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Effect of seaweed (*Kappaphycus alvarezii*) sap and boron on growth and yield of maize (*Zea mays* L.)

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Abstract
In the 2023 *Zaid* season, a field experiment was carried out at the Department of Agronomy's Crop Research Farm. The experiment consisted of three replications and a randomized block design with ten treatments. There were three stages to the treatments: seaweed sap (2.5%, 5.0%, and 7.5%) and three levels of boron (2.5 kg/ha, 1%, 1.25 kg/ha + 0.5%) soil, as well as foliar spray and a control (N-P-K 120-60-60 kg/ha). Application of seaweed sap (7.5%) and boron (1.25 kg/ha + 0.5%) (treatment 9) recorded maximum plant dry weight (162.10 g/plant), number of cobs per plant (1.90), number of grains per cob (258.00), seed index (27.80), seed yield (6.40 t/ha) and Additionally, the greatest benefit-cost ratio (2.19) was obtained for treatment 9.

Keywords: Maize, seaweed sap, boron, growth, yield and economics

Introduction
Originally cultivated as a cereal grain and domesticated in central America, maize (*Zea mays* L.) is the most extensively grown crop in the world. Maize is an annual plant belonging to the grass family (Poaceae). Globally, maize is known as the 'Queen of cereals' because of its highest genetic yield potential. It is one of the most versatile emerging crops having wider adaptability. All four seasons of the year-*kharif* (monsoon), post-monsoon, rabi (winter), and spring-can be used to grow maize. After rice and wheat among the grains, corn comes in third place. Maize has a huge potential to lower malnutrition, food shortages, and poultry feed. since it is less expensive and produces a higher yield than wheat and rice (Rahman, 2011) [10]. Maize is utilized in India for human consumption (25%) as well as for animal feed (12%), poultry feed (49%), industrial products (made of starch) (12%), drinks, and seeds (1% each). According to Hokmalipour *et al.* (2010) [5], maize has a high nutritional value because it comprises 72% starch, 10% protein, 8.5% fiber, 4.8% oil, 3.0% sugar, and 1.7% ash. Due to many multiple uses of maize as food, feed and fodder improves its demand and had a very great shot over low demand situation.

One of the world's most significant marine resources is seaweed. An essential component of marine coastal habitats is seaweed. They consist of the microscopic and multicellular marine algae that are frequently seen along the ocean's coasts. Seaweed extracts, or "saps," have been sold as fertilizer additives for a number of years, and there have been documented positive effects from their use (Booth, 1965) [2]. Numerous trace elements, minerals, proteins, iodine, bromine, vitamins, and bioactive compounds can all be found in seaweed. Seaweed sap is a new generation of nutrient- rich natural organic fertilizers and biostimulants that can speed up seed germination, increase agricultural productivity, and improve the resistance of many crops (Dwivedi *et al.*, 2014) [3]. The synthesis of cell walls, the transportation of sugar, cell division, differentiation, membrane function, root elongation, control of plant hormone levels, and generative growth of plants are all impacted by boron (Marschner, 1995) [8]. Boric acid, which is absorbed by plants, is translocated gradually. A failure of the root tips to extend, inhibition of the synthesis of DNA and RNA, and inhibition of cell division at the shoot apex of early leaves are examples of deficiencies. It is also recognized that boron plays a crucial role in the elongation of the pollen tube (Salisbury and Ross, 1992) [3].

Applying boron increases plant growth, increases stress tolerance, and increases grain yield.

Materials and Methods

In 2023, a field experiment was carried out at the Department of Agronomy's Crop Research Farm during the *Zaid* season. In the sandy loam soil of the experimental plot, the available nitrogen and potassium levels were medium (225 and 240.7 kg/ha), the electrical conductivity was 0.29 ds/m, and the available phosphorus level was low (38.2 kg/ha). The soil reaction was virtually neutral (pH 7.1). Maize seeds (Hybrid Maize G-0786) were sown on April 24, 2023 with a spacing of 45 × 10 cm. Hand hoeing was used to make 4-5 cm deep furrows along the seed rows in preparation for the application of fertilizers as band placement. The recommended NPK/ha dose of 120-60-60 kg was used. When seeds were sown, basal amounts of potash, full phosphorus, and half of nitrogen were applied. At 30 and 45 days following seeding, manual weeding was carried out. Foliar application of seaweed sap at 20 DAS and 40 DAS and boron at 45 DAS was done after sowing as per the treatments. The data recorded was statistically analysed (Gomez and Gomez, 1984) [4].

Results and Discussion

Plant dry weight

Treatment 9 recorded the considerably greatest dry weight of 162.10 g at 80 DAS. Treatments 7 and 8 (154.10 g and 152.20 g, respectively) were discovered to be statistically equivalent to the maximum, nevertheless.

According to Kalaivanan and Venkatesalu (2012) [6], seedlings treated with 10% concentration of S. myriocystum showed increases in shoot length, root length, fresh weight, and dry weight. Vigna mungo's fresh and dry weights decreased with an additional rise in the concentration of seaweed extract. Elevations of Boron led to a considerable rise in dry weight. Since boron normally affects cell division, it may also improve plant development by enhancing the uptake of nitrogen from the soil, which is reflected in the dry weight of the plant. These results are consistent with the findings of Kumar *et al.* (2019) [7].

Number of cobs/plant

Treatment 9 produced a significant and maximum number of cobs/plant (1.90), while treatments 6, 7, and 8 (1.62, 1.70, and 1.80, respectively) were statistically equivalent to the maximum.

The increased migration of photosynthates from the vegetative portion to the developing grains may be responsible for the improvement in maize yield features (Nooden and Leopold, 1978) [9].

Number of grains/cob

Significant and maximum number of grains/cob (256.07) was recorded in treatment 9. However, treatments 7 and 8 (245.00 and 249.37 respectively) were statistically at par with the maximum.

The number of kernel rows per ear in the maize crop was considerably impacted by the application of B. Grain yield and the number of kernel rows per ear have a significant positive correlation. B was applied, and the number of grain rows per ear increased (Akram *et al.*, 1999) [1].

Seed index (g)

Significant and maximum seed index (27.80 g) were recorded in treatment 9. However, treatments 8 (26.30) were statistically at par with the maximum.

The results of (Rasool *et al.*, 1987) [11] provided support for the current study's findings. They reported that an increase in the uptake level of B increases the weight of 100 grains because an increase in B availability causes an increase in enzyme activation, which in turn increases the partitioning of nutrients from leaves to grains and increases seed weight.

Seed yield (t/ha)

The highest seed production of Treatment 9 (6.40 t/ha) was noted, and it was noticeably higher than that of any other treatment. Nonetheless, it was discovered that treatments 7 and 8 (5.70 t/ha and 5.90 t/ha, respectively) were statistically equivalent to the maximum.

A higher yield could be attributed to the presence of minerals in the seaweed extract and plant growth regulator in the sap, which either increased photosynthate or delayed leaf senescence. This would have increased the amount of photosynthate available for grain filling, resulting in bolder grain and a higher grain yield (Singh *et al.*, 2016) [13].

Economics

In treatment 9, the highest benefit-cost ratio (2.28) was seen.

Table 1: Impact of seaweed sap and boron on growth and yield of maize

S. No.	Treatments	Dry weight (g) at 80 DAS	Number of cobs per plant	Number of grains per cob	Seed index (g)	Seed yield (t/ha)	Benefit cost ratio
1.	K sap 2.5% + Boron 2.5 kg/ha	127.70	1.25	217.67	20.50	3.90	1.11
2.	K sap 2.5% + Boron 1%	135.50	1.33	219.04	21.50	4.20	1.29
3.	K sap 2.5% + Boron 1.25 kg/ha + Boron 0.5%	138.10	1.43	226.22	22.30	4.40	1.38
4.	K sap 5.0% + Boron 2.5 kg/ha	140.90	1.46	227.67	23.20	4.70	1.54
5.	K sap 5.0% + Boron 1%	143.10	1.51	229.00	24.10	5.00	1.71
6.	K sap 5.0% + Boron 1.25 kg/ha + Boron 0.5%	146.60	1.62	233.67	24.70	5.20	1.79
7.	K sap 7.5% + Boron 2.5 kg/ha	154.10	1.70	245.00	25.20	5.70	2.02
8.	K sap 7.5% + Boron 1%	152.20	1.80	249.37	26.30	5.90	2.15
9.	K sap 7.5% + Boron 1.25 kg/ha + Boron 0.5%	162.10	1.90	256.07	27.80	6.40	2.28
10.	N-P-K 120-60-60 kg/ha (Control)	111.20	1.20	210.00	19.70	3.70	1.05
	S.Em (±) CD (P=00.5)	3.86	0.09	2.72	0.77	0.30	-
		11.48	0.29	8.09	2.30	0.90	-

Conclusion

It is concluded that seaweed sap at 7.5%, along with soil application of boron at 1.25 kg/ha and foliar application of boron at 0.5% (Treatment 9), recorded the highest seed yield and benefit cost ratio in maize.

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