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Effect of hydrogel and nano solution on agro-meteorological indices of greengram

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Abstract
India is the largest producer and consumer of pulses in the world accounting for about 35 percent and 25 percent of world's area and production respectively. A field experiment was conducted to study climate resilient crop management practices for increasing production and productivity of greengram in rice fallow by application of hydrogel and nano solution at the instructional farm, Odisha University of Agriculture and Technology, Bhubaneswar during *rabi* 2018-19. The experiment was with sixteen treatments with combination of two cultivar such as Virat and IPM 02- 14 and eight combination of moisture saving elements along with control of environmental and improved practice. All the plants grown in T_8 (Plants grown with Improved practice, Hydrogel, Nano Solution and *Trichoderma*) with Virat variety produces maximum yield and required less water and its water use efficiency was also high. Due to treatment with hydrogel and nano solution the root proliferation occurs and number of root nodules were also increased and it provides maximum yield. As we known root always goes in search of water. So where we applied hydrogel water was available with in a short distance. For this reason the growth of plant is very good here and the plants finish their life cycle at exact time. Where as in drought condition where water is not available the plants are completed their life cycle with in short period of time. So in farmers practice it requires very less GDD (1098.9 ^oC), HTU(7783.8 ^oC hr) and PTU(12455.6 ^oC hr). Where as highest GDD(1132.5 ^oC), HTU(7974.2 ^oChr) and PTU(13075.8 ^oC hr) recorded in the plants grown in T_8 (Plants grown with Improved practice, Hydrogel, Nano Solution and *Trichoderma*).

Keywords: Hydrogel, nano solution, rabi season, Virat, IPM 02- 14, GDD, HTU, PTU

Introduction
India is the world's largest producer as well as consumer of green gram (*Vigna radiata* L.). Green gram output accounts for about 10-12% of total pulse production in the country. To meet the needs of pulses the traditional rice fallows can be converted into productive lands by growing green gram. Different chemicals like hydrogel and Nano solutions are used to conserve the soil moisture in rabi season.

Hydrogels are a family of super absorbent polymers with a swelling potential to absorb between 350-500 times their weight in pure water. The application of hydrogel in arid and semi–arid regions improve soil properties, increases the water holding capacity of the soil, enhance the soil water retention, improving irrigation efficiency, increase the growth of various crops, and enhancement water productivity of the crop. It also provides a conducive atmosphere for the better growth of roots in well–drained soils and ultimately increases the yield. According to chemical and physical structures of hydrogels, it can be used as absorbent in environment preservation in the agricultural sector as water retention, soil conditioners, and nutrient carriers (Waleed Abobatta., 2018). The hydrogel modified the soil water retention properties. The soil moisture at field capacity increased with the highest hydrogel percentage up to 400% compared to the not amended soil, and at wilting point (-15 bar) was similar to that at field capacity of the not amended soil (Montesano *et al.*,2015) [3]. The addition of hydrogel increased the moisture content at field capacity of both sandy loam and loam soils. The effects of hydrogel treatment in sandy loam soil on seed germination or seedling growth of chickpea were not consistent. Seed germination was significantly higher in 0.2% gel treatments compared with control. (Akhter *et al.*, 2004) [1]. In loamy and clay soils, AWC is almost doubled (1.8–2.2 fold) at maximum compared to the control.

Thus, application of hydrogels can result in significant reduction in the required irrigation frequency (Koupai *et al*., 2008) [2].

"Nano-solutions" is an organic compound which helps plant root enhancement. For rice and legume crops grown in rainfed environments application of "Nano solutions" may increase both subsurface (15-30 cm) soil moisture content and nutrient availability. With the use of such nanomaterials rice fallow areas in Odisha can potentially be brought under cultivation with green gram in the dry season resulting directly in increases the productivity of the cropping systems and farmers' income. Different Agro-meteorological indices are Growing degree days (GDD), Photo thermal unit (PTU), Helio thermal unit (HTU)are popular because of its simplicity in the field of agriculture for guiding the farmers in areas of forecasting the planting and harvesting, modifying microclimate, forecasting incidence of disease and pests. Plant growth is basically controlled by length of day and night and heat requirements vary with photoperiod. As such, the product of summation of day length and summation of temperature may provide a less variable unit to discuss the phenological stages than the temperature units alone.

Methodology

The present experiment was laid out at the Agrometeorology research field of College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar during rabi 2018-19. The experimental site is situated at 20º 15'N Latitude and 85º 52' E Longitude at an elevation of 25.9 m above the mean sea level and at about 64 km away from the Bay of Bengal. It comes under the East and South Eastern Coastal Plain Agroclimatic Zone of Odisha. The field experiment was conducted in a Factorial Randomized Block Design with three replications. Eight treatments were randomly allotted to the plots as per the lay out plan. Two varieties of green gram such as Virat and IPM 20-14 are used here. The dimension of experimental area was 30 x 35m^2 with each sub plot dimension. The experimental plots are provided with irrigation channels of 1 meter and the individual plots are demarcated with bunds. Several observations were taken according to the need of research work including pre-harvest, post-harvest and weather data.

Pre harvest observations

Pre-harvest observations include tagged plant data where three tag plants will be selected from each plots and data on height of the plants, number of branches, total number of leaves and number of leaves in main shoot will be observed in 15 days interval. For taking leaf area-data sample plants will be collected and leaf area data will be taken and dry weight of shoot and root leaf, no. and weight of nodules and different growth indices like Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR) are taken. Phenologi cal observation dates of occurrence of following phenological stages are visually noted, flowering, pod initiation, pod filling, physiological maturity.

Post-harvest observation Observations on following post-harvest operations are noted Pods per plant (no.), Seeds per pod (no.), 1000 seed weight (g), Seed yield (kg ha^{-1}), Haulm yield (kg ha^{-1}), harvest index (%).

Agro-meteorological Indices

Different agro-meteorological indices were also observed such as GDD, HTU, PTU.

Growing degree days (GDD)

Growing degree days (GDD), also called growing degree units (GDUs) or heat unit. A heat unit is the departure from the mean daily temperature. Heat unit or GDD are calculated as indicated below:

$$GDD = \frac{T\max - T\min}{2} - T_b$$

Where, Tmax is maximum temperature (ºC), Tmin is minimum temperature (ºC) and Tb is the base temperature (ºC= 10 ^{0}C).

The sum of difference between mean temperature and base temperature or threshold temperature gives the GDD. The base temperature is the temperature below which no growth takes place. It varies with the crops, generally, higher values for tropical crops and lower values for temperate crops.

Photo thermal unit (PTU)

Plant growth is basically controlled by length of day and night and heat requirements vary with photoperiod. As such, the product of summation of day length and summation of temperature may provide a less variable unit to discuss the phenological stages than the temperature units alone.

It has been found that photothermal units, obtained by multiplying the day degrees with photoperiod

PTU = GDD*L

Where GDD is growing degree days and L is maximum possible sunshine hour.

Helio thermal unit (HTU)

This is calculated by multiplying GDD with actual bright sunshine hour measured with sunshine recorder.

HTU = GDD* BSS

Where GDD is growing degree days and BSS is bright sun shine hours.

Result and Dissection

The observations were recorded at germination, flowering, pod initiation stage. Maturity data presented in Table-1 revealed that lesser GDD (1089 ºC) gives lowest yield that is 472.1 kg/ha in the plants grown in Farmers practice. The total GDD requirement of the crop varies between 1090 ºC to1133 ºC approximately. If we grow plants only by applying hydrogel that is without Trichoderma and nano solution then also it required comparatively high GDD (1109.6 ºC) than T_8 (Plants grown with Improved practice, Hydrogel, Nano Solution and *Trichoderma*). Whereas the lowest yield recorded at lowest GDD (1089.9 ºC) in farmers practice. From the Table it is found that highest GDD (570-610 ºC approximately) required during germination to flowering stage in all treatments. Because of higher root proliferation and higher number of root nodule the crop growth rate is high. The plants mature at right time due to no stress condition. So it required high growing degree days in T_8 (Plants grown with improved practice, Hydrogel, Nano Solution and *Trichoderma*).

PTU recorded at germination, flowering, pod initiation and maturity. Based on the data calculated in the Table-2 revealed that the highest value of PTU was observed in T8 (440.4, 6937.5, 879.4, 4856.5 ºC hr) i,e plants grown by application of hydrogel with improved practice and seed treatment with nano solution and *Trichoderma* followed by T_7 (Plants grown with Improved practice, Hydrogel and *Trichoderma*). Farmers practice required total lesser photo thermal unit (12958.2 ºC

hr) as compared to the other treatments. Lowest photo thermal unit required by T_1 (Plants grown under farmers practice) which gives lesser yield because due to hydrogel, nano solution and *Trichoderma* treatment the root growth was much more in T_8 (Plants grown with Improved practice, Hydrogel, Nano Solution and *Trichoderma*) so it mature at right time.

HTU recorded at germination, flowering, pod initiation and maturity. Based on the data calculated in the Table-3 revealed that the total HTU requirement in green gram ranges from 7780-8095 ºC hr. T8 needs highest HTU (345.8, 4349.6, 423.9, 2973.2 ºC hr) to mature. In farmers practice we did not gave hydrogel, nano solution and *Trichoderma*, so for that root and root nodules are not well developed and it requires less days to mature i,e it matures early. To produce highest yield the plants grown by application of hydrogel with improved practice and seed treatment with nano solution and *Trichoderma* (T_8) required more helio thermal unit (8092.5 ºC hr) as compared to the other treatments. When the plants grown in improved practice with hydrogel it also required comparatively lesser HTU (7934.3 ºC hr) than T_8 (Plants grown with improved practice, Hydrogel, Nano Solution and *Trichoderma*). T_1 (Farmers practice) gives lesser yield with lowest HTU. So it is seen that hydrogel with nano solution and *Trichoderma* gives highest result because it get adequate time tomature.

Table 1: GDD (ºC) requirement of green gram cultivars at different stages affected by hydrogel, nano solution and *Trichoderma*

Treatments	GDD (ºC)					Seed Yield (kg/ ha)
	Sowing to Germination	Germination to Flowering	flowering to Pod initiation	Pod initiation to Maturity	Total	
T1: Farmers Practice	39.5	576.5	78.4	404.5	1098.9	472.1
T2: IP(Line sowing + FIR + RDF)	39.5	576.5	78.4	404.5	1098.9	657.6
T3:IP+Hydrogel(@2.5kg/ha)	39.5	606.4	80.7	404.4	1131.2	667.8
T4:IP+Nanosolution	39.5	606.4	59.6	424.4	1131.2	678.4
T5: IP+ Hydrogel + Nano solution	25.5	606.4	80.7	404.4	1131.2	678.3
T6: IP + *Trichoderma*	39.5	606.4	80.7	404.4	1131.2	671.9
T7:IP+Hydrogel+*Trichoderma*	25.5	619.1	63.1	424.8	1132.5	742.2
T8: IP + Hydrogel Nano solution + *Trichoderma*	25.5	619.1	63.1	424.8	1132.5	752.2

Table 2: PTU (ºC hr) requirement of greengram cultivars at different stages affected by hydrogel, nano solution and *Trichoderma*

Treatments	PTU (ºC hr)					Seed Yield (kg/ha)
	Sowing to Germination	Germination to Flowering	Flowering to Pod initiation	Pod initiation to Maturity	Total	
T1: Farmers Practice	440.4	6601.5	879.4	4534.3	12455.6	472.1
T2: IP (Line sowing + FIR + RDF)	440.4	6601.5	879.4	4534.3	12455.6	657.6
T3:IP+Hydrogel(@2.5kg/ha)	440.4	6937.5	905.2	4534.3	12817.4	667.8
T4: IP + Nanosolution	440.4	6937.5	668.6	4798.2	12844.7	678.4
T5:IP+Hydrogel+Nanosolution	284.3	6937.5	905.2	4856.5	12983.5	678.3
T6: IP+ *Trichoderma*	440.4	6937.5	905.2	4534.3	12817.4	671.9
T7:IP+Hydrogel+*Trichoderma*	284.3	7079.1	707.9	5004.5	13075.8	742.2
T8: IP + Hydrogel + Nano solution + *Trichoderma*	284.3	7079.1	707.9	5004.5	13075.8	752.2

Table 3: HTU (ºC hr) requirement of greengram cultivars at different stages affected by hydrogel, nano solution and *Trichoderma*

Treatments	HTU (ºC hr)				Total HTU	Seed Yield (kg/ha)
	Sowing To Germination	Germination to Flowering	Flowering to Pod initiation	Pod initiationto Maturity		
T1: Farmers Practice	345.8	4305.2	282.9	2799.9	7783.8	472.1
T2:IP(Linesowing+FIR+RDF)	345.8	4305.2	282.9	2799.9	7783.8	657.6
T3:IP+Hydrogel(@2.5kg/ha)	345.8	4349.2	305.7	2944.8	7945.5	667.8
T4: IP+ Nano solution	345.8	4349.2	305.7	2944.8	7945.5	678.4
T5:IP+Hydrogel+Nanosolution	345.8	4349.2	305.7	2968.4	7969.1	678.3
T6: IP + *Trichoderma*	345.8	4349.6	305.7	2968.4	7969.5	671.9
T7:IP+Hydrogel+*Trichoderma*	228.2	4349.6	423.9	2973.2	7974.9	742.2
T8: IP + Hydrogel +Nanosol^n + *Trichoderma*	228.2	4349.6	439.4	2973.2	7990.4	752.2

Conclusion

The study revealed that application of hydrogel with improved practice and seed treatment with nano solution and *Trichoderma* (T_8) produced the significantly higher yield (752.2 kg ha-1). Among two varieties Virat gives better results than IPM 02-14. It matured within 55-58 days, so it is a better choice for rice fallow than the other one. The combination of T8 with variety Virat gives best result. The crops grown with T8required significantly higher GDD (1132.1 ºC), PTU (13113.8 ºC hr), HTU (8092.5 ºC hr) than other plants to mature and to give more yield

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