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Response of Sweet Corn (*Zea mays* saccharata L.) to Varying Tillage Methods and Seaweed Bio-stimulant Application

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ABSTRACT

Background: The study on the effect of sweet corn (*Zea mays* saccharata L.) to varying tillage methods and seaweed bio-stimulant application was carried out at the Experimental Research Farm, Department of Agronomy, SAS, Nagaland University, Medziphema, Nagaland during *Kharif* season of 2021-2022.

Methods: The experiment was laid out in the split-plot design (SPD). The treatment consisted of three tillage practices (conventional tillage, minimum tillage and zero tillage) in the main-plots while sub-plots received two different types of seaweed-sap from species *i.e. Kappaphycus alvarezii* (K-Sap) and *Sargassum wightii* (S-Sap) with three concentrations (5, 10 and 15%) used for seed treatment followed by foliar spray at three different stages of crop growth.

Result: Analysis of variance revealed significant differences among the tillage practices and concentration and species of seaweed sap for maximum traits under studied. Growth attributes, yield attributes and yield was found to be significantly higher in CT as compared to MT and ZT at all crop stages. Similarly application of S-Sap upto 10% concentration resulted in significantly higher values as over K-Sap.

Key words: Growth, Seaweed, Sweet corn, Yield, Zero tillage.

INTRODUCTION

Maize (*Zea mays*) is the world's third leading cereal crop after wheat and rice (Ram *et al.,* 2023). It accounts for 8 per cent area and 25 per cent production of the world's cereal (Pinjari and Chavan, 2017). Globally, maize is known as "queen of cereals' because it has the highest genetic potential among the cereals (Tollenaar and Lee, 2006). Sweet corn (*Zea mays* saccharata L.) is one of the groups of corn (*Zea mays*) and is classified on the basis of kernel characteristics. Sweet corn varies from normal corn essentially for genes, that affect starch synthesis in the seed endosperm where in one or more simple recessive alleles alter the carbohydrate content of the endosperm and elevate the level of water soluble polysaccharides and decrease starch. Thus, the kernels of sweet corn taste much sweeter than normal corn. The net income from sweet corn is quite higher as compared to grain maize. During 2023-2024, total maize production in India was 33.5 million metric tons from an area of 9.98 million hectares. In the North East region of India, maize has the potential to become a significant crop, with its proportion of total area coverage becoming the second highest after rice. Corn occupies a place of pride among cereals as it is second important cereal crop grown in Nagaland over an area of 0.69 million ha with 1.4 million tonnes of production highest among the North Eastern states (Statistical Handbook of Nagaland, 2020).

Among the various agronomic factors determining yield, tillage and nutrient management is considered as one the basic factors. At present, zero tillage practices have gained importance as it reduces variable cost, because 25-30% of energy is utilized in land preparation and crop establishment (Ali and Behera, 2014). Seaweed extracts, derived from seaweeds, hold significance as sources of biostimulants. They have been harnessed to effectively showcase their ability to promote sustainable growth and increased yield in different crops, with a notable focus on maize (Layek *et al.,* 2015).

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MATERIALS AND METHODS

An on-farm field experiment was conducted in the *kharif* season of 2021 and 2022 on experimental research farm, Department of Agronomy, SAS, Nagaland University, Medziphema, situated at 25°45′3.68″N latitude and 93° 51′29.79″E longitude. Weekly average meteorological data during the span of experimentation was recorded at ICAR research complex for NEH region (Jharnapani), Nagaland centre. The soil of the experimental site at 0-15 cm depth showed medium (210.24 kg ha^{-1}) in available nitrogen

(Alkaline permanganate method; Subbiah and Asija, 1956), medium (23.43 kg ha^{-1}) in available phosphorus (Bray's P1 method; Bray and Kurtz, 1945) as well as medium (221.48 kg ha^{-1}) in available potassium (Ammonium Acetate method; Hanway and Heidel, 1952) with high (1.35%) organic carbon content (Walkley and Black's rapid titration method; Jackson, 1973). The soil was sandy clay-loam in texture, acidic (4.86) and non-saline (0.06 dSm^{-1}) in nature. The study comprised three different tillage methods *i.e.* conventional tillage, minimum and zero tillage and three sprays of different concentrations (5, 10 and 15%) of two species of seaweed *i.e. Kappaphycus alvarezii* and *Sargassum wightii* at different growth stages of crop. Seed priming with respective concentration of seaweed-sap was done prior to sowing followed by foliar spray of seaweed extracts through knapsack sprayer at 30, 50 and 70 DAS of sweet corn. Water soaked seeds were used as control which received water spray only. Chemical composition of K-sap revealed the presence of nitrogen (0.33%), phosphorus (0.08%), potassium (1.97%), calcium (0.04%), magnesium (0.05%), sulphur (3.29%), sodium (8.81%), IAA (1117 ppb), GA3 (14.31 ppm), Zeatin (568 ppb), carotenoids (4.26 mg g^{-1}) and ascorbate (334.67 µg g^{-1}) whereas in S-Sap; nitrogen (1.60%), phosphorus (0.95%), potassium (4.1%), calcium (4.5 %), magnesium (1.1%), sulphur (3.22%), sodium (1.85%), IAA (381.07 ppb), Zeatin (3868.4 ppb), carotenoids (4.11 mg g^{-1}) and ascorbate (902.64 µg g^{-1}) as well as presence of other micronutrients, pigments and antioxidants in both saps in appreciable level (Rathore *et al.,* 2009; Kumar *et al.,* 2015 and Vaghela *et al.,* 2023). Twenty one treatment combinations were tried in a split plot design, replicated thrice. The plot size adopted for the experiment was 6 m × 5 m. Sweet corn variety 'Misthi' was used as test variety and was sown at spacing of 50 cm × 20 cm. The plots were fertilized as per the recommended dose of nutrients at the rate of 80:60:40 kg ha^{-1} in the form of urea (46% N), single super phosphate (16% P) and muriate of potash (60% K). 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. All other recommended package of practices was followed in this study. Thinning and gap filling was done after germination occurred nicely at 15 DAS to maintain the plant population according to treatment in order to attain recommended plant population and to avoid overcrowding for proper growth and yield of the crop.

Growth attributing characters *viz.,* plant height, number of leaves, stem girth, dry weight plant^{-1}, SPAD and yield attributing characters were recorded as per the standard method. For dry weight, plant were cut just above the ground level and dried in the sun followed by oven drying the samples at 65±5°C temperature for 48-72 hours or till the samples attained a constant weight. Five tagged plants from each respective plots were used for recording post harvest observations like number of cobs plant^{-1}, cob length, cob girth, test weight, number of kernels row^{-1}, number of kernels cob^{-1}, green cob weight and green cob yield. The number of kernels per cob was worked out by using the formula:

Number of kernels cob^{-1} =

Number of kernel row cob^{-1} × Number of kernel row^{-1}

Statistical analysis

The experimental data pertaining to each parameter were subjected to statistical analysis by using the technique of analysis of variance and their significance was tested by 'F' test (Gomez and Gomez, 1984). Standard errors of mean (SEm±) and critical difference (CD) at 5% probability (P=0.05) were worked out for each character studied to evaluate differences between treatment means.

RESULTS AND DISCUSSIUON

Growth attributes of sweet corn

It is conspicuous from the data that growth attributes of sweet corn increased with advancement in the crop age. The results of present study given in Table 1 indicated that conventional tillage recorded significantly highest plant height (168.79 cm), stem girth (2.26 cm), SPAD (39.95) and dry weight (156.20 g plant^{-1}) followed by minimum tillage. This might be due to increased availability of plant nutrients in CT that resulted in better growth over ZT. Chassot *et al.* (2001) also observed that 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. The increased crop growth might lead to increase in the sink strength due to translocation of more photosynthates under CT resulting in increased dry weight. This result is in confirmation to the findings of Kumar and Angadi (2016). SPAD value gives an indirect measurement of the nitrogen content of maize leaf (Kumari *et al.,* 2021). Increase in SPAD values under CT might be due to increase in chlorophyll content *viz.,* correlated with an increase in the net photosynthetic rate. The observations recorded for number of leaves noted numerically higher values under CT followed by MT and ZT. Similarly, application of seaweed sap proved effective in bringing significant changes in plant height (173.80 cm), no. of leaves (11), stem girth (2.38), SPAD (40.99) and dry weight (161.53 g plant^{-1}) with increasing S-Seaweed sap concentration up to 10%, henceforth it reduced significantly. Seaweed sap contains important minerals and growth-stimulating hormones which can naturally degrade and foliar application of these liquid fertilizers derived from macroalgae has the potential to amplify nutrient absorption, thereby stimulating plant growth and development, while also reducing the dependency on inorganic fertilizers. This positive impact due to seaweed could be attributed due to increased root establishment and proliferation, enabling plants to extract nutrients more effectively from deeper and farther-reaching soil horizons (Trivedi *et al.,* 2017). The increase in chlorophyll content is a result of reduced chlorophyll degradation, likely influenced by existence of amino acids, betaines and other active substances in the seaweed extract (Whapham *et al.,* 1993). Presence of growth promoting substances in seaweed extracts aids in enzyme activation, cell elongation and cellular stability. Increased plant growth with 10% S-Sap might be due to increased nutrient availability with increased concentration of sap applied while, increasing sap concentration above 10% exhibited inhibitory effect due to high salt index (Beckett and van Staden, 1990). Our results corroborated with the findings reported previously by Singh *et al.,* 2016 and Meshram (2021).

Yields attributes and yield of sweet corn

On the framework established by growth parameters, yield attributes are developed and the aggregate of all yield attributes is finally expressed in the form of yield. The results of study presented in Table 2 illustrated statistically significant differences with regard to length of cob (cm), girth of cob (cm), number of kernels row-1and number of kernels cob^{-1} due to different tillage methods adopted. The results are closely associated with findings of Nath (2020) who reported maximum value of cob length, cob girth with deep tillage as compared to minimum tillage treatment. The effect of tillage practices on yield attributing characters in the present study agreed with the previous findings of Monsefi

Table 1: Growth parameters of sweet corn as influenced by tillage practices and seaweed sap.

Treatments	Plant height (cm)	No. of leaves plant^{-1}	Stem girth (cm)	Chlorophyll index (SPAD)at 60 DAS	Plant dry weight (g plant^{-1})
Tillage practices (T)					
T_1: Conventional tillage	168.79	10.55	2.26	39.95	156.20
T_2: Minimum tillage	165.05	10.40	2.10	38.67	151.03
T_3: Zero tillage	159.09	10.23	1.95	37.63	147.34
SEm±	0.71	0.12	0.03	0.21	0.60
CD (P=0.05)	2.47	NS	0.10	0.72	2.10
Seed treatment and Seaweed-sap spray (S)					
S_1: Water spray	144.44	9.60	1.87	36.25	140.47
S_2: K- Seaweed sap 5%	166.40	10.41	2.07	38.84	151.14
S_3: K- Seaweed sap 10%	171.12	10.75	2.27	40.55	157.59
S_4: K- Seaweed sap 15%	161.99	10.17	1.97	37.57	147.15
S_5: S- Seaweed sap 5%	168.43	10.52	2.12	39.15	153.65
S_6: S- Seaweed sap 10%	173.80	11.00	2.38	40.99	161.53
S_7: S- Seaweed sap 15%	163.97	10.30	2.04	37.91	149.12
SEm±	1.49	0.21	0.03	0.44	1.026
CD (P=0.05)	4.32	0.60	0.10	1.28	2.97

K- Seaweed: *Kappaphycus alvarezii*, S- Seaweed: *Sargassum wighti.*

Table 2: Yield attributes and yield of sweet corn as influenced by tillage practices and seaweed sap.

Treatments	Cobs plant^{-1}	Length of cob (cm)	Cob girth (cm)	Test weight (g)	No. of kernels row^{-1}	No. of kernels cob^{-1}	Green cob weight (g cob^{-1})	Green cob yield (t ha^{-1})
Tillage practices (T)								
T_1: Conventional tillage	1.67	22.45	15.74	183.11	37.64	538.12	396.70	18.49
T_2: Minimum tillage	1.53	21.65	14.30	183.12	36.58	479.95	382.49	17.48
T_3: Zero tillage	1.51	20.43	13.64	180.22	35.33	468.59	371.73	16.38
SEm±	0.03	0.22	0.15	2.26	0.21	2.84	2.92	0.20
CD (P=0.05)	NS	0.75	0.50	NS	0.73	9.84	10.11	0.7
Seed treatment and Seaweed-sap spray (S)								
S_1: Water spray	1.54	19.68	12.58	176.12	33.97	459.34	369.40	13.60
S_2: K- Seaweed sap 5%	1.53	21.14	14.54	182.58	36.48	482.91	381.88	17.76
S_3: K- Seaweed sap 10%	1.53	22.55	15.05	186.04	37.78	513.71	391.07	18.78
S_4: K- Seaweed sap 15%	1.70	20.37	14.36	179.37	35.73	477.46	375.95	16.52
S_5: S- Seaweed sap 5%	1.59	21.64	14.94	184.39	37.2	486.99	384.40	18.67
S_6: S- Seaweed sap 10%	1.54	24.57	15.96	184.91	37.88	571.54	404.91	19.37
S_7: S- Seaweed sap 15%	1.57	20.63	14.50	181.62	36.58	476.91	377.87	17.45
SEm±	0.08	0.48	0.30	2.27	0.54	11.75	4.33	0.37
CD (P=0.05)	NS	1.39	0.87	NS	1.55	34.00	12.53	1.06

et al. (2013) who observed that conventional tillage system resulted in higher yield attributing characters in wheat and soybean than zero tillage. The increase in green cob weight (g cob^{-1}) and green cob yield (t ha^{-1}) in CT plots might be mainly due to higher amount of post-anthesis dry matter accumulation and better grain filling 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 weight as compared to ZT plots. These observations are in strong compliance with the findings of Ramesh *et al.* (2016) who also noted highest fresh cob weight in tilled plots while the lowest were obtained in the no tilled plots. Shahid *et al.* (2016) also made similar observations in maize under deep tillage over minimum tillage. Among the seaweed sap treatment, foliar spray of S-Seaweed sap 10% recorded significantly higher yield attributes and yield. It progressively increased with increasing sap concentration up to 10%, thereafter it decreased which might be due to increased salt index of SWS as reported by Salat (2004). Similar results were obtained by Meshram (2021) in maize with S-Seaweed sap over K-Seaweed saps. Yield increase in seaweed treated plants is thought to be associated with the hormonal substances present in the extracts. Various seaweed concentrates and marine macro-algal extracts contain an array of phytohormones and plant growth regulators such as auxins, gibberellins, cytokinins, which promote rooting, growth, flowering, fruit development and other essential processes when applied externally. Increased green cob weight might be due to spraying of SWS at critical growth stages which was used by the crop in an efficient manner and expressed higher growth and yield (Sivasankari *et al.,* 2006). However, number of cobs $plant^{-1}$ and test weight of sweet corn remain unaffected. This might be attributed to the reason that number of cobs $plant^{-1}$ and test weight is a genetic trait so it does not get much variation due to external factors. The present findings are within the close vicinity of those reported by Layek *et al.* (2015) and Meshram *et al.* (2020).

Interaction effect

The interaction effect of tillage and seaweed sap application was found to be non-significant in respect to all the growth characters studied whereas interaction effect of different tillage practices and seaweed sap application presented in Table 3 exhibited significant variation with respect to yield of sweet corn. The positive effect on length of cob and green cob yield might be due to the multifactor effect of conventional tillage practices and foliar application of 10% S-Sap nutrients which enhanced nutrient availability for crop growth and development. It's worth noting that while seaweed extracts may exhibit bioactivity at lower

Table 3: Interaction effect of different treatments on yield attributes and yield of sweet corn.

Treatments	Length of cob (cm)	No. of kernels cob^{-1}	Green cob yield (t ha^{-1})
T_1S_1	21.32	472.06	15.84
T_1S_2	22.35	605.86	19.05
T_1S_3	22.76	554.47	19.43
T_1S_4	20.88	558.12	17.31
T_1S_5	23.92	527.81	18.93
T_1S_6	26.15	550.94	21.09
T_1S_7	19.78	497.58	17.78
T_2S_1	20.74	480.46	15.39
T_2S_2	21.64	414.99	18.55
T_2S_3	23.22	481.14	18.53
T_2S_4	20.19	448.42	16.03
T_2S_5	18.77	507.01	18.29
T_2S_6	25.12	587.72	17.84
T_2S_7	21.88	439.94	17.75
T_3S_1	16.98	425.51	9.57
T_3S_2	19.43	427.89	15.7
T_3S_3	21.68	505.52	18.37
T_3S_4	20.05	425.84	16.22
T_3S_5	22.23	426.16	18.8
T_3S_6	22.44	575.97	19.18
T_3S_7	20.23	493.21	16.83
SEm± (S × T)	0.83	20.35	0.63
CD (P=0.05)	2.42	58.88	1.84
SEm± (T × S)	0.67	15.64	0.52
CD (P=0.05)	1.97	45.55	1.55

concentrations, higher concentrations such as those with elevated levels of potassium which might hinder crop growth and metabolic processes. This inhibition could be due to excess hormones or mineral accumulation.

CONCLUSION

Analysis of variance in the present investigation indicated that the treatments differed significantly in terms of growth parameters, yield attributes and yield of sweet corn studied. Conventional tillage performed better than other tillage methods studied while application of 10% S-Sap recorded maximum values which were at par with 10% K-Sap. For generating a holistic recommendation on the experiment, subsequent execution of factor 1 treatments *i.e.* tillage has to be studied in coming year to assess the positive and negative impacts on various tillage practices in long term on soil health and crop as there is paucity of research in terms of tillage methods in NER region of India as well as there is a need to do further research on seaweed saps to know its efficacy and suitability, whether it can reduce the recommended dose of nutrient to some extent of this region.

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Conflict of interest

All authors declare that they have no conflict of interest.

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