Eco. Env. & Cons. 29 (2) : 2023; pp. (763-768)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i02.037

Evaluation of foliar application of seaweed sap on growth and yield of maize under rainfed condition

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(Received 3 October, 2022; Accepted 23 December, 2022)

ABSTRACT

A field experiment was conducted at Product testing Unit Agronomy, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur to evaluate the effect of foliar application of seaweed saps (K-sap from *Kappaphycus sp*. and G-sap from *Gracilaria sp*.) at different concentrations with recommended dose of fertilizer (RDF) on growth and yield of maize in sandy clay loam soil of Kymore plateau. The foliar spray of K-sap and G-sap at 2.5, 5.0, 7.5 and 10.0% v/v with 100% RDF and 6.25% v/v of K and G-sap with 50% RDF was performed thrice (at 25, 50 and 75 Days after sowing). Results revealed that application of K-sap or G-sap at different concentrations along with RDF significantly enhanced the plant growth parameters and yield attributes. In general, gradual increase in growth parameters, yield attributes and yields were observed with increasing the concentration of K-sap or G-sap. The highest grain and stover yields were recorded under the application of 10% K-sap with 100% RDF, resulting in 34.78 and 20.12% during 2012 and 18.32 and 23.60% increases during 2013, respectively over control (water spray with 100% RDF) and closely followed by 10% G-sap with 100% RDF.

Key words: *Kappaphycus, Seaweed sap, Growth and yield, Maize*

Introduction

Maize (*Zea mays L.*) is third most important cereal crop in India after rice and wheat for human food by contributing almost 8 % to India's food basket. It is having special significance because it is staple food of the tribal areas, which provide nutritional security due to its high nutritional value as it contain 10% protein, 70% carbohydrates, 4.1% oil, 4% fat, 1-3% sugar and 2.3% crude fibre. Besides its use as human food and animal feed, it has enormous significance as a source of large number of industrial products. Major quantity of the total maize production in India, approximately 47%, is used as poultry feed and out of remaining, 13% used as livestock feed and food purpose each, 12 % for industrial purposes, 14% in starch industry, 7% as processed food, and 6% for export and other purpose. In India it is grown in 9.18 m ha land with production of 27.23 m tonnes and 2965 kg ha^{-1} productivity, while in Madhya Pradesh it is grown in 1.37 m ha area with 3.68 m tonnes production and 2697 kg ha^{-1} productivity (Anonymous, 2019).

Maize is called as the "Miracle crop" or "Queen of the Cereals" due to its high yield potential compared to other Poaceae family members (Kannan *et al.*, 2013). On account of its genetic potentials of high yield and fast growth habits, maize is a highly nutrient exhaustive crop. It requires more nitrogen and phosphorus than any other essential elements for the development of all growth stages. To attain high yield and sustain soil fertility, it is quite necessary that essential nutrient elements should be supplied in an appropriate proportion. However, applying the recommended dose of fertilizer through chemical fertilizer alone continuously, in a production system can deteriorate soil health and decline the productivity in subsequent years. While, the simultaneous use of chemical fertilizer and organic manure has revealed diverse positive results relative to the plant types and soil characteristics. The balanced fertilization through the integration of organic and inorganic source of nutrients has been proved to set up the synergistic effects and improved synchronization of nutrient uptake and release by crops, ultimately resulted in higher yields (Palm *et al.,* 1997). Another study by Almaz and colleagues (2017) also revealed that in the maize-based cropping systems, integrated application of inorganic fertilizers with organic manures has significant benefits to enhance maize productivity, improve nutrient uptake by plants, and maintain soil nutrient status.

Now a day the use of seaweed extracts has gained popularity due to their potential use in organic and sustainable agriculture (Russo and Beryln, 1990). The seaweed extracts are considered as biostimulants have positive effects on the growth and development of many crops plants including vegetables, trees, flowering plants, and grain crops (Stirk *et al*., 2004; Hernández-Herrera *et al.,* 2014). Chemical analysis of seaweeds and their extracts have revealed the presence of amino acids, vitamins, growth promoting substances like cytokinins, auxin, gibberellins, abscisic acid and betaines, as well as macronutrients such as Ca, K and P and micronutrients like Fe, Cu, Zn, B, Mn, Co and Mo (Wildgoose *et al.,* 1978; Crouch and Van Staden, 1993; Jameson, 1993; Durand *et al*., 2003; Zhang and Ervin, 2004; Strik *et al*., 2004; Zhang and Ervin, 2008; Khan *et al*., 2009; Zodape *et al.,* 2010; Karthikeyan and Shanmugam, 2016). However, the seaweed concentrates are applied to crops as root dips, soil drenches, or foliar sprays but, when applied to plants as a foliar spray, can increase the rate of cell division and elongation in those plants. Since, the seaweed liquid extracts have been widely used in recent years, as foliar applied fertilizers for many plants (Karthikeyan and Shanmugam, 2016). Results of previous studies revealed that these extracts had positive effects on germination, cellular metabolism, leaf size, root and plant growth, yield, quality traits, tolerating unfavorable soil conditions and, nutrient uptake from the soil (Singh and Naik, 2016; Ali, 2019; Ali, 2021). While, there is no report on foliar application of seaweed sap on maize under rainfed condition for kymore plateau satpura hills of India. Thus, the present study was an attempt to assess the effect of seaweed sap of *Kappaphycus* and *Gracilaria* on growth, and yield of maize.

Materials and Methods

The field experiment was conducted during the *kharif* season of 2012 and 2013 at Product testing Unit Agronomy, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, and Madhya Pradesh, India. The soil of the site was sandy clay loam in texture, neutral in reaction (7.30), medium in available nitrogen (292 kg ha^{-1}) as well as available phosphorus (17.45 kg ha^{-1}) and high in available potassium (297 kg ha^{-1}). The electrical conductivity (0.31 ds m^{-1}) was normal. The climate of the region is characterized as typically sub-humid and tropical. The experimental site is located at 23°11′ North latitude, 79°58′ East longitude and altitude is 411.78 m above mean sea level. During the whole life span of maize, there was 1162.5 and 2382.5 mm received rainfall at the *kharif* season of 2012 and 2013, respectively. The experiment comprised ten treatments (*viz.,* T_1 - 2.5% K-sap + 100% RDF (Recommended dose of chemical fertilizers - 120 kg N, 60 kg P_2O_5, 40 kg K_2O ha^{-1}), T_2- 5.0 % K-sap + 100% RDF, T_3 - 7.5% K-sap + 100% RDF, T_4 - 10.0% K-sap + 100% RDF, T_5 - 2.5% G-sap + 100% RDF, T_6 - 5.0% G-sap + 100% RDF, T_7 - 7.5% G-sap + 100% RDF, T_8 - 10.0% G-sap + 100% RDF, T_9 – water spray + 100% RDF, T_{10} - 6.25% K-sap + 50% RDF) were tested in a randomized block design with three replication. Maize variety PRO Agro-4212 was sown on 18th July 2012 and harvested on 30th October 2012 during first year of experiment and under the second year of experiment sowing was done on 15th July 2013 and harvested on 10th November 2013. Sowing was done by dibbling of two seeds per hill in rows 25cm apart at the depth of 3-4 cm. The thrice foliar application of K-sap (*Kappaphycus alvarezii*) and G-sap (*Gracilaria edulis*) with total spray volume of 550 l ha^{-1} were made in each application, at 25, 50 and 75 days after sowing (DAS). The recommended dose of fertilizer (RDF) *i.e.,* 120, 60, 40 kg ha^{-1} (N, P_2O_5, K_2O) was given through urea, single super phosphate and muriate of potash, respectively. The

50% recommended dose of nitrogenous fertilizer along with full dose quantity of P and K fertilizer was applied as basal at the time of sowing. Remaining 50% N was top dressed in two equal splits at 30 and 45 DAS.

Five plants were randomly selected and tagged in each plot for recording observations. The height was recorded at the time of harvest from ground level to the extreme growing tip using meter scale. The observations on Chlorophyll concentration (g m^{-2}) were made at 60 DAS through random sampling. The chlorophyll concentration (g m^{-2}) of leaves was determined by chlorophyll content metre. Similarly, number of leaves per plant, number of cobs per plant, cob weight (gm), cob length (cm), cob girth (cm), number of grain rows per cob, number of grains per cob, seed index (100 grains weight), and yield parameters viz., grain and stover yield were recorded in each plot.

Data obtained on various observations were tabulated and then subjected to using analysis of variance (ANOVA) following randomized block design (Gomez and Gomez, 1984). Differences were considered significant at 5% level of probability.

Results and Discussion

Effect on growth parameters of maize

Data recorded on plant height and number of leaves per plant at harvest and chlorophyll content at 60 DAS during the *Kharif* season of 2012 and 2013 in Table 1 illustrated that the foliar application of both seaweed saps at different concentrations applied at different growth stages of maize along with RDF caused an enhanced effect on plant growth parameters (*viz.,* plant height, number of leaves per plant and chlorophyll content) in comparison to water spray with RDF. In general, gradual increase in growth parameters were observed with increasing the concentration of seaweed saps. The observation recorded on plant height indicated that the highest height was recorded under treatment 10% K-sap + 100% RDF closely followed by 10% G-sap + 100% RDF, while lowest plant height was observed under water spray with 100% RDF. Data recorded for number of leaves per plant showed that seaweed saps had significant influence and spray of 10% K-sap + 100% RDF produced the maximum number of leaves per plant, which was statistically similar to application of 7.5% K-sap, 7.5 and 10% of G-sap with 100% RDF. This increase in above mentioned growth parameters with higher concentration of saps applied might be due to more availability of plant nutrient and growth promoting hormones (*viz.,* Auxins, Cytokinins, Gibberellins), which ultimately resulted in the higher values of the growth parameters(Anantharaj and Venkatesalu, 2001). Similar results were observed on the earlier studies conducted on green gram (Pramanick *et al*., 2013), wheat (Shah *et al.*, 2013) and black gram (Singh *et al*., 2015), where significantly higher values of growth parameter was recorded with highest dose of K-sap with RDF as compared to control (water spray). However, the minimum number of leaves were recorded under treatment water spray with 100% RDF.

Table 1. Influence of foliar application of seaweed sap on growth parameters of maize

Treatments	Plant height (cm)		Number of leaves per plant		Chlorophyll index (g m^{-2})	
	2012	2013	2012	2013	2012	2013
T_1 - 2.5% K-sap + 100% RDF	174.00	170.27	12.82	12.14	45.26	44.59
T_2- 5.0 % K-sap + 100% RDF	174.73	174.10	12.87	12.32	46.05	45.28
T_3 - 7.5% K-sap + 100% RDF	177.07	175.87	13.03	12.86	50.69	50.04
T_4 - 10.0% K-sap + 100% RDF	177.30	177.20	13.30	12.93	51.20	50.17
T_5 - 2.5% G-sap + 100% RDF	170.27	170.20	12.77	12.11	44.26	42.42
T_6 - 5.0% G-sap + 100% RDF	174.20	174.07	12.83	12.18	46.24	44.56
T_7 - 7.5% G-sap + 100% RDF	175.87	174.73	12.96	12.65	48.43	47.24
T_8 - 10.0% G-sap + 100% RDF	177.20	177.00	13.27	12.89	48.97	48.80
T_9 – water spray + 100% RDF	163.67	163.07	12.60	12.03	44.58	43.29
T_{10} - 6.25% K-sap + 50% RDF	169.07	168.66	12.73	12.10	45.19	43.51
Sem+=	2.13	0.59	0.14	0.16	0.59	0.47
CD at 5%	6.33	1.75	0.41	0.48	2.36	1.43

In case of chlorophyll content, the highest values of it were recorded under spray of 10% K-sap with 100% RDF, which was significantly higher over rest of treatment except 7.5% K-sap and 10% G-sap with 100% RDF. Increased chlorophyll content might be owing to the presence of high amount of Mg (Kalaivanan *et al.*, 2012). However, the difference between 6.25% K-sap with 50% RDF and water spray with 100% RDF in all growth parameter were not marked.

Effect on yield attributes and yields of maize

The yield contributing characters like number of cobs per plant, cob weight (g), cob length (cm), cob girth (cm), number of grain rows per cob, number of grain per cob and seed index (g) were presented in Table 2. Data on number of cobs per plant revealed that spray of 10% K-sap with 100% RDF produce maximum number of Cobs per plant which was significantly higher over rest of treatment but statistically similar to 5% and 7.5% K-sap or 7.5% and 10% G-sap during 2012 and 7.5% K-sap or 10% G-sap with 100% during 2013. In case of cob weight, all the combination of K-sap and G-sap with RDF recorded significantly higher weight of cob over the control treatment (water spray with 100% RDF) but 6.25 K-sap with 50% RDF was statistically similar to control during 2012. However, maximum gain in cob weight was achieved under the spray of 10% K-sap with 100% RDF. Similarly, a significant increase in the cob length was observed with the foliar application of K or G-sap at different concentration as compared to water spray with 100% RDF. However, maximum cob length and cob girth was attained under the spray of 10% K-sap with 100% RDF. Data on number of grain rows per cob, number of grain per cob and seed index indicated that increase in the concentration of either K or G sap from 2.5% to 10% increased the number of grain rows per cob, number of grain per cob and seed index. However, the highest number of grain rows per cob, number of grain per cob and seed index were recorded under the application of 10% K-sap with 100% RDF, followed by 10% G-sap with 100% RDF. The probable reason of this increase might be ascribed to greater accumulation of carbohydrates, protein and their translocation to the reproductive organs which in turn, maximized the yield parameters in seaweed treated plants (Venkataraman and Mohan, 1997; Bai *et al.*, 2008).

The data on grain and stover yields of maize in

Table 2. Influence of foliar application of seaweed sap on yield attributes and yields of maize

Treatments	Cobs per plant		Cob weight (gm)		Cob length (cm)		Cob girth (cm)		Number of grain rows per cob		Number of grain per cob		Seed index (g)		Grain yield (q ha^{-1})		Stover yield (q ha^{-1})	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
T1	1.10	1.07	174.67	185.00	16.33	16.58	3.90	3.83	12.53	12.27	425.47	424.13	28.37	29.97	30.84	30.07	102.08	95.83
T2	1.17	1.13	178.00	189.00	16.50	17.14	3.90	3.95	12.67	12.87	436.73	427.67	28.43	28.30	31.08	30.25	103.25	96.08
T3	1.27	1.25	186.67	193.33	17.00	17.28	4.05	4.13	13.07	13.00	441.27	432.27	28.50	28.37	32.07	31.40	105.67	98.76
T4	1.33	1.31	192.00	198.35	17.33	17.47	4.35	4.30	13.87	13.85	458.67	440.87	28.70	28.67	33.98	33.13	107.61	101.64
T5	1.07	1.05	168.67	181.33	16.26	16.22	3.83	3.79	12.27	12.13	424.13	423.47	28.30	27.80	30.87	29.82	101.05	94.38
T6	1.13	1.10	176.00	184.00	16.37	17.00	3.90	3.91	12.67	12.76	431.87	426.78	28.40	28.15	31.59	29.95	102.49	95.68
T7	1.20	1.18	181.67	190.00	16.80	16.96	4.03	4.01	13.07	12.85	437.87	431.73	28.47	28.31	32.13	30.80	103.97	97.05
T8	1.30	1.28	190.00	197.00	17.27	17.18	4.15	4.28	13.07	13.70	451.53	437.35	28.70	28.63	33.27	32.68	105.75	100.58
T9	1.07	1.03	149.00	176.33	15.17	15.60	3.63	3.70	12.13	12.15	414.33	410.28	28.03	27.87	25.21	28.00	89.58	82.23
T10	1.07	1.05	158.67	181.00	15.92	16.00	3.80	3.78	12.20	12.22	405.20	418.00	28.27	27.90	25.90	29.05	90.14	89.58
Sem+=	0.05	0.02	5.04	0.82	0.52	0.55	0.08	0.48	0.45	0.43	21.89	7.23	0.29	0.20	0.58	0.29	0.51	0.14
CD at 5%	0.16	0.07	14.98	2.43	1.54	1.63	0.23	NS	1.34	0.60	NS	21.29	NS	0.59	1.73	0.87	1.51	0.42

[T_1 - 2.5% K-sap + 100% RDF, T_2- 5.0 % K-sap + 100% RDF, T_3 - 7.5% K-sap + 100% RDF, T_4 - 10.0% K-sap + 100% RDF, T_5 - 2.5% G-sap + 100% RDF, T_6 - 5.0% G-sap + 100% RDF, T_7 - 7.5% G-sap + 100% RDF, T_8 - 10.0% G-sap + 100% RDF, T_9 – water spray + 100% RDF, T_{10} - 6.25% K-sap + 50% RDF]

Table 2 indicated that the increasing dose of K-sap or G-sap with RDF increased the yields markedly. Increase in the yields under these treatments could be owing to enhancement of yield components. Mondal *et al*., (2015) also suggested that the yield improvement in maize due to an increase in the number of grains per plant which was brought about by enhanced cob length and consequent greater kernel set, but no improvement in single seed weight was observed in their study. Although, in present study maximum grain and stover yields were recorded under the application of the highest dose of K-sap (10%) with 100% RDF followed by 10% G-sap with 100% RDF. This is in conformity with similar results obtained for *Phaseolus aureus* (Bai *et al.,* 2008), *Phaseolus radiata* (Zodape *et al.,* 2010; Pramanick *et al.,* 2013) and *Phaseolus mungo* (Pramanick *et al.,* 2016; Singh *et al.,* 2022). Another studies suggested the yield increases in seaweed-treated plants might be associated with the presence of micro- elements and plant growth regulators, especially cytokinins in *Kappaphycus* and *Gracilaria* extracts that could be the reason for this yield enhancement (Featonby-Smith and Van Staden, 1983; Zhang and Ervin, 2008). However, minimum grain and stover yields were observed under water spray with 100% RDF.

Conclusion

This study concluded that use of seaweed sap with RDF is effective to attaining better growth and yield of maize over conventional method (recommended dose of fertilizer alone). The practice of thrice foliar application of highest dose of K-sap (10%) at 25, 50 and 75 DAS with 100% RDF may be recommended to achieve more yields of maize cultivation under rainfed condition.

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