.7 and 21.9 percents, respectively on 3rd day after irrigation followed by sowing of Okra,. Field capacity of gel treated soils increased over untreated soil (T7-control), 6.5% in T1, 7.8% in T2 and 8.7% in T3 treatments as observed after 3 days of water application. The very 1st observation of soil moisture after 3 DAS reveals that the water holding capacity of gel treated soils increased considerably, maximum in T3 followed by T2 and T1. The soil moisture content in all treatments in lower medium land soil depleted gradually till 30th DAS. The moisture content, in T7 (control), depleted to 11.2% which was 50% of Field Capacity. At this point all the pots were watered though the treated pots still had good amounts of moisture. The soil moisture depletion between 3 DAS and 30 DAS was very steep in case of T7 where as the depletion was gradual and steady in gel treated pots. During this period, the highest soil moisture was maintained in T3 pot (20 g gel/pot) which depleted from 30.7% (3 DAS) to 25.6 % (30 DAS). It was followed by T2 and T1, depleting from 29.8% to 28.6% and 28.5% to 24.5 %, respectively. All the pots were watered on 30th DAS (3 days later than watering in upper medium land soil) the soil moisture contents increased to the maximum as recorded in next reading (33rd DAS) where in T7 reached to 22% only whereas the soil moisture contents in T1, T2 and T3 reached to 27.5, 28.6 and 29.4 percents, respectively. The trend of moisture depletion after watering was maintained more or less in same order till 84th DAS when the last watering was done. After 84th DAS no watering was done as the crop didn't need watering as well as it was to be seen that to what extent gel treated and untreated soils retain moisture. Soil moisture contents maintained an average gap of 12% between untreated control pot (T7) and the best performing treatment T3 (20g gel/plot) almost uniformly till 84th DAS in lower medium land soil. However, after 84th DAS (last watering) the gap between untreated control (T7) and treated (T1-T3) ones widened markedly. From 87th DAS to 105th DAS moisture content in T7 depleted from 20.4% to 9.4% (below the wilting point) whereas in treated pots it depleted from 26.6% to 23.2% (T1), 27.8% to 24.1% (T2) and from 28.5% to 26.3% (T3). It is again observed that in case of no watering, gel treated soils maintained very good soil moisture status, much above field capacity till 105th DAS and would have not depleted to WP for many more days, had the observations continued. On the other hand, untreated soils (T7) exhibited very sharp soil moisture depletion which depleted to below WP on 102 DAS itself and depleted further to much below WP on 105th DAS. Here too, it is assumed that Okra crop growing in gel treated soils of lower medium land would have required much less frequent watering as compared to untreated soils. The highest average soil moisture retention of 27.5% was found in case of the treatment T3 with 76.7% advantage over control (T7). This was followed by T2 and T1 having retained 26.7 and 25.6 percent soil moisture with 71.2% and 64.3% advantages, respectively over control (T7). Similar results has been reported by Shankarappa et.al.,[12] Again the advantages of incorporation of different levels of Pusa Hydrogel in lower medium land too, has been observed even higher than upper medium land soils. It imparted moisture support to the crop for even longer period requiring less frequent watering/irrigation. However, the advantage of higher levels of gel incorporation seems to be limited as the difference in moisture content between different levels, 5 g gel/pot(T1), 10 g gel/pot(T2) and 20 g gel/pot (T3) is of around 1-2% only in this soil also. Though the higher levels of Pusa Hydrigel incorporation have exhibited higher soil moisture retention even the lowest level of 5 g gel/pot (T1) would be sufficient for comfortable cultivation of Okra and such other vegetables in moisture scarce situations. In view of the high cost of Hydrogels opting for the lowest level (5 g gel/pot) would reduce the cost of cultivation as compared to higher levels.

4. CONCLUSIONS

It can now be inferred that different levels of Pusa Hydrogel incorporation increased the ability of soil to hold and retain more moisture with steady and gradual release of soil moisture requiring less and less frequent watering as compared to untreated soils. This advantage increased with higher levels of gel incorporation. But inter difference in moisture retention among the levels remaining only 1-2 percent. Hence, the lowest level of 5 g gel/pot too, could be much more advantageous over no gel incorporation. All these impacts were marginal more in lower topo-sequences than upper ones.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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