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Effect of different climate resilient crop management practices on growth parameters (CGR, RGR, NAR) of greengram (*Vigna radiata* L.)

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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 green gram 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 was 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. Crop growth rate (5.76 g m^{-2} day^{-1}), Relative growth rate (1.41* 10^{-2} g g^{-1} day^{-1}), Net assimilation rate (0.021 g cm^{-2} day^{-1}) are also high in the plants which are grown under T_8 treatment.

Keywords: Hydrogel, nano solution, rabi season, Virat, IPM 02- 14, CGR, RGR, NAR

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. While coducting this experiment we adopted different climate resilient crop management practices such as we had developed an artificial drought by minimising the irrigation and to mitigate the dry condition we used hydrogel, nanosolution, *Rhizobium*, *Trichoderma* in greengram so that crop should give optimum yield in the dry condition in rice fallow by utilising the residual soil moisture. 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. *Trichoderma harzianum* is a safe and effective biocontrol agent in both natural and controlled environments that does not accumulate in the food chain and to which it has not been described resistance (Monte *et al.*, 2003). So that's why we used such chemicals and biofertilisers in our experiment. Different crop growth parameters are Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR) popular because of its simplicity in the field of agriculture for guiding the farmers.

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 Agro climatic 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 02-14 are used here. The dimension of experimental area was 30 x 35 m^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 parameters like Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR) are taken. Phonological observation dates of occurrence of following phonological stages are visually noted, flowering, pod initiation, pod filling, and physiological maturity.

Post-harvest observation Observations

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

Crop growth parameters

Different crop growth parameters are Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR).

Crop growth rate (CGR)

The average daily increment in plant growth is an important characteristic. It is the rate of dry matter production per unit ground area per unit time. It was calculated by using the following formula and expressed as m^{-1} day^{-1}.

$$\mathbf{CGR} = \frac{W2 - W1}{t2 - t1} * \frac{1}{GA}$$

Where, W_1 and W_2 are dry matter of preceding and succeeding stages and t_1 and t_2 represent the time period at which W_1 and W_2 were recorded. GA is the ground area.

Relative growth rate (RGR)

It is an index of the amount of growing material per unit dry weight of plant per time. It expresses the dry weight increase in time interval in relation to the initial weight and is expressed in g^{-1} day^{-1}. It is also called efficiency index.

$$\mathbf{RGR} = \frac{\ln W2 - \ln W1}{t2 - t1}$$

Where, W_2 and W_1 are the dry weight (g) at time t_1 and t_2 respectively and log is natural log.

Net assimilation rate (NAR)

It is increase in dry wt. of plant per unit leaf area per unit time and is expressed in g m^{-2} leaf area day^{-1}. NAR is calculated from the following equation: -

$$\mathbf{NAR} = \frac{(W2 - W1)(\ln A2 - \ln A1)}{(t2 - t1)(A2 - A1)}$$

Where A_1 and A_2 are total leaf are at time t_1 and t_2 respectively. W_1 and W_2 are total dry weight in time t_1 and t_2 respectively.

Result and Dissection

Crop growth rate (g m-2 day-1)

For the assessment of average daily increment in stand biomass, crop growth rate is an important characteristic, which is termed as rate of dry matter production. It was determined as rate of dry matter accumulation by crop stand per unit ground area per unit time.

The observations on CGR were recorded at 15-30, 30-45 and 45- harvest days interval stages of the crop. The data presented in Table no.1 revealed that the rate of growth was maximum within 30 – 45 DAS followed by 15 -30 DAS and 45 DAS to maturity in all the treatments. Maximum CGR (9.94 g m^{-2} day^{-1}) was noticed at 30 – 45 days stage in plants grown with application of hydrogel with improved practice and seed treatment with nano solution and *Trichoderma* and the minimum CGR recorded in the plants which are grown under farmers practice (7.18g m^{-2} day^{-1}). During later part of crop growth stage (45 DAS to harvest) the rate of growth was almost similar in all the treatments including farmer practice (5.13 g m^{-2} day^{-1}) and in T_6 (5.52 g m^{-2} day^{-1}), T_8 (5.76 g m^{-2} day^{-1}). whereas during 15 – 30 DAS the maximum growth rate (7.73 g m^{-2} day^{-1}) was noticed in same plants as in 30 – 45 DAS but it was closely followed by the plants (7.21 g m^{-2} day^{-1}) grown with improved practice with hydrogel application and seed treatment with *Trichoderma* (T7).

Relative growth rate (* 10 -2 g g-1 day-1)

It is an index of the amount of growth per unit dry weight of plant per unit time. The relative growth rate (RGR) at any stage is the ratio of the increase in biomass per unit of

biomass. It is also called efficiency index.
The observations were recorded at 15-30, 30-45 DAS and 45-harvest interval stages of the crop. The data presented in Table no. 2 revealed that the RGR during 15- 30, 30-45 DAS and 45 - harvest days interval of the crop was decreased progressively with the advancement of age and was influenced significantly by the different crop management practices in greengram. Higher RGR (7.76 * 10 -2 g g-1 day-1) in greengram was noticed when plants grown with application of hydrogel with improved practice and seed treatment with nano solution and *Trichoderma* (T8) at during 15- 30 days after sowing, at that time the lowest RGR (6.10 * 10 -2 g g-1 day-1) recorded in the plants grown under farmers practice (T_1) followed by the plants grown (6.25 * 10 -2 g g-1 day-1) under improved practice (T_2). Lowest RGR (0.72 * 10 -2 g g-1 day-1) noticed during 45-harvest in farmers practice (T1).

Net assimilation rate (g cm−2 day−1)

Net assimilation rate (NAR) a value that relates plant productivity to plant size. It is obtained by dividing the rate of increase in dry weight by leaf size (usually leaf area).
The observations were recorded at 15-30, 30-45 DAS and 45-harvest interval stages of the crop. The data presented in Table 3 revealed that the NAR during 15- 30, 30-45 DAS and 45 - harvest days interval of the crop was decreased progressively with the advancement of age and was influenced significantly by the different crop management practices in greengram. Higher NAR in greengram was noticed when plants grown with application of hydrogel with improved practice and seed treatment with nano solution and *Trichoderma* (T8) at all the crop growth stages. During 15-30 DAS highest NAR recorded in T_8 (0.079 g cm−2 day−1) followed by T_7 (0.079 g cm−2 day−1). Lowest NAR (0.016 g cm−2 day−1) noticed during 45-harvest in farmers practice (T1) followed by T_3 (0.018 g cm−2 day−1) in this treatment plants are grown with application of hydrogel (@2.5 kg / ha) and improved practice (Line sowing + FIR + RDF), where as in almost all the treatments threre is near about same (0.020 g cm−2 day−1) NAR in 45DAS to harvesting but little beat high (0.021 g cm−2 day−1) in T_8.

Table 1: CGR (g m-2 day-1) of greengram cultivars at different stages affected by hydrogel, nano solution and *Trichoderma*

Treatments	CGR (g m^{-2} day^{-1})		45DAS-Harvest
	15-30 DAS	30-45 DAS	
T1: Farmers Practice	5.37	7.18	5.13
T2: IP (Line sowing + FIR + RDF)	5.48	7.29	5.29
T3: IP + Hydrogel (@2.5 kg / ha)	5.56	7.43	5.32
T4: IP + Nano solution	6.21	7.82	5.48
T5: IP + Hydrogel + Nano solution	6.53	8.01	5.48
T6: IP + *Trichoderma*	6.84	8.27	5.52
T7: IP + Hydrogel + *Trichoderma*	7.21	9.53	5.63
T8: IP + Hydrogel + Nano sol^n+ *Trichoderma*	7.73	9.94	5.76
S.Em±	0.23	0.65	0.51
CD (P = 0.05)	0.25	1.31	1.29
Varieties			
V1: Virat	5.48	8.21	5.38
V2: IPM 02-14	5.62	8.09	5.23
S.Em±	0.19	0.41	0.39
CD (P = 0.05)	0.20	1.27	1.24
CV %	12.56	13.73	12.05

Table 2: RGR (* 10 -2 g g-1 day-1) of greengram cultivars at different stages affected by hydrogel, nano solution and *Trichoderma*

Treatments	RGR (* 10 $^{-2}$ g g^{-1} day^{-1})		45DAS-Harvest
	15-30 DAS	30-45 DAS	
T1: Farmers Practice	6.10	2.14	0.72
T2: IP (Line sowing + FIR + RDF)	6.25	2.16	0.98
T3: IP + Hydrogel (@2.5 kg / ha)	6.31	2.23	0.92
T4: IP + Nano solution	6.54	2.36	1.07
T5: IP + Hydrogel + Nano solution	7.34	2.31	1.21
T6: IP + *Trichoderma*	7.41	2.52	1.29
T7: IP + Hydrogel + *Trichoderma*	7.52	2.75	1.37
T8:IP+Hydrogel + Nano sol^n+ *Trichoderma*	7.76	2.89	1.41
S.Em±	0.25	0.17	0.13
CD (P = 0.05)	0.69	0.38	0.29
Varieties			
V1: Virat	6.85	2.39	1.08
V2: IPM 02-14	6.62	2.34	1.07
S.Em±	0.22	0.11	0.08
CD (P = 0.05)	0.66	0.32	0.21
CV %	14.21	12.64	12.98

Table 3: NAR (g cm−2 day−1) of greengram cultivars at different stages affected by hydrogel, nano solution and *Trichoderma*

Treatments	NAR (g cm−2 day−1)		45DAS-Harvest
	15-30 DAS	30-45 DAS	
T1: Farmers Practice	0.060	0.030	0.016
T2: IP (Line sowing + FIR + RDF)	0.042	0.022	0.020
T3: IP + Hydrogel (@2.5 kg / ha)	0.055	0.025	0.018
T4: IP + Nano solution	0.052	0.026	0.020
T5: IP + Hydrogel + Nano solution	0.068	0.031	0.020
T6: IP + *Trichoderma*	0.062	0.029	0.020
T7: IP + Hydrogel + *Trichoderma*	0.073	0.030	0.021
T8: IP+Hydrogel+Nanosol^{n}+*Trichoderma*	0.079	0.031	0.021
S.Em±	0.27	0.15	0.11
CD (P = 0.05)	0.62	0.35	0.21
Varieties			
V1: Virat	0.055	0.028	0.018
V2: IPM 02-14	0.050	0.027	0.018
S.Em±	0.22	0.11	0.08
CD (P = 0.05)	0.53	0.31	0.19
CV %	12.21	13.64	12.88

Conclusion

CGR was recorded maximum (9.94 g per m^2 per day) at 30 – 45 days interval, RGR and NAR was recorded highest (7.76 $*10^{-2}$ g g^{-1} day^{-1}, 0.079 g cm^{-2} day^{-1}) at 15 - 30 days interval was recorded with application of hydrogel with improved practice and seed treatment with nano solution and *Trichoderma* (T8) and significantly influenced by different treatments.

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