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Effect of tillage practices and liquid seaweed as foliar spray on growth and yield of Sweet corn (*Zea mays*, *saccharata,* L.)

SHIVANI KUMARI, LANUNOLA TZUDIR*, T. GOHAIN AND MERENTOSHI

School of Agricultural Sciences (SAS), Nagaland University, Medziphema, Nagaland

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ABSTRACT

A field experiment was conducted during the Kharif -2021 and 2022, at Agronomy farm, School of Agricultural Sciences, Nagaland University, Medziphema on sandy clay loam soil to evaluate the response of different tillage practices and liquid seaweed on sweet corn (Zea mays, saccharata, L.). The result of the study revealed that among different tillage methods conventional tillage recorded significantly higher growth characteristics viz. plant height, dry matter accumulation, green cob yield, green fodder yield and protein yield. Foliar applications of liquid seaweed significantly enhanced the growth, yield attributes, yield and quality parameters. The highest growth and yield was recorded with applications of 10% Sargassum-sap followed by 10% Kappaphycus-sap over control. The highest green cob yield (18.49 t ha^{-1}), green fodder yield (25.54 t ha^{-1}) and protein content (11.10%) was also observed under conventional tillage among different tillage methods. Among seaweeds, application of 10% Sargassum-sap recorded maximum green cob yield (19.37 t ha^{-1}) and green fodder yield (27.50 t ha^{-1}) while highest protein content (11.35%) was noted with application of 15% Sargassum-sap among two species and three concentrations of liquid seaweed used.

Keywords: foliar, quality, seaweed, sweet corn, tillage, yield

INTRODUCTION

Maize holds significance as an important cereal crop cultivated across over 160 countries. In regions such as sub-Saharan Africa, Latin America, and Asia, it serves as a primary staple food for the local populations (Singh *et al.,* 2016). Approximately 25% of the total maize production serves as a staple food in various forms, including sweet corn. The CGIAR research program on maize predicts that by 2050, the demand of maize is expected to double with a concomitant increase in levels of per capita consumption. In contrast, its production has been predicted to decrease by 10% due to several factors including climate change effects (CGIAR, 2016). In the North East region of India, maize holds significant potential to become a major crop, with its area coverage ranking second highest after rice and is mostly grown under rainfed hilly upland conditions. In this region, maize production plays a significant role in ensuring food security and is used both for direct consumption and as well as for second cycle produce in piggery and poultry farming. The average productivity of maize in the region is very low (<1.5 t ha^{-1}) (Ansari *et al.*, 2015). Being the second most important cereal crop in Nagaland, it is cultivated across 0.69 million hectares and yielding the highest production among the North Eastern states, totaling 1.4 million tonnes (Statistical Handbook of Nagaland, 2020). Sweet corn, referred to scientifically as *Zea mays saccharata* distinguishes itself from field corn by its soft, sweet kernels. It is a special type of corn used for table purpose and has been known since 18th century (Aathithyan *et al.*, 2019). Unlike field corn, typically harvested when kernels are dry for livestock feed or industrial use, sweet corn is picked at the milky stage, guaranteeing maximum sweetness and tenderness. It can be consumed fresh straight from the cob, incorporated into various dishes like soups, salads, and stir-fries, or preserved by freezing or canning for enjoyment throughout the year. It is a challenging task to improve crop productivity in a sustainable manner to meet the burgeoning demand.

Tillage is the basic and one of the most important components of crop production system which provides favorable condition for plant growth and influences crop yield to a greater extent. Various resource conservation techniques like minimum tillage and zero tillage were found to enhance the wheat production but

*Corresponding author email: lanunola@nagalanduniversity.ac.in

their feasibility is maize production is yet to be confirmed in North-Eastern Himalayan regions. The outcome of the crop production process, which is affected by multiple elements, relies heavily on the conditions of the seedbed (Ahmad *et al.*, 2009). There is a need for adoption of the different tillage practices in India for harnessing maximum crop production profitability (Yadav *et al.*, 2016). In north east farmers have apathy towards use of agrochemicals in crop production (Das *et al.*, 2018). Liquid extracts obtained from seaweed have been reported as green technology for enhancing growth, yield and quality of several crops and widely used in agriculture (Pramanick *et al.*, 2013; Battacharyya *et al.*, 2015; Ghosh *et al.*, 2015) as it contains major and minor nutrients, amino acids, vitamis, cytokinins, auxins and abscisic acid like growth promoting substances etc. Considering the above fact, an experiment was undertaken to study the effect of different tillage methods and liquid seaweed on sweet corn crop.

MATERIALS AND METHODS

The study was carried out at the Agronomy Research Farm, School of Agricultural Sciences, Nagaland University, Nagaland during *kharif* 2021 and 2022. The experimental site lies in a humid sub-tropical region with annual rainfall ranging from 2000-2500 mm. Weekly average meteorological data during the span of experimentation was recorded at ICAR research complex for NEH region (Jharnapani), Nagaland centre. The soil of experimental site was acidic in reaction (pH 4.86), non-saline (EC 0.06 dS m^{-1}), sandy clay loam in texture, medium available N (210.24 kg ha^{-1}) as well as medium in available phosphorus (23.43 kg ha^{-1}) and available potassium (221.48 kg ha^{-1}). The organic carbon status was on higher side (1.35%). The experiment was laid out in split plot design and replicated thrice. The treatment consisted of combination of two factors; factor one consisted of three different practices (conventional, minimum and zero) and factor two consisted of two types of liquid seaweed; *Kappaphycus alvarezii* (K-Sap) and *Sargassum wightii* (S-Sap), 3 concentration (5, 10 and 15%) and 3 sprays, scheduled at 30, 50 and 70 days after sowing (DAS) along with control *i.e.* water spray. The spray volume was 500 litre ha^{-1}. Foliar application was carried with mentioned concentrations of different saps using a manually operated knapsack sprayer. Similarly, in control, instead of sap equivalent volume of water was sprayed. The plot size was 6 m × 5 m and sowing was done at a spacing of 50 cm × 20 cm. Sweet corn variety 'Misthi' developed through F_1 hybrid breeding by 'Nuziveedu seeds limited' was used a test variety. Recommended dose of NPK @ 80:60:40 kg ha^{-1} was applied through Urea, SSP and MOP. Nitrogen was applied in three split doses, 50% of recommended dose of nitrogen, full dose of phosphorus and potassium was applied as basal dose at the time of sowing while rest 50% of N was applied in two splits at critical growth stages *i.e.* 25% at knee height stage and rest 25% at the time of tasseling. Seed priming was done with respective concentration and species of liquid seaweed used for foliar spray in respective treatments. Data on each parameter were collected from plants, excluding those in border rows from each plot. Plant height was measured from base of the plant to last leaf collar of tagged plants. For dry matter accumulation five plants were randomly selected at regular interval of 15 days and cut just above the ground level and dried in the sun followed by oven drying the samples at 65±5℃ temperature for 48-72 hours or till the samples attained a constant weight. After that samples were weighed to record dry matter accumulation. The post harvest observations like number of cobs $plant^{-1}$, cob length, kernels cob^{-1}, green cob yield, green fodder yield, grain yield, protein content and protein yield were recorded as per standard methods. Crop growth rate (CGR) and relative growth rate (RGR) was computed as per the formula at particular stages of growth, respectively.

CGR (g m^{-2} day^{-1}) = $W_2 - W_1 / t_2 - t_1 \times GA$

RGR (g g^{-1} day^{-1}) = Ln (W2) - Ln (W_1) / $t_2 - t_1$

Where,

W_1 and W_2 are initial and final dry weight of plant at time interval t_2 and t_1.

Ln W_1 and Ln W_2 are the natural logarithm of total dry weight of plant at the time interval t_2 and t_1.

GA is ground area covered by a plant, respectively.

Protein content in the grains was determined by multiplying the nitrogen content of grains obtained from each treatment with a nitrogen-to-protein conversion factor (6.25). Protein yield was calculated from the formula, Protein yield (kg ha^{-1}) = Grain yield (kg ha^{-1}) × Protein content in grain (%) /100

The data recorded on various parameters were subjected to statistical analysis by the method of analysis of variance as outlined by (Gomez and Gomez, 1984). The level of significance used in “F” test was given at 5%.

RESULT AND DISCUSSION

Growth attributes

The results of study noted that tillage practices differed significantly with plant height (Table 1). At maturity, conventional tillage (CT) registered the highest plant height (168.79 cm) while the lowest (159.09 cm) was observed in zero tillage (ZT). The main reason behind this could be due to increased availability of plant nutrients in CT that resulted in better growth over ZT. The growth and development of shoot and root was slower in zero tillage as compared to conventional tillage which might be due to lower top soil temperature in ZT as compared to CT (Chassot *et al.*, 2001). Similar findings with respect to tillage on plant height were reported by Kumar and Angadi (2016). Foliar application of liquid seaweed had significance influence on plant height of sweet corn and significantly maximum plant height at harvest (173.80 cm) was recorded with *Sargassum* - Sap 10% while the lowest value (144.44 cm) was observed in control *i.e.* water spray. In general a gradual increase in plant height and dry matter accumulation was observed with increasing concentration of liquid seaweed sap up to 10% thereafter it reduced. S- Sap performed better than K- Sap at all concentrations up to 10%. Applying seaweed sap as a foliar spray during critical growth stages of sweet corn enhances their metabolic activity, acting as a growth stimulant to foster robust plant development. The enhanced growth of plants using a 10% concentration of S-Sap may result from greater nutrient availability resulting from the higher concentration of sap applied. However, raising the sap concentration beyond 10% showed a suppressive impact likely caused by a high salt index (Beckett and van Staden, 1990).

Table 1: Effect of tillage practices and liquid seaweed as foliar spray on growth attributes, CGR and RGR of sweet corn

Treatments	Plant height (cm)	Dry matter accumulation (g $plant^{-1}$)	Crop growth rate (g m^{-2} day^{-1})				Relative growth rate (g g^{-1} day^{-1})			
	At harvest	At harvest	15-30 DAS	30-45 DAS	45-60 DAS	60 DAS-harvest	15-30 DAS	30-45 DAS	45-60 DAS	60 DAS-harvest
Tillage Practices (T)										
T_1: Conventional tillage	168.79	156.20	2.31	14.74	35.98	25.38	0.136	0.125	0.075	0.022
T_2: Minimum tillage	165.05	151.03	2.22	14.00	34.52	24.8	0.133	0.124	0.076	0.023
T_3: Zero tillage	159.09	147.34	2.19	12.71	34.17	24.41	0.132	0.12	0.079	0.023
SEm±	0.71	0.606	0.066	0.323	0.544	0.189	0.002	0.002	0.001	0.00
CD (P=0.05)	2.47	2.10	NS	1.12	NS	NS	NS	NS	NS	NS
Seed treatment and Seaweed-sap spray (S)										
S_1: Water spray	144.44	140.47	1.95	10.80	34.47	23.04	0.127	0.116	0.086	0.023
S_2: K- Seaweed sap 5%	166.40	151.14	2.21	13.87	35.00	24.67	0.133	0.124	0.076	0.022
S_3: K- Seaweed sap 10%	171.12	157.59	2.39	15.26	35.11	25.98	0.138	0.126	0.072	0.023
S_4: K- Seaweed sap 15%	161.99	147.15	2.08	12.90	34.18	24.30	0.129	0.123	0.078	0.023
S_5: S- Seaweed sap 5%	168.43	153.65	2.29	14.49	35.11	25.10	0.135	0.125	0.075	0.022
S_6: S- Seaweed sap 10%	173.80	161.53	2.58	15.99	36.00	26.39	0.142	0.124	0.071	0.022
S_7: S- Seaweed sap 15%	163.97	149.12	2.18	13.40	34.36	24.56	0.132	0.123	0.077	0.023
SEm±	1.49	1.026	0.056	0.326	0.679	0.468	0.002	0.002	0.001	0.000
CD (P=0.05)	4.32	2.97	0.160	0.940	NS	1.350	0.004	NS	0.004	NS

Note: K-Sap: Kappaphycus alvarezii, S-Sap: Sargassum wightii

There was significant variation in dry matter accumulation with advancement in crop age. The enhanced dry matter accumulation at maturity (156.20 g $plant^{-1}$) in conventional tillage was attributed due to increase in the sink strength due to translocation of more SHIVANI photosynthates under CT resulting in increased dry matter accumulation. Corroborating with the present findings, Nayak *et al.* (2006) and Singh *et al.* (2013) also recorded highest value of dry matter accumulation under conventional tillage and deep tillage treatment. Among seaweed, highest DMA (161.53 g plant^{-1}) was observed under treatment *Sargassum*-Sap 10% whereas, lowest DMA were recorded under control (140.47 g plant^{-1}). The noticeable increase in the vegetative growth of maize plants resulting from the application of two seaweed saps can be linked to the presence of plant growth hormones such as cytokinins within them, which facilitate both cell division and enlargement (Crouch *et al.,* 1990). This confirms the findings of Mondal *et al.* (2015) and Singh *et al.* (2016).

Physiological indices

Data pertaining to CGR and RGR presented in Table 1 revealed that variations among tillage practices were non-significant at all growth stages of sweet corn except at 30-45 DAS. However, CGR of sweet corn gradually increased with the advancement in crop age and reached its peak at 45-60 DAS and further it declined gradually as the crop proceeded towards maturity. Significant variation was observed at 30- 45 DAS, and maximum CGR (14.74 g m^{-2} day^{-1}) was noted in CT. Similarly, there was no significant variation in RGR of sweet corn due to tillage practices and numerically higher RGR was noted in CT at 15-30 DAS and 30-45 DAS. However, it was observed that RGR gradually decreased with the advancement of crop age. RGR of wheat and maize displayed a declining trend from beginning until maturity of both crops (Puran, 2013). The results are closely associated with the findings of Nath (2020) and Pandey (2021) who elucidated that there was no significant effect of tillage on relative growth rate of wheat and maize. Application of liquid seaweed had profound effect on CGR of sweet corn except at 45-60 DAS where variation was not significant. It was observed that at 60 DAS- harvest, CGR (26.39 g m^{-2} day^{-1}) was maximum with treatment seed priming followed by foliar spray of *Sargassum* -Sap 10%. Whereas, control *i.e.* water spray resulted in lower value of CGR. In addition to essential macro and micronutrients, seaweed extracts alsocontain plant growth regulators such as IAA, gibberellins, cytokinins, and glycine betaine which triggers physiological responses in plants (Pramanick *et al.,* 2013). Increase in crop growth rate with foliar application of seaweed extract coincides with the findings of Zodape *et al.* (2009). There was significant difference between treatments for RGR of sweet corn except at 30-45 DAS and 60 DAS-harvest, where variation was not significant. However, at 15-30 DAS significantly maximum RGR (0.142 g g^{-1} day^{-1}) was noted with *Sargassum* -Sap 10%. While at 60 DAS- harvest no clear-cut trend in RGR was noted. Seaweed sap is responsible for eliciting many physiological responses in plant which together lead to better growth and effect quality and productivity of crops (Layek *et al.,* 2015).

Yield attributes, yield and quality

Tillage practices had significant influence on yield attributes, yield and protein yield of sweet corn (Table 2). Both treatments *i.e.* tillage practices as well as application of liquid seaweed failed to produce significant effect on the number of cobs plant^{-1} of sweet corn. This might be attributed to the reason that number of cobs plant^{-1} is a genetic trait of sweet corn rather than external influence of cultural practices (Ehsanullah *et al.,* 2015). Yield attributes were significantly influenced and maximum cob length (22.45 cm), no. of kernels cob^{-1} (538.12), green cob yield (18.49 t ha^{-1}), green fodder yield (25.54 t ha^{-1}), grain yield (2.97 t ha^{-1}) and protein yield (330.24 kg ha^{-1}) were recorded under treatment conventional tillage. The treatment exhibiting better growth and having superior yield attributes were also observed to be the higher yielders. This could be due to increased photosynthesis, improved transportation of photosynthates, apart from greater sink and more robust reproductive phase as reflected from number of kernels cob^{-1} and green cob yield. Similar results were obtained by Ramesh *et al.* (2016) in maize under CT over ZT. The findings of Kumar and Karmakar (2015) also support the result of present study which revealed that CT recorded highest green and dry fodder yield of oat over ZT and MT. Grain yield is simply a function of interplay of various yield attributes that are affected directly by environment and crop management practices. In a study, Das *et al.* (2018) reported that NT lowered the maize grain and stover yields by 7 and 4.9% respectively than those under CT. However, tillage practices did not result in significant variation in protein content of sweet corn. Monteva *et al.* (2017) noted that when conventional tillage was adopted, overall sweet corn grains protein content was higher than when no tillage was adopted.

Table 2: Effect of tillage practices and liquid seaweed as foliar spray on yield attributes, yield and quality of sweet corn

Treatments	Cobs plant^{-1}	Length of cob (cm)	No. of kernels cob^{-1}	Green cob yield (t ha^{-1})	Green fodder yield (t ha^{-1})	Grain yield (t ha^{-1})	Protein content (%)	Protein yield (kg ha^{-1})
Tillage Practices (T)								
T_1: Conventional tillage	1.67	22.45	538.12	18.49	25.54	2.97	11.10	330.24
T_2: Minimum tillage	1.53	21.65	479.95	17.48	24.02	2.65	11.02	291.93
T_3: Zero tillage	1.51	20.43	468.59	16.38	22.03	2.41	10.98	264.41
SEm±	0.03	0.22	2.84	0.20	0.51	0.03	0.05	4.69
CD (P=0.05)	NS	0.75	9.84	0.70	1.76	0.11	NS	16.22
Seed treatment and Seaweed-sap spray (S)								
S_1: Water spray	1.54	19.68	459.34	13.60	18.23	2.32	10.56	245.39
S_2: K- Sap 5%	1.53	21.14	482.91	17.76	23.93	2.65	10.93	289.34
S_3: K- Sap 10%	1.53	22.55	513.71	18.78	26.89	2.91	11.05	321.82
S_4: K- Sap 15%	1.70	20.37	477.46	16.52	22.31	2.43	11.23	273.60
S_5: S- Sap 5%	1.59	21.64	486.99	18.67	25.11	2.76	10.96	302.68
S_6: S- Sap 10%	1.54	24.57	571.54	19.37	27.50	3.16	11.16	352.25
S_7: S- Sap 15%	1.57	20.63	476.91	17.45	23.07	2.50	11.35	283.62
SEm±	0.08	0.48	11.75	0.37	0.70	0.07	0.07	7.80
CD (P=0.05)	NS	1.39	34	1.06	2.04	0.19	0.21	22.58

Yield attributes, yield and protein content and protein yield significantly improved with the application of K- Sap and S -Sap. Application of 10% S-Seaweed sap recorded significantly higher length of cob (24.57 cm) and was significantly superior among all other foliar application except for the treatment *i.e.* seed treatment followed by foliar application of K-Seaweed 10% which was found to be at par. This confirms the findings of Dilavarnaik *et al.* (2017) who reported that application of SWS increased the length of *Ablemoschus esulantus*, sweet corn and hybrid maize. It was noted that *Sargassum* sap was more effective in enhancing the number of kernels cob^{-1} than that of *Kappaphycus* sap. The magnitude of increase was more pronounced in case of S-Sap at 5 and 10% concentrations as compared to K- Sap. However, increasing sap concentration above 10% results in decreased values of these parameters. It is in line with the findings of (Singh *et al.*, 2015) who also noted that increasing sap concentration gradually increased the productive tillers, panicle length and 1000-grain weight up to 10%, thereafter it decreased possibly due to high saltindex of the SWS at higher concentration as reported by Salat (2004). Application of S- Sap 10% recorded significantly highest green cob yield (19.37 t ha^{-1}), green fodder yield (27.50 t ha^{-1}), grain yield (3.16 t ha^{-1}) and protein yield (352.25 kg ha^{-1}) than control which recorded lowest values while protein content (11.35%) was found to be significantly highest under application of S- Sap 15%. Difference in the hormone concentration might be the reason for this difference in efficacy of these two seaweed saps. These findings clearly showed that application of S-Sap had significant influence on the yield of sweet corn due to presence of reasonable quantity of micronutrients and cytokinins in *Sargassum* species (Crouch and Staden, 1993). The beneficial effects of SWS on yield of wheat have been reported by Zodape *et al.* (2009), Singh *et al.* (2015) on rice, Dilavarnaik *et al.* (2017) on maize Seaweed extracts can enhance the effectiveness of chemical fertilizers as well as utilization of nutrients from the soil (Demir *et al.,* 2006) and thus increased the N and protein content (Layek *et al.,* 2019). Sivasankari *et al.* (2006) also found an increased protein content in *Vigna radiata* with 10% concentration of seaweed liquid fertilizer prepared from *Sargassum wightii*.

CONCLUSION

The experiment conducted to study the effect of tillage practices and liquid seaweed as foliar spray on growth and yield of sweet corn revealed that conventional tillage gave more profound effect on growth, yield parameters and protein content while among seaweed application of 10% *Sargassum*-sap gave maximum growth, yield attributes and yield while protein content of sweet corn was found to be highest with application of 15% *Sargassum*-sap. Thus, taking into consideration the above factors conventional tillage with application of 10% *Sargassum*-sap proved to be the good in terms of growth and yield of sweet corn crop under Nagaland conditions.

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