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Effect of seaweed treatments on growth and quality of chickpea in western Uttar Pradesh

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Abstract

A field experiment was conducted during *Rabi* season of 2021-22 and 2022-23 at agriculture Research Farm, Raja Balwant Singh College, Bichpuri, Agra. The experiment was laid out in Split Plot Design along with two factor viz., three chickpea varieties V₁- Pusa-362, V₂- IPC 2004-98, and V₃- IPC 2005-62 as main plot and six seaweed treatment combination T₁-Foliar application of seaweed extract @ 750 ml/ha at pre-flowering stage, T₂- Foliar application of seaweed extract @ 750 ml/ha at pre-flowering and pod formation stage, T₃- Foliar application of seaweed extract @ 750 ml/ha at pre-flowering, flowering, and pod formation stage, T₄- Basal application of seaweed granules @ 25 kg/ha + top dressing of seaweed granules @ 25 kg/ha after first irrigation, T₅- Basal application of seaweed granules @ 25 kg/ha + foliar application of seaweed extract @ 750 ml/ha at flowering stage, T₆- Basal application of seaweed granules @ 25 kg/ha + foliar application of seaweed extract @ 750 ml/ha at flowering and pod formation stage, as sub-plot factor treatment along with granule and water spray and their combination of 18 treatments replicated four times. Result revealed that higher AGR for plant height, volume of seed, swelling index and hydration index were recorded in variety IPC 2004-98 and AGR for dry weight and RGR were recorded in variety IPC 2005-62 at all the growth stages. Seaweed granule and extract that are able to induce vegetative growth of chickpea. At the time of sowing basal application of seaweed granules @ 25 kg ha⁻¹ increase the AGR for plant height, AGR for dry weight and RGR up to 30 DAS and application of seaweed extract @ 750 ml ha⁻¹ at pre-flowering, flowering and pod formation stages was also increase plant growth. AGR for plant height, AGR for dry weight and RGR were increases at different stages of seaweed extract application. Application of seaweed extract at pre flowering stages increase higher plant growth than flowering and pod formation stages. Seaweed granule and seaweed extract did not significantly effect on volume of seed, swelling index and hydration index.

Keywords: Seaweed extract, chickpea, growth parameters

Introduction

Chickpea, also known as Bengal gram or garbanzo, is a vital winter legume globally, rich in protein, carbohydrates ^[1], and essential nutrients like calcium, magnesium, and vitamins A, B, and C ^[2]. India leads in chickpea cultivation, with 85% of global acreage and significant production, followed by Turkey and Russia. India stands out as the top pulse-producing nation, with Madhya Pradesh leading within the country. Uttar Pradesh ranks sixth in pulse production nationally, contributing to around 7.84% of India's pulse area and 9.25% of its production. The total chickpea area in India is approximately 10.91 Mha, yielding 13.75 Mt, with a productivity of 1260 kg/ha. Maharashtra is the leading state in chickpea cultivation, while Uttar Pradesh contributes around 0.62 Mha to chickpea cultivation, yielding 0.77 Mt with a productivity of 1250 kg/ha ^[3]. Nitrogen fixation in chickpea varies between 100 to 176 kg/ha per season based on cultivation methods, cultivar, rhizobia presence, and environmental conditions ^[4].

The rise in conventional chemical fertilizers is driven by the growing global population and increasing food demand, raising environmental concerns ^[5]. Consequently, farmers are shifting to organic farming, utilizing sustainable resources like seaweeds. Seaweeds are used in food, feed, biofuels, cosmetics, fertilizers, nutraceuticals, and pharmaceuticals ^[6]. Their extracts, rich in growth regulators, trace elements, vitamins, and amino acids, are used as foliar sprays or presoaking agents to stimulate plant growth ^[7]. Over 15 million tons of seaweeds are produced

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annually, with a significant portion used as biofertilizers [8]. Seaweed extracts, containing plant growth-promoting molecules such as IAA, GA, ABA, cytokinins, and polyamines [9], along with phenols, betaines, lipids, proteins, sugar alcohols, alginates, and laminarins [10], enhance root and shoot growth, chlorophyll content, and antioxidant activity [11]. They also boost antioxidative and nitrogen-metabolizing enzymes like glutamine synthetase [12] and enhance photosynthetic efficiency by upregulating carbon fixation genes [13]. Recognized as a rich source of nutrients, seaweed extracts significantly improve wheat development, increasing grain weight and yield per plant.

Materials and Methods

The experiment was conducted during the *Rabi* seasons of 2021-22 and 2022-23 at the Agriculture Research Farm, Raja Balwant Singh College, Bichpuri, Agra (27.2° N, 77.9° E) on loam sandy soil. Agra has a semi-arid subtropical climate with extreme temperatures. Summers (May-June) reach 46-48 °C, monsoons (July-September), and winters (December-February). Initial soil conditions were nearly neutral (pH 8.05 and 8.08), low in organic carbon (0.34% and 0.36%), medium in available nitrogen (179.30 and 182.52 kg/ha), medium in phosphorus (26.60 and 26.85 kg/ha), and low in potassium (281.26 and 282.11 kg/ha). The experiment used a split-plot design with eighteen treatments combination and four replications. Main plots included three cultivars: (V1) Pusa-362, (V2) IPC 2004-98, and (V3) IPC 2005-62. Subplots had six seaweed treatments (T1) Foliar application @ 750 ml/ha at pre-flowering, (T2) Foliar application @ 750 ml/ha at pre-flowering and pod formation, (T3) Foliar application @ 750 ml/ha at pre-flowering, flowering, and pod formation, (T4) Basal seaweed granules @ 25 kg/ha + top dressing @ 25 kg/ha post first irrigation, (T5) Basal seaweed granules @ 25 kg/ha + foliar @ 750 ml/ha at flowering, (T6) Basal seaweed granules @ 25 kg/ha + foliar @ 750 ml/ha at flowering and pod formation. Fertilizers were applied as per recommended doses using urea, DAP, and muriate of potash. Irrigation and cultural practices followed standard recommendations. Growth data (AGR of plant height, AGR of dry weight, RGR) and quality parameters (swelling and hydration) were collected and analyzed using ANOVA. Treatment means were compared using critical difference (CD) at P=0.05 level of significance [14] (Gomez and Gomez, 1984). Absolute growth rate is the total gain of height and weight by the plant with in stipulated time interval. AGR calculated using given formula.

$$\text{AGR for plant height} = \frac{H_2 - H_1}{t_2 - t_1} \text{ (cm day}^{-1}\text{)}$$

$$\text{AGR for dry weight} = \frac{W_2 - W_1}{t_2 - t_1} \text{ (g day}^{-1}\text{)}$$

Relative growth rate is the rate of increase in dry weight per unit dry weight already present. RGR calculated using Radford formula (1967).

$$\text{RGR} = \frac{\text{Loge } W_2 - \text{Loge } W_1}{t_2 - t_1} \text{ (g g}^{-1} \text{ day}^{-1}\text{)}$$

Results and Discussion

Growth parameters

Data on growth characteristics, such as plant height (cm) and dry matter accumulation (g), were analyzed to determine various growth rates, including AGR for plant height and dry matter, and RGR at different crop growth stages and quality parameters, presented on a mean basis. The AGR data (plant height in cm day⁻¹ plant⁻¹ and dry matter g day⁻¹ plant⁻¹) under different treatments at various growth stages and quality parameters are shown in Table 1.

Studies on growth functions AGR, RGR of different varieties

Among the different varieties, variety IPC 2004-98 had the significantly higher AGR for plant height compared to Pusa-362 and IPC 2005-62. Pusa-362 also had higher AGR than IPC 2005-62 from sowing to 30 DAS in both of the years and 30-60 DAS during 2021-22. While there were no significant increases in AGR for plant height during the period of 30 to 60 DAS, 60 to 90 DAS and 90 to at harvest stages, IPC 2004-98 still recorded the highest AGR for plant height, followed by Pusa-362 and IPC 2005-62 in both of the years.

Among the different varieties, variety IPC 2005-62 had the significantly higher AGR for dry matter and RGR as compared to Pusa-362 and IPC 2004-98. Pusa-362 also had higher AGR for dry matter and RGR than IPC 2004-98 from sowing to 30 DAS in both of the years. Additionally, IPC 2005-62 recorded the highest RGR from sowing to 30 DAS, while Pusa-362 and IPC 2004-98 had similar rates in both of the years.

From 30 to 60 DAS, variety IPC 2005-62 had the significantly higher AGR for dry matter, surpassing Pusa-362 and IPC 2004-98. Pusa-362 also had a higher AGR for dry matter than IPC 2004-98 during both of the years. While there were no significant increases in RGR during this period, IPC 2005-62 still recorded the highest AGR for both, followed by Pusa-362 and IPC 2004-98 in both of the years.

At 60 to 90 DAS and 90 to at harvest stages there was no significantly increases in AGR for dry matter and RGR but variety IPC 2005-62 recorded highest AGR for dry matter and RGR followed by Pusa-362 and IPC 2004-98 during both of the years. similar result reported by Rawat *et al.*, (2023) [15] reported significantly higher AGR, CGR, RGR were recorded with the variety Radhey compared to KGD-1168 and KWR-108.

Studies on growth functions AGR, RGR of various seaweed treatments

The application of different levels of seaweed, recorded the significantly higher the AGR for plant height, AGR for dry matter at 0 to 30, 30 to 60 DAS, RGR at 0 to 30 DAS with the basal application of seaweed granules @ 25 kg ha⁻¹ + foliar application of seaweed extract @ 750 ml ha⁻¹ at Flowering and pod formation stage (T₆) as compared to T₃, T₂ and T₁ but at par with T₅ and T₄ during both of the years. Similarly, treatment T₆ was non significantly increases AGR for plant height during 2022-23. From 30 to 60 DAS there was significantly increases in RGR with the Foliar application of seaweed extract @ 750 ml ha⁻¹ at pre Flowering stage (T₁) recorded highest RGR compared to T₄, T₅, T₆ respectively but at par with T₂ and T₃ during both of the years.

Table 1: Absolute growth rate of chickpea for plant height (cm day⁻¹) as influenced by various treatments at successive stages of crop growth.

Treatments	0-30 DAS		30-60 DAS		60-90 DAS		90-At Harvest	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Main plot (Varieties)								
V ₁	0.511	0.494	0.662	0.572	0.560	0.514	0.233	0.163
V ₂	0.546	0.530	0.712	0.616	0.585	0.540	0.278	0.189
V ₃	0.480	0.450	0.609	0.530	0.533	0.487	0.193	0.145
S.Em±	0.010	0.009	0.020	0.024	0.034	0.033	0.022	0.025
CD (P=0.05)	0.034	0.030	0.069	NS	NS	NS	NS	NS
Sub plot (Seaweed treatment)								
T ₁	0.484	0.450	0.603	0.526	0.542	0.503	0.122	0.062
T ₂	0.489	0.457	0.621	0.543	0.544	0.504	0.332	0.260
T ₃	0.494	0.461	0.640	0.557	0.674	0.634	0.349	0.267
T ₄	0.533	0.518	0.683	0.595	0.540	0.483	0.114	0.059
T ₅	0.537	0.524	0.701	0.605	0.528	0.476	0.170	0.103
T ₆	0.540	0.538	0.717	0.611	0.529	0.483	0.320	0.245
S.Em±	0.012	0.010	0.026	0.024	0.042	0.039	0.031	0.034
CD (P=0.05)	0.033	0.028	0.074	NS	NS	NS	0.088	0.096
Interaction (V*T)								
S.Em±	0.020	0.017	0.045	0.042	0.073	0.068	0.054	0.059
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Absolute growth rate of chickpea for dry matter (g day⁻¹) as influenced by various treatments at successive stages of crop growth.

Treatments	0-30 DAS		30-60 DAS		60-90 DAS		90-At Harvest	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Main plot (Varieties)								
V ₁	0.072	0.078	0.286	0.337	0.261	0.259	0.142	0.156
V ₂	0.066	0.071	0.249	0.308	0.242	0.222	0.104	0.132
V ₃	0.078	0.085	0.322	0.368	0.284	0.295	0.173	0.177
S.Em±	0.001	0.002	0.007	0.008	0.017	0.018	0.020	0.020
CD (P=0.05)	0.005	0.006	0.025	0.029	NS	NS	NS	NS
Sub plot (Seaweed treatment)								
T ₁	0.053	0.060	0.242	0.297	0.239	0.236	0.094	0.121
T ₂	0.056	0.062	0.248	0.307	0.264	0.256	0.202	0.215
T ₃	0.057	0.064	0.261	0.312	0.360	0.359	0.199	0.210
T ₄	0.087	0.094	0.312	0.363	0.234	0.230	0.072	0.090
T ₅	0.089	0.097	0.322	0.375	0.237	0.234	0.090	0.104
T ₆	0.091	0.098	0.328	0.382	0.239	0.239	0.183	0.192
S.Em±	0.002	0.002	0.009	0.008	0.022	0.020	0.024	0.027
CD (P=0.05)	0.005	0.005	0.024	0.024	0.062	0.058	0.069	0.076
Interaction (V*T)								
S.Em±	0.003	0.003	0.015	0.015	0.038	0.035	0.042	0.046
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Relative growth rate of chickpea (g g⁻¹ day⁻¹) as influenced by various treatments at successive stages of crop growth.

Treatments	0-30 DAS		30-60 DAS		60-90 DAS		90-At Harvest	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Main plot (Varieties)								
V ₁	0.0243	0.0277	0.0541	0.0562	0.0183	0.0160	0.0070	0.0070
V ₂	0.0221	0.0256	0.0524	0.0557	0.0192	0.0152	0.0055	0.0065
V ₃	0.0273	0.0304	0.0551	0.0563	0.0180	0.0168	0.0076	0.0071
S.Em±	0.0007	0.0007	0.0010	0.0010	0.0009	0.0010	0.0010	0.0008
CD (P=0.05)	0.0024	0.0025	NS	NS	NS	NS	NS	NS
Sub plot (Seaweed treatment)								
T ₁	0.0153	0.0195	0.0571	0.0595	0.0195	0.0165	0.0052	0.0061
T ₂	0.0165	0.0204	0.0569	0.0597	0.0207	0.0174	0.0103	0.0100
T ₃	0.0180	0.0218	0.0569	0.0588	0.0252	0.0222	0.0087	0.0085
T ₄	0.0316	0.0343	0.0510	0.0529	0.0153	0.0135	0.0034	0.0040
T ₅	0.0327	0.0354	0.0507	0.0527	0.0153	0.0133	0.0042	0.0045
T ₆	0.0335	0.0360	0.0508	0.0528	0.0149	0.0132	0.0083	0.0081
S.Em±	0.0010	0.0009	0.0012	0.0011	0.0013	0.0011	0.0011	0.0012
CD (P=0.05)	0.0028	0.0026	0.0035	0.0031	0.0038	0.0030	0.0032	0.0033
Interaction (V*T)								
S.Em±	0.0017	0.0016	0.0021	0.0019	0.0023	0.0018	0.0019	0.0020
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

From 60 to 90 DAS there was significantly increases in AGR for dry matter and RGR. However, the Foliar application of seaweed extract @ 750 ml ha⁻¹ at pre Flowering, Flowering and Pod formation stage (T₃) recorded higher AGR for dry matter and RGR followed by treatments T₂, T₄, T₁, T₆ and T₅ during both of the years. During the same treatment T₃ was recorded the non-significantly higher AGR for plant height followed by all treatments during both of the years.

Foliar application of seaweed extract @ 750 ml ha⁻¹ at pre Flowering, Flowering and Pod formation stage (T₃) was recorded the significantly higher AGR for plant height as compared to T₅, T₁, T₄ respectively but at par with T₂ and T₆ at 90 to at harvest stage during both of the years. Similarly, the Foliar application of seaweed extract @ 750 ml ha⁻¹ at pre Flowering and pod formation stage (T₂) was recorded the significantly higher AGR for plant height and RGR as compared to T₁, T₅, T₄ respectively but at par with T₃ and T₆ at 90 to at harvest stage during both of the years. similar result reported by Meshram et. al. 2022 ^[16] he found seaweed sap at different concentration (5%, 7.5% & 10%) While in case of seaweed sap foliar application maximum accumulate growth rate (AGR), crop growth rate (CGR) and relative growth rate (RGR) recorded statistically superior by Seaweed sap 10% foliar application at 20-40 DAS, and 40-60 DAS, respectively.

Interaction effect

The interaction effect between different varieties and levels of seaweed treatments did not significantly affect AGR for plant height, AGR for dry weight, or RGR at any stage during both years.

Quality

Effect on swelling index and hydration index of different varieties

Observations related to seed volume, swelling index and hydration index of chickpea crop under different varieties and levels of seaweed treatment has been presented in Table 4.

Among the various varieties, variety IPC 2004-98 had the significantly higher seed volume as compared to Pusa-362 and IPC 2005-62 during both of the years. Similar study was recorded in hydration index during 2021-22. There was non-significant effect on hydration index during 2022-23 and swelling index during both of the years. Similar result reported by Sastry et al. 2019 ^[17] observed the seed volume range from 131 to 548 mm³ with a mean of 256 mm³, swelling index and hydration index. The While there was on swelling index a non-significant impact and hydration index. However, IPC 2004-98 Variety recorded the higher swelling index followed by Pusa 362, IPC 2005-62 pooled results.

Effect on swelling index and hydration index of different seaweed treatments

The different levels of seaweed treatment did not affect significantly seed volume, swelling index and hydration index during both of the years. Result shows, the application of seaweed T₂- Foliar application of seaweed extract @ 750 ml ha⁻¹ at pre Flowering and pod formation stage., recorded higher swelling index and T₃- Foliar application of seaweed extract @ 750 ml ha⁻¹ at pre Flowering, Flowering and Pod formation stage, recorded higher seed volume and hydration index followed by another treatment during both of the years.

Interaction effect

The results with respect to interaction effect between different

varieties and levels of seaweed treatments did not significantly affect swelling index of Chickpea during both of the years.

Table 4: Seed volume (mm³), Swelling index and Hydration index of chickpea as influenced by various treatments after harvest during pooled result

Treatments	Seed volume (mm ³)		Swelling index		Hydration index	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Main plot (Varieties)						
V ₁	167.63	169.34	2.52	2.62	2.09	2.20
V ₂	235.13	236.84	2.59	2.66	2.22	2.31
V ₃	131.80	133.51	2.48	2.60	2.02	2.16
S.Em±	3.40	3.60	0.06	0.06	0.04	0.05
CD (P=0.05)	11.76	12.44	NS	NS	0.15	NS
Main plot (Treatments)						
T ₁	173.97	175.42	2.52	2.63	2.11	2.21
T ₂	178.30	180.06	2.57	2.67	2.12	2.22
T ₃	182.97	184.92	2.49	2.58	2.12	2.23
T ₄	176.30	177.86	2.51	2.60	2.09	2.22
T ₅	176.97	178.62	2.56	2.66	2.11	2.22
T ₆	180.63	182.49	2.53	2.62	2.12	2.23
S.Em±	3.82	4.05	0.07	0.07	0.04	0.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction effect						
S.Em±	6.62	7.02	0.12	0.13	0.07	0.08
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Conclusion

Result revealed that higher AGR for plant height, volume of seed, swelling index and hydration index were recorded in variety IPC 2004-98 and AGR for dry weight and RGR were recorded in variety IPC 2005-62 at all the growth stages.

Seaweed granule and extract that are able to induce vegetative growth of chickpea. At the time of sowing basal application of seaweed granules @ 25 kg ha⁻¹ increase the AGR for plant height, AGR for dry weight and RGR up to 30 DAS and application of seaweed extract @ 750 ml ha⁻¹ at pre-flowering, flowering and pod formation stages was also increase plant growth. AGR for plant height, AGR for dry weight and RGR were increases at different stages of seaweed extract application. Application of seaweed extract at pre flowering stages increase higher plant growth than flowering and pod formation stages. Seaweed granule and seaweed extract did not significantly effect on volume of seed, swelling index and hydration index.

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