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Effect of seaweed extract of *Solieria chordalis-Gracilera edulis* and *Sargassum* sap on the performance of potato in the Laterite soil of West Bengal

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Abstract

A field investigation was conducted in the rabi season of 2021-2022 at the Agricultural Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva- Bharati, Sriniketan, Birbhum, West Bengal to assess the effect of foliar application of seaweed saps of *Solieria chordalis- Gracilera edulis* and *Sargassum* on the growth, yield parameters and yield of potato. The experiment followed a randomized block design with three replications and 14 treatments which are T₁- 0.5% SG Sap + 75% RDF, T₂- 1% SG Sap+75% RDF, T₃-2.5% SG Sap + 75% RDF, T₄- 5% SG Sap + 75% RDF, T₅- 7.5% SG sap + 75% RDF, T₆- 10% SG sap, + 75% RDF T₇-0.5% S sap + 75% RDF, T₈ – 1% S sap +75% RDF, T₉- 2.5% S sap + 75% RDF, T₁₀- 5% S sap + 75% RDF, T₁₁-7.5% S sap+ 75% RDF, T₁₂-10% S sap + 75% RDF, T₁₃- 75% RDF+ Water spray, T₁₄- 100% RDF + Water spray. Results showed that the treatment T₆-10% SG sap, + 75% RDF showed best (34 t/ha) results particularly in terms of yield and yield parameters whereas the treatment T₁₂-10% S sap + 75% RDF gave the second highest yield (33.16 t/ha) in this particular soil type.

Keywords: Seaweed sap, foliar, randomized block design, *Solieria*

1. Introduction

Potato [*Solanum tuberosum* L.] is one of the most important tuber crops ensuring global food and nutritional security. Potato is fourth in production and consumption after rice, wheat and maize. It is recognized as the "King of Vegetables" due to its high productivity per unit area and time, wider adaptability and high nutritional value. Globally, it is cultivated in over 20.32 million ha with a production of 376 million tonnes. India is the second largest producer of potato in the world after China, contributing about 15% to the world production. West Bengal is the leading state in potato production, contributing about 26% of total area and 28% of production with an average productivity of 24.18 t/ ha. Potato is largely concentrated in the alluvial zones of West Bengal. However, there is considerable scope to expand and intensify its cultivation in the Red and Lateritic Zone comprising districts of Purulia, Bankura, Birbhum, Jhargram and western part of Paschim Medinipur. This zone covers about 23.5% of the total geographical area of the state and is characterized by undulating topography, compact and shallow soils with poor water holding capacity. The soils are typically acidic in reaction [pH 4.8-6.2], low in organic carbon [0.31-0.50%], low in available nitrogen, phosphorus and potassium, poor in cation exchange capacity and suffer from Fe and Al toxicity and P-fixation problems. Consequently, the productivity of potato in this zone [18-20 t/ha] is considerably lower than the state average. The yield gap is attributed to poor crop growth, restricted root development and inefficient nutrient utilization under moisture stress and acidic soil conditions.

Potato is a heavy feeder and highly responsive to nutrient management. The indiscriminate use of chemical fertilizers to achieve higher yields in these fragile soils has led to deterioration of soil health, nutrient imbalance and escalating cost of cultivation for small and marginal farmers. Therefore, there is an urgent need for sustainable and eco-friendly approaches to improve growth and productivity without degrading the resource base. The use of biostimulants of natural origin has emerged as a promising strategy in this context.

Among various biostimulants, seaweed extracts are gaining considerable attention these days. Seaweed extracts are derived from marine macro-algae such as *Kappaphycus alvarezii*, *Sargassum wightii*, *Gracilaria edulis* and *Ascophyllum nodosum* [Khan *et al.*, 2009]. Commercial formulations like Sagarika [K sap + G sap] developed by IFFCO and CSIR-CSMCRI are now widely available in India. These extracts are rich sources of macro and micronutrients, amino acids, vitamins, and diverse range of plant growth promoting substances like auxins, cytokinins, gibberellins, betaines and abscisic acid. They also contain complex polysaccharides such as alginates, laminarins, fucoidans and carrageenans which improve soil physical condition and microbial activity [Bhattacharyya *et al.*, 2015]^[2].

Seaweed extracts applied as foliar spray or as granules in soil influence various physiological and biochemical processes. They enhance chlorophyll content, photosynthetic rate, delay leaf senescence, promote root proliferation and improve nutrient uptake and fertilizer use efficiency. The presence of betaines and cytokinins helps in mitigating abiotic stresses like drought and acidity, which are common constraints in lateritic soils. Enhanced root growth and early vigour are particularly important for tuber crops as they determine the source-sink relationship and tuber bulking.

Several studies have reported positive effects of seaweed application on potato. Pramanick *et al.* [2013]^[4] observed significant increase in plant height, leaf area index, dry matter accumulation and tuber yield with application of seaweed extract @ 2.5-5.0 ml. Pramanick *et al.* [2017]^[5] reported 12-18% increase in potato tuber yield with foliar application of *Kappaphycus* and *Gracilaria* sap in the Indo-Gangetic plains. Similarly, application of seaweed extract improved number of tubers per plant, average tuber weight and quality parameters like starch and ascorbic acid content. However, most of the studies were conducted in alluvial or black soils and information on the efficacy of seaweed biostimulant on growth and tuber productivity of potato under the specific edapho-climatic condition of red and lateritic soils of West Bengal is meagre.

Keeping in view the above facts and the need for productivity enhancement in red and lateritic belt, the present investigation was undertaken with the objective to assess the effect of different doses and time of application of seaweed extract on growth attributes, yield components and productivity of potato and to evaluate its potentiality to improve fertilizer use efficiency and soil health in the red and lateritic soils of West Bengal.

2. Materials and Methods

2.1 Experimental site

The field experiment was conducted at the P.S.B. Agricultural Farm, Palli Siksha Bhavana, Visva-Bharati, Sriniketan, Birbhum, West Bengal, situated in the Lateritic Agro-climatic Zone of West Bengal during the rabi season of 2021-22. The soil of the experimental plot was found to be sandy loam in nature.

2.2 Experimental details

The present investigation was conducted to evaluate the effect of foliar application of seaweed extracts of *Solieria chordalis-Gracilaria edulis* and *Sargassum* sap on the growth, yield parameters and yield, of potato. The experiment was done in Randomised block design with 14 treatments and 3 replications. The treatments are depicted in table 1.

The seaweed saps were sourced from CSIR-CSMCRI, Bhavanagar, Gujrat. The seaweed saps were applied as foliar sprays using a knapsack sprayer fitted with a hollow-cone nozzle to ensure uniform coverage of the plant canopy. The required

concentrations of *Solieria chordalis-Gracilaria edulis* (SG) sap and *Sargassum* (S) sap were prepared by diluting the stock solution with clean water immediately before spraying. In potato, three foliar sprays were applied at 40, 55 and 70 days after planting (DAP). Potato variety Kufri Jyoti was cultivated with all the standard package of practices

Table 1: Treatment details of the experiment conducted

Treatment	Description
T ₁	0.5% SG sap+ 75% RDF
T ₂	1.0% SG sap+75% RDF
T ₃	2.5% SG sap+75% RDF
T ₄	5.0% SG sap+75% RDF
T ₅	7.5% SG sap+75% RDF
T ₆	10% SG sap+75% RDF
T ₇	0.5% S sap+ 75% RDF
T ₈	1.0% S sap+ 75% RDF
T ₉	2.5% S sap+ 75% RDF
T ₁₀	5.0% S sap+ 75% RDF
T ₁₁	7.5% S sap+ 75% RDF
T ₁₂	10% S sap+ 75% RDF
T ₁₃	75% RDF +Waterspray
T ₁₄	100% RDF + Waterspray

Where- SG sap = *Solieria chordalis* sap + *Gracilaria edulis* sap S sap = *Sargassum* sap

2.3 Observations Recorded

The observations were recorded at various successive growth stages for plant height, leaf area, leaf area index, dry matter accumulation, tuber growth rate and tuber yield. For each observation, five tagged plants were chosen from each plot. The dry matter accumulation was determined by oven drying method. From the sample rows in each plot, two plants were randomly selected and stored separately. After the tubers and shoots were thoroughly cleaned of any debris or dust, they were measured using a physical balance. The materials were dried at 70°C in an electric oven till they reached a consistent weight. Once more, the dry matter was determined by weight and expressed in grams. Similarly, leaf area was measured with the help of leaf area meter and was expressed sq.cm. The data were subjected to statistical analysis using analysis of variance (ANOVA) for a randomized block design, and treatment means were compared at the 5% level of significance following the procedure.

3. Results and Discussion

Effect of seaweed sap on growth attributes

During 2021-22, significant differences among treatments were observed at all growth stages. The maximum plant height at 30 and 45 DAP was recorded under T₆ (10% SG sap + 75% RDF), giving 35.77 and 57.47 cm, respectively, whereas at 60 DAP the highest plant height was recorded under T₁₂ (10% S sap + 75% RDF) (79.62 cm) and at 75 DAP under T₅ (7.5% SG sap + 75% RDF) (82.50 cm). These treatments were statistically at par with each other at most of the stages. The minimum plant height at 30 and 45 DAP was recorded under T₁ (0.5% SG sap + 75% RDF) (23.32 and 40.08 cm, respectively), whereas T₁₃ (75% RDF + water spray) recorded the lowest values at 60 and 75 DAP (53.33 and 59.44 cm, respectively). The findings are depicted in the Table 2. The significant increase in the height of the plant under higher dose of seaweed sap concentration can be due to the presence of phytohormones. They induce or rather stimulate the necessary meristematic activities and results in better height of the plant [Bhattacharyya *et al.*, 2015]^[2].

The maximum leaf area was consistently recorded under T₆ (10% SG sap + 75% RDF), registering 210.14, 503.80, 731.54 and

590.00 cm² at 30, 45, 60 and 75 DAP, respectively, which was statistically at par with T₁₂ (10% S sap + 75% RDF) (192.20, 470.67, 639.34 and 530.00 cm²) and T₅ (7.5% SG sap + 75% RDF) (185.91, 450.00, 660.00 and 540.00 cm²) at all the stages. The minimum leaf area was recorded under T₁₃ (75% RDF + water spray), registering 102.47, 204.64, 343.03 and 300.00 cm² at 30, 45, 60 and 75DAP, respectively. The observations of leaf area are given in the Table 3.

The highest LAI values were recorded under T₁₂ (10% S sap + 75% RDF), registering 1.05, 1.49, 2.70 and 3.73 at 30, 45, 60 and 75DAP, respectively. At 45, 60 and 75DAP, this treatment remained statistically at par with T₄ (5% SG sap + 75% RDF) (1.50, 2.70 and 3.50), T₅ (7.5% SG sap + 75% RDF) (1.45, 2.60 and 3.40) and T₁₀ (5% S sap + 75% RDF) (1.45, 2.60 and 3.37), respectively. The lowest LAI was recorded under T₁₃ (75% RDF + water spray), registering 0.72, 1.03, 1.81 and 2.44 at 30, 45, 60 and 75 DAP, respectively. The findings are depicted in the Table 4.

The highest dry matter accumulation was registered under T₆ (10% SG sap + 75% RDF), recording 16.32, 29.18, 45.18, 57.75 and 47.97 g m⁻² at 30, 45, 60, 75 and 90 DAP, respectively, which remained statistically at par with T₁₂ (10% S sap + 75% RDF) (13.88, 22.79, 39.48, 54.10 and 49.50 g m⁻²) and T₅ (7.5% SG sap + 75% RDF) (12.80, 22.50, 37.40, 43.00 and 42.32 g m⁻²) at most of the stages. The lowest dry matter accumulation was observed under T₁₃ (75% RDF + water spray), registering 5.14, 12.26, 20.85, 28.00 and 28.29 g m⁻² at the respective stages. Seaweed extracts are known to enhance Rubisco activity and carbohydrate synthesis pathways, thus, increasing biomass production (Kumar *et al.*, 2020) [3]. The findings are depicted in the Table 5.

Effect of seaweed sap on yield parameter and yield-

Tuber Growth Rate (TGR) represents the rate of increase in tuber weight per plant per unit time and reflects the efficiency of assimilate translocation towards developing tubers. TGR increased up to 60-75 DAP and declined thereafter during 75-90 DAP. The highest TGR values were recorded under T₆ (10% SG sap + 75% RDF), registering 8.69, 10.49 and 5.50 g plant⁻¹ day⁻¹ during 45-60, 60-75 and 75-90 DAP, respectively, which was

statistically at par with T₁₂ (10% S sap + 75% RDF) (8.06, 13.38 and 5.20 g plant⁻¹ day⁻¹) and T₅ (7.5% SG sap + 75% RDF) (7.20, 9.03 and 5.00 g plant⁻¹ day⁻¹) at all the growth intervals. The lowest TGR was recorded under T₁₃ (75% RDF + water spray), registering 3.80, 5.00 and 2.70 g plant⁻¹ day⁻¹ at 45-60, 60-75 and 75-90 DAP, respectively. Seaweed sap increase the activities of invertase and sucrose synthase, increasing the hexose availability in sink tissues and thus resulting in higher TGR (Ali *et al.*, 2021) [1]. The findings are depicted in the table 6.

Yield per hectare represents the final economic yield and overall treatment efficiency under field conditions. During 2021-22, the highest yield per hectare was recorded under T₆ (10% SG sap + 75% RDF) (34.00 t ha⁻¹), which was statistically at par with T₁₂ (10% S sap + 75% RDF) (33.16 t ha⁻¹) and T₁₁ (7.5% S sap + 75% RDF) (32.96 t ha⁻¹). The lowest yield per hectare was recorded under T₁₃ (75% RDF + water spray) (19.04 t ha⁻¹). The findings are depicted in the Table 7.

Table 2: Effect of foliar application of seaweed saps on the plant height of potato

Treatments	30DAP	45DAP	60DAP	75DAP
T ₁ -0.5% SG sap +75% RDF	23.32	40.08	57.39	64.52
T ₂ -1% SG sap +75% RDF	23.92	43.21	64.11	69.56
T ₃ -2.5% SG sap +75% RDF	30.10	50.04	67.99	70.75
T ₄ -5% SG sap +75% RDF	32.50	52.02	70.75	74.67
T ₅ -7.5% SG sap +75% RDF	34.80	56.2	75.50	82.50
T ₆ -10% SG sap +75% RDF	35.77	57.47	76.11	81.38
T ₇ -0.5% S sap +75% RDF	23.84	41.65	54.82	64.61
T ₈ -1% S sap +75% RDF	24.09	40.09	55.67	66.19
T ₉ -2.5% S sap +75% RDF	25.09	43.18	63.09	68.25
T ₁₀ -5% S sap +75% RDF	30	48.5	68.34	74.5
T ₁₁ -7.5% SG sap +75% RDF	34.50	56.05	72.50	78.5
T ₁₂ -10% SG sap +75% RDF	35	55.69	79.62	81.98
T ₁₃ -75% RDF +waterspray	23.51	41.03	53.33	59.44
T ₁₄ -100% RDF +waterspray	30	46.5	59.22	59.51
S.Em	1.076	1.387	1.642	2.094
CD (5%)	0.025	4.033	4.772	6.087
CV(%)	6.40	5.01	4.34	5.1

Table 3: Effect of foliar application of seaweed saps on the leaf area of potato

Treatments	30 DAP	45 DAP	60 DAP	75 DAP
T ₁ -0.5% SG sap +75% RDF	106.70	228.89	446.27	333.17
T ₂ -1% SG SAP +75% RDF	130.31	340.00	500.04	387.61
T ₃ -2.5% SG SAP +75% RDF	151.49	368.29	560.00	450.00
T ₄ -5% SG SAP +75% RDF	165.92	416.08	610	500
T ₅ -7.5% SG sap +75% RDF	185.91	450	660	540.0
T ₆ -10% SG SAP +75% RDF	210.14	503.8	731.54	590.0
T ₇ -0.5% S sap +75% RDF	115.0	299.91	470	328.24
T ₈ -1% S SAP +75% RDF	133.46	325	503.44	400
T ₉ -2.5% S SAP +75% RDF	141.21	365.25	574.13	430
T ₁₀ -5% S SAP +75% RDF	158.97	393.46	583.84	470
T ₁₁ -7.5% SG sap +75% RDF	179.37	467.48	610	500
T ₁₂ -10% SG SAP +75% RDF	192.20	470.67	639.34	530
T ₁₃ -75% RDF +WATERSPRAY	102.47	204.64	343.03	300
T ₁₄ -100% RDF +WATERSPRAY	120.56	312.78	480	352.92
S.Em(±)	4.574	11.06	19.01	20.6
CD (5%)	13.295	32.148	55.267	59.893
CV (%)	5.30	5.22	5.98	8.18

Table 4: Effect of foliar application of seaweed saps on the LAI of potato

Treatments	30 DAP	45 DAP	60 DAP	75 DAP
T ₁ -0.5% SG sap +75% RDF	0.82	1.2	2.03	2.7
T ₂ -1% SG SAP +75% RDF	0.8	1.3	2.3	3
T ₃ -2.5% SG SAP +75% RDF	0.9	1.4	2.5	3.3
T ₄ -5% SG SAP +75% RDF	0.92	1.5	2.7	3.5
T ₅ -7.5% SG sap +75% RDF	0.91	1.45	2.6	3.4
T ₆ -10% SG SAP +75% RDF	0.87	1.37	2.2	3.45
T ₇ -0.5% S sap +75% RDF	0.74	1.15	2.00	2.56
T ₈ -1% S sap +75% RDF	0.76	1.20	2.21	3.15
T ₉ -2.5% S sap +75% RDF	0.84	1.35	2.4	3.10
T ₁₀ -5% S sap +75% RDF	0.86	1.45	2.6	3.37
T ₁₁ -7.5% SG sap +75% RDF	0.88	1.4	2.5	3.2
T ₁₂ -10% SG sap +75% RDF	1.05	1.49	2.7	3.73
T ₁₃ -75% RDF +WATERSPRAY	0.72	1.03	1.81	2.44
T ₁₄ -100% RDF +WATERSPRAY	0.83	1.26	2.07	2.90
S.Em(±)	NS	0.042	0.094	0.175
CD (5%)	NS	0.181	0.287	0.510
CV (%)	9.63	8.16	7.01	9.70

Table 5: Effect of foliar application of seaweed saps on the dry matter accumulation of potato

Treatments	30 DAP	45 DAP	60 DAP	75 DAP	90DAP
T ₁ -0.5% SG sap +75% RDF	8.1	14.72	24.16	33.3	33.86
T ₂ -1% SG sap +75% RDF	9.3	17.92	26.8	35.2	34.04
T ₃ -2.5% SG sap +75% RDF	10.5	19.00	29.30	38.1	36.68
T ₄ -5% SG sap +75% RDF	11.7	20.8	31.5	40.5	39.83
T ₅ -7.5% SG sap +75% RDF	12.8	22.5	37.4	43	42.32
T ₆ -10% SG sap +75% RDF	16.32	29.18	45.18	57.75	47.97
T ₇ -0.5% S sap +75% RDF	7.27	15.03	23.78	34.17	29.79
T ₈ -1% S sap +75% RDF	8.5	14.91	24.8	35.15	35.98
T ₉ -2.5% S sap +75% RDF	9.5	18.26	27.52	34.8	33
T ₁₀ -5% S sap +75% RDF	10.35	18.5	29.11	37.5	34.67
T ₁₁ -7.5% SG sap +75% RDF	12	20.2	30.50	39.8	38.55
T ₁₂ -10% SG sap +75% RDF	13.88	22.79	39.48	54.1	49.5
T ₁₃ -75% RDF +waterspray	5.14	12.26	20.85	28	28.29
T ₁₄ -100% RDF +waterspray	8.47	15.28	27.40	31.77	28.59
S.Em(±)	0.664	1.196	2.27	3.181	4.35
CD(5%)	1.931	3.478	6.606	9.245	12.659
CV(%)	11.17	11.01	13.19	14.2	20.58

Table 6: Effect of foliar application of seaweed saps on the TGR of potato

Treatments	45-60 DAP	60-75 DAP	75-90 DAP
T ₁ -0.5% SG sap +75% RDF	4.43	5.80	2.99
T ₂ -1% SG sap +75% RDF	5.14	6.50	3.5
T ₃ -2.5% SG sap +75% RDF	5.8	7.20	4.55
T ₄ -5% SG sap +75% RDF	6.5	8.02	5.25
T ₅ -7.5% SG sap +75% RDF	7.2	9.03	5
T ₆ -10% SG sap +75% RDF	8.69	10.49	5.5
T ₇ -0.5% S sap +75% RDF	4.2	6.95	3
T ₈ -1% S sap +75% RDF	4.8	6.20	3.4
T ₉ -2.5% S sap +75% RDF	5.5	7.05	3.8
T ₁₀ -5% S sap +75% RDF	6.2	7.80	4.30
T ₁₁ -7.5% S sap +75% RDF	7.0	11.86	4.8
T ₁₂ -10% SG sap +75% RDF	8.06	13.38	5.2
T ₁₃ -75% RDF + waterspray	3.8	5.00	2.7
T ₁₄ -100% RDF + waterspray	4.45	5.88	3.13
S.Em(±)	0.291	0.762	0.280
CD (5%)	0.846	2.214	1.102
CV (%)	8.68	16.65	11.91

Table 7: Effect of foliar application of seaweed saps on the yield (t/ha) of potato

Treatments	Yield (t/ha)
T ₁ -0.5% SG sap +75% RDF	21.27
T ₂ -1% SG sap +75% RDF	24.87
T ₃ -2.5% SG sap +75% RDF	27.01
T ₄ -5% SG sap +75% RDF	28.50
T ₅ -7.5% SG sap +75% RDF	31.70
T ₆ -10% SG sap +75% RDF	34.00
T ₇ -0.5% S sap +75% RDF	24.01
T ₈ -1% S sap +75% RDF	22.50
T ₉ -2.5% S sap +75% RDF	27.0
T ₁₀ -5% S sap +75% RDF	27.58
T ₁₁ -7.5% S sap +75% RDF	32.96
T ₁₂ -10% S sap +75% RDF	33.16
T ₁₃ -75% RDF + waterspray	19.04
T ₁₄ -100% RDF + waterspray	27.33
S.Em(±)	1.579
CD (5%)	4.59
CV (%)	10.05

Conclusion

It can be well concluded from the conducted experiment that the treatment T₆ (10% SG sap + 75% RDF) is the best performing treatment in the red-laterite zone of Birbhum district and can be recommended to the farmers of this region. The superior response of this particular treatment was attributed to the presence of naturally occurring plant growth regulators, amino acids, micronutrients and other bioactive compounds in seaweed extracts, which enhanced the process of photosynthesis, nutrient absorption and assimilate translocation.

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