To study the effect of various combinations of Biofertilizer (BF), Biosap (BS) andChemical fertilizer (CF) on the vegetative growth of crop plant, *Amaranthus dubius,* and to determine the best combination for maximum yield

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ABSTRACT

The experiment was designed, carried out in duplicate over a period of three months, and the crop chosen was *Amaranthus dubius* that is known to require a short growth duration and low maintenance. The experiment was primarily aimed at analysing the effect of three products created for improving crop health and increasing the water retention of the soil.

The biofertilizer used was a new invention with a specific microbial consortia capable of surviving in all sorts of environmental conditions and enhancing nutrient uptake. The other twoproducts provided by Hindustan Gums and Chemicals Ltd. were the Biosap and the Chemicalfertilizer infused Biosap. The Biosap component is a new product which is essentially a polymer that when applied to soil increases its water holding capacity. When used in combination with chemical fertilizer, the uptake of the nutrients seemed to increase in the laboratory results. Accordingly, the experiment was designed with eight treatments to find outwhich combinations of these products would give better yield based on crop type. The treatments were laid down in randomized block design. The parameters analysed were germination percentage, plant height, internode length, photosynthetic area, number of leavesand root spread.

From the results obtained, treatment 8, which was the combination of biofertilizer, and chemical fertilizer infused biosap, gave the best results with respect to all the parameters except photosynthetic area. Treatment 2 which contained only chemical fertilizer showed the best photosynthetic area of the plant compared to all other treatments. The best treatments used in the experiment has a future potential for introduction on a large scale into field application that would reduce the amount of chemical fertilizer applied, which is well known to cause soil degradation in the long run and prove to be a cost-effective alternative.

KEYWORDS

Amaranthus dubius, Biofertilizer, Chemical Fertilizer, Biosap.

INTRODUCTION AND OBJECTIVE

This study was conducted for the duration of 3 months, from March to May, and was aimed todetermine which specific concentration of BF, CF, and BS, used inherently, or in combination with the other additives of the soil, yields the maximum yield in terms of vegetative parameters,like photosynthetic area, number of leaves, internode length to name a few.

Coming to what this crop is, and why we have chosen it for our study, *Amaranthus dubius*, commonly known as Laal Sag in Bengal is an underrated source of high amount various microas well as micronutrients, and needs to be popularized, is grown primarily in West Bengal only. And, in our country, where people still suffer from various disorders pertaining to nutrient deficiencies, Laal Sag is a viable alternative to many food crops used in other parts of India, since it has high calorific value compared to many other food crops used in the country.

Apart from the nutritional aspect, our choice was also determined by the feasibility in terms of the growing conditions, which was ideal in our case.

Coming to the additives used, **Biofertilizers** are a mixture of various microbial consortia including bacteria, fungi,

cyanobacteria etc. which colonize the rhizosphere and promote plantgrowth by enhancing the nutrient acquisition by the plant. Various kinds of microbes used in BF include Nitrogen-fixers and Phosphate-solubilizers, to name a few.

Chemical fertilizers are a mix of synthetically produced fertilizers which contain definite amounts of various macronutrients. The most common variety found in the market, are of the NPK kind, which contain Nitrogen(N), Phosphorus (P), and Potassium (K) in specific ratios.

Biosap, is a polymer which helps in improving the water-retention capacity of the soil, whichis quite an important aspect when it comes to growing crops in the summer months, as water evaporated rapidly from the soil owing to very high temperatures, and leads to wilting of cropplants, and in very severe cases can cause death of the plant.

MATERIALS AND METHODS

Principle

The experiment had been laid down in **randomized block design** (RBD) with 8 treatments and
1 replicate. A randomized block design (RBD) is an experimental design where the experimental units are in groups called blocks. The treatments are randomly allocated to the experimental units inside each block. This kind of design is used to minimize the effects of systematic error.

Materials required

- 8 pots
- Garden soil (The soil used in this experiment was clayey loam in texture).
- Seeds of *Amaranthus dubius.*
- Prescribed doses of Chemical fertilizer, Bio Fertilizer and Bio Sap.
- A source of fresh water supply for irrigation.
- A Scientific Weighing balance.
- Gardening gloves.

Treatments

The experiment consists of 8 treatments –

- **T1 (control) –** Crop planted in 1 kg garden soil with no additives.
- **T2 –** Crop planted in 1 kg garden soil and 5g CF. (Base – 750g soil + 3g CF and Top –250g soil + 2g CF).
- **T3 –** Crop planted in 1 kg garden soil and 40g BF. (Base – 750g soil + 20g BF and Top –250g soil + 20g BF).
- **T4 –** Crop planted in 1 kg garden soil along with 5g CF and 40 g BF (Base – 750g soil +3g CF + 20g BF and Top – 250g soil + 2g CF + 20g BF).
- **T5 –** Crop planted in 1kg garden soil and 3g BS. (Base – 750g soil + 2g BS and Top – 250gSoil + 1g BS).
- **T6 –** Crop planted in 1 kg garden soil along with 3g BS and 5g CF. (Base – 750g soil + 2gBS + 3g CF and Top – 250g soil + 1g BS + 2g CF).
- **T7 –** Crop planted in 1kg garden soil along with 3g BS and 40g BF. (Base – 750g soil + 2gBS + 20g BF and Top – 250g soil + 1g BS + 20g BF).
- **T8 –** Crop planted in 1kg garden soil along with 3g BS, 5g CF and 40g BF. (Base – 750gsoil + 2g BS + 3g CF + 20g BF and Top – 250g soil + 1g BS + 2g CF + 20g BF).

Methods

- The required amounts of fertilizers were added to the soil prior to sowing.
- Equal number of seeds were broadcasted in 8 pots each having a diameter of 13 cm.
- Irrigation was scheduled at two times in a day preferably in the morning and evening.
- Care was taken to protect the plants from insects, gusts, squalls, and mechanical damage.
- One plant from each pot was plucked out from the soil once in a week very carefully and held under running tap water to wash away the loose soil particles for measuring the required parameters.

RESULTS

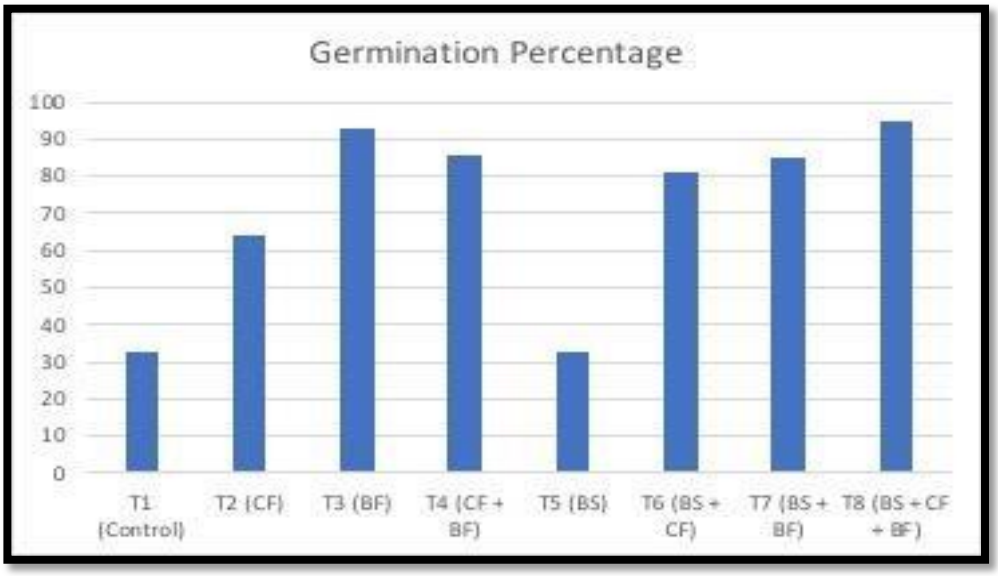
GERMINATION PERCENTAGE

Germination percentage is the percentage of seeds that have produced seedlings, with respectto the number of seeds sown.

Table 1: Germination percentage of all the treatments

Treatment	Percentage
T1	32.5
T2	64
T3	93
T4	85.5
T5	32.5
T6	81
T7	85
T8	94.75

Fig 1: Graph representing germination percentage vs treatments



T8(BS+BF+BS) shows the highest percentage of germination (94.75%), followed by T3 (BF)(93%).

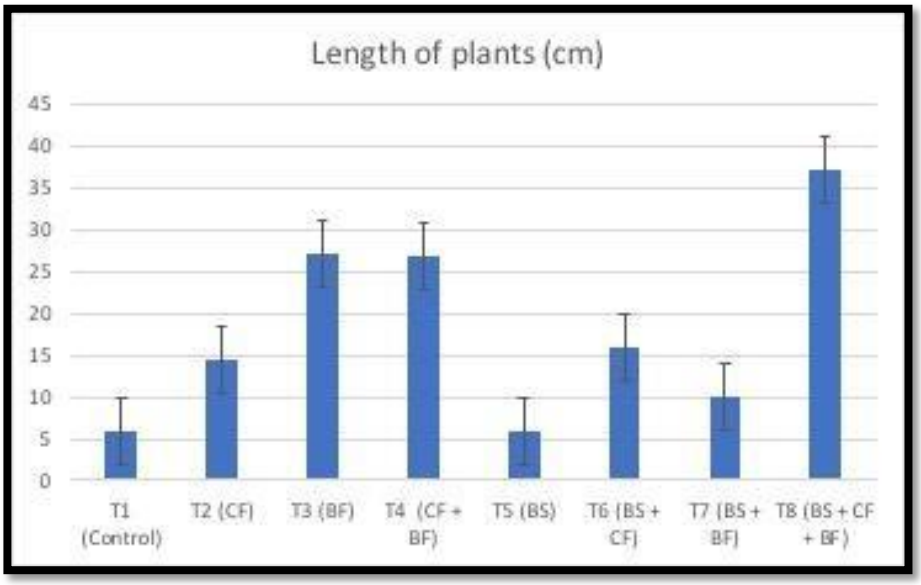
LENGTH OF PLANTS (cm)

Table 2: The length of plants (in cm)

Treatment	Length
T1	6 ± 0.2
T2	14.55 ± 0.2
T3	27 ± 0.2
T4	26.75 ± 0.2
T5	**5.9 ± 0.2**
T6	15.85 ± 0.2
T7	9.9 ± 0.2
T8	**37.05 ± 0.2**

The highest plant length is observed in T8 (CF+BS+BF), followed by T3 (BF).

Fig 2: Graph representing length of plants vs treatments



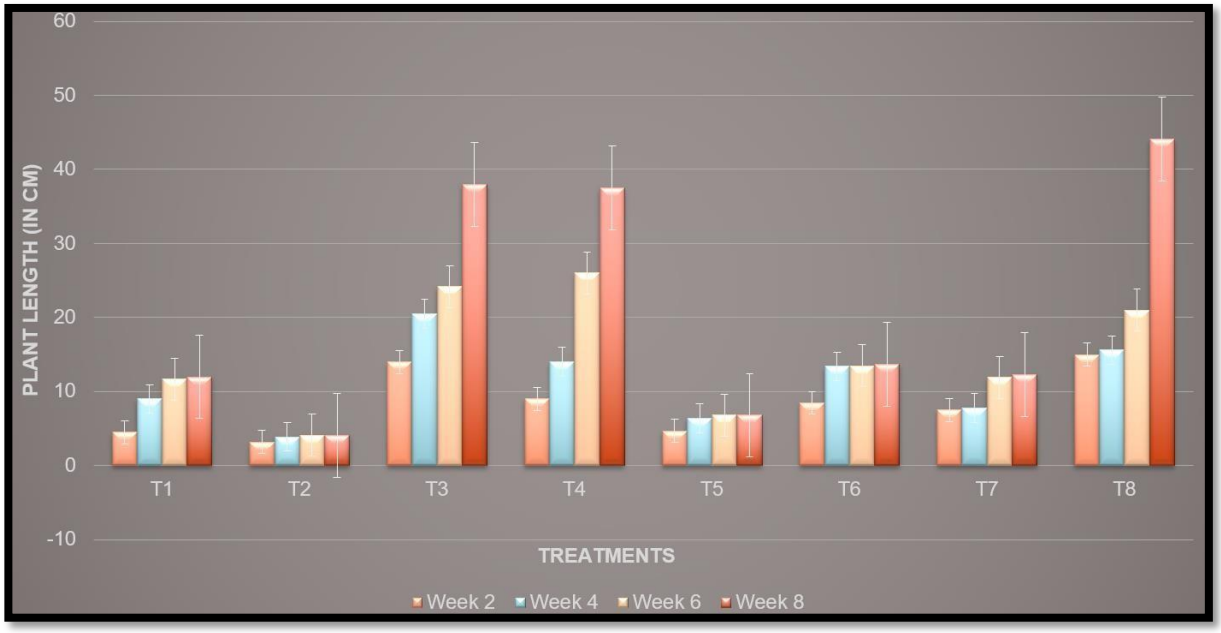
Week wise comparison of plant length (in cm)

Table 3: Week wise comparison of plant length (in cm)

	Week 2	Week 4	Week 6	Week 8
T1	4.5	9.0	11.7	12.0
T2	3.2	3.9	4.1	4.1
T3	14.0	20.5	24.2	38.0
T4	9.0	14.0	26.0	37.5
T5	4.7	6.4	6.8	6.8
T6	8.5	13.4	13.5	13.7
T7	7.5	7.8	11.9	12.3
T8	15.0	15.6	21.0	44.1

T8 (CF+BF+BS) shows drastic growth in the 8th week as compared to the 2nd, 4^{th,} and 6th week.

Fig 3: Graph showing week wise comparison of plant length (in cm)



T3 (BF) and T4 (BF+CF) also show a sharp rise in plant length in the 8th week in comparisonto week 6. The other treatments do not show any drastic change.

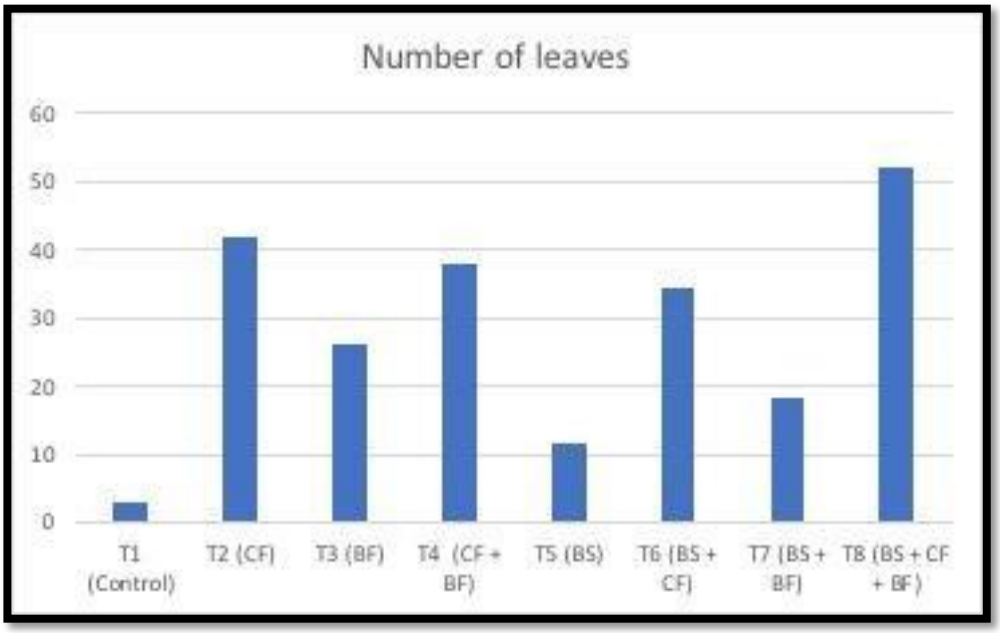
NUMBER OF LEAVES

Table 4: Number of leaves

Treatment	Number of Leaves
T1	3
T2	42
T3	26
T4	38
T5	11.5
T6	34.5
T7	18.5
T8	52

T8 (CF+BF+BS) shows the highest number of leaves, followed by T2 (CF).

Fig 4: Graph representing number of leaves vs treatments

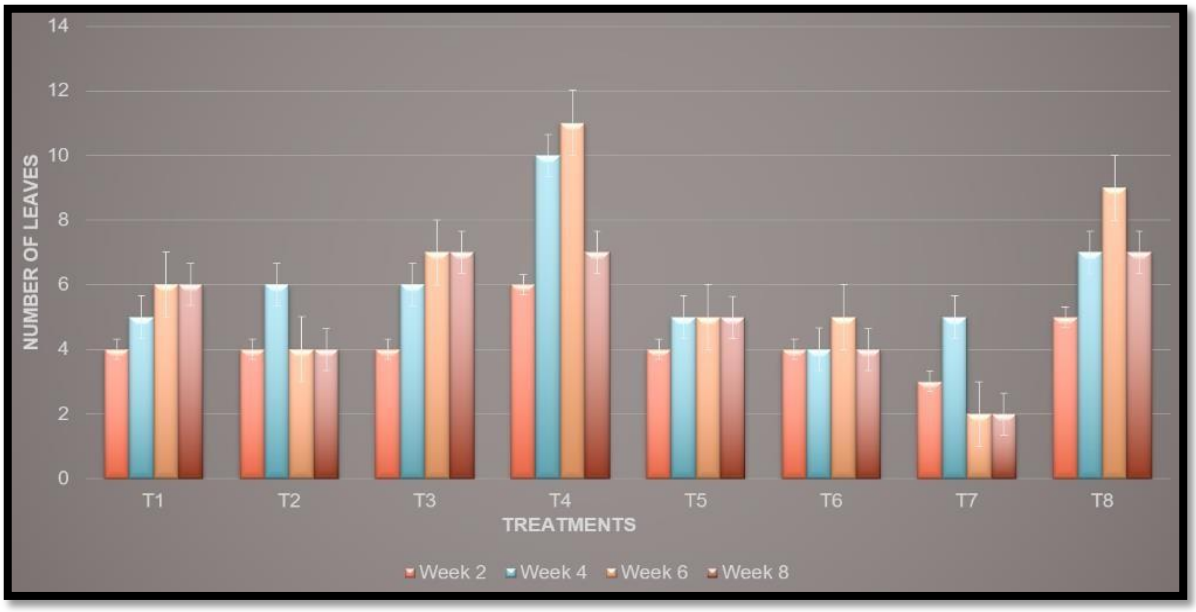


Week wise comparison of the number of leaves

Table 5: Week wise comparison of number of leaves

	Week 2	Week 4	Week 6	Week 8
T1	4	5	6	6
T2	4	6	4	4
T3	4	6	7	7
T4	6	10	11	7
T5	4	5	5	5
T6	4	4	5	4
T7	3	5	2	2
T8	5	7	9	7

Fig 5: Graph showing week wise comparison of number of leaves



T4(CF+BF) shows a rise in the number of plant leaves in the 6th week, but a rapid deteriorationin the 8th week.

T5 (BS) remains stagnant.

Most treatments do not show an increase in the number of leaves.
The decrease in the number of leaves might be due to the hot and humid climate.

INTERNODE LENGTH (cm)

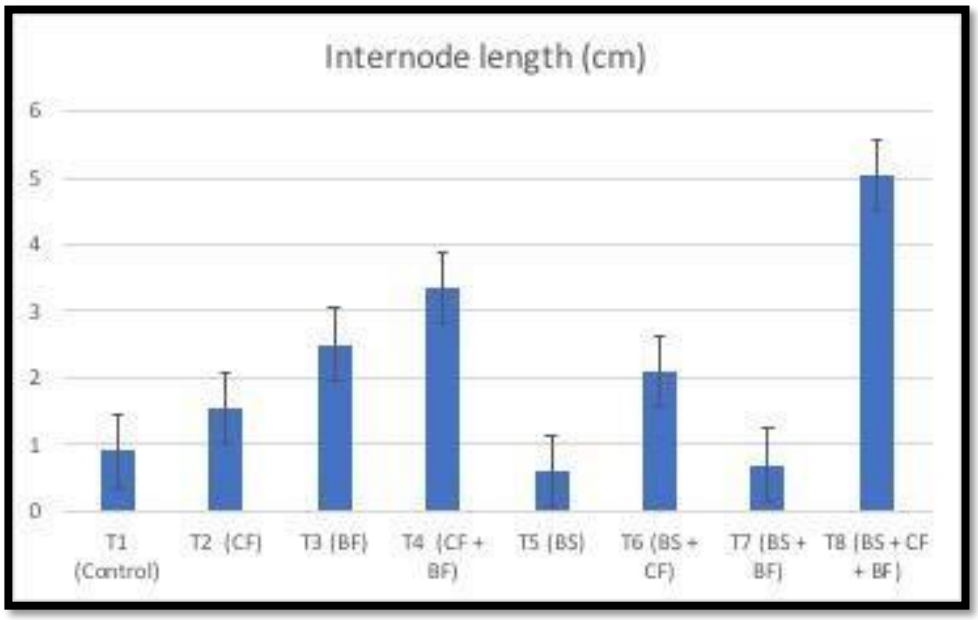
The internode length is the length of the stem between two nodes.

Table 6: Internode length (in cm)

Treatment	Internode length
T1	0.9 ± 0.2
T2	1.55 ± 0.2
T3	2.5 ± 0.2
T4	3.35 ± 0.2
T5	**0.6 ± 0.2**
T6	2.1 ± 0.2
T7	0.7 ± 0.2
T8	**5.05 ± 0.2**

T8 (CF+BS+BF) shows the highest internode length, followed by T6 (BS+CF).

Fig 6: Graph representing internode length vs treatments

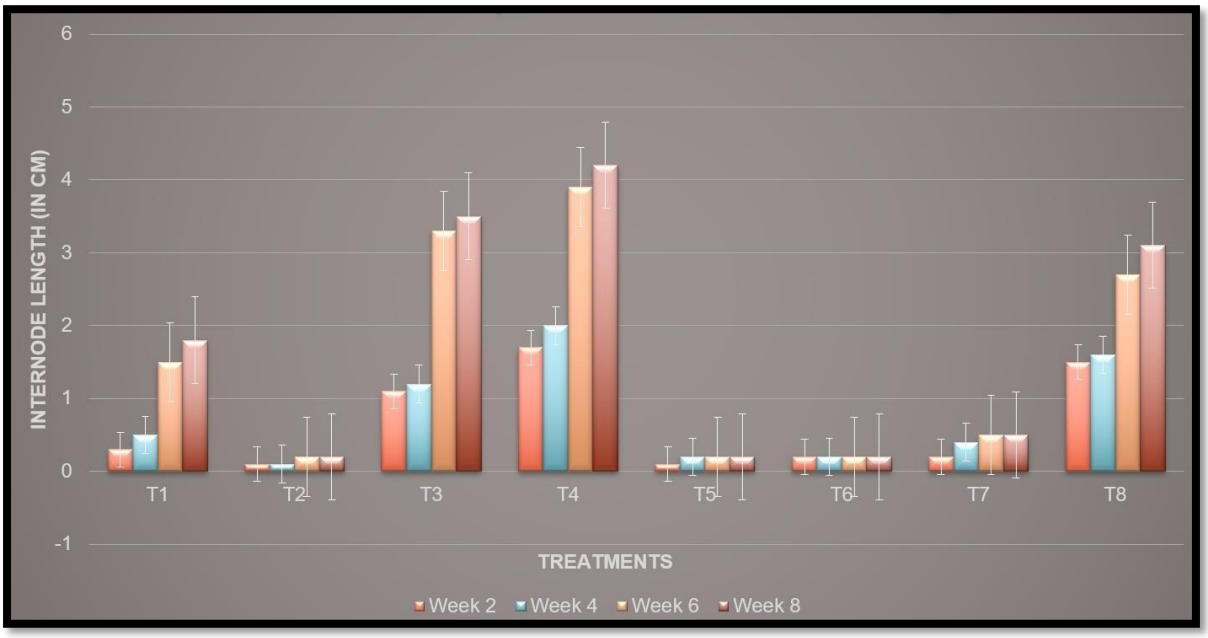


Week wise comparison of internode length (in cm)

Table 7: Week wise comparison of internode length (in cm)

	Week 2	Week 4	Week 6	Week 8
T1	0.3	0.5	1.5	1.8
T2	0.1	0.1	0.2	0.2
T3	1.1	1.2	3.3	3.5
T4	1.7	2.0	3.9	4.2
T5	0.1	0.2	0.2	0.2
T6	0.2	0.2	0.2	0.2
T7	0.2	0.4	0.5	0.5
T8	1.5	1.6	2.7	3.1

Fig 7: Graph showing week wise comparison of internode length



T3 (BF) and T4 (CF+BF) show a gradual increase in the internode length in week 6 and 8.

PHOTOSYNTHETIC AREA (cm^2)

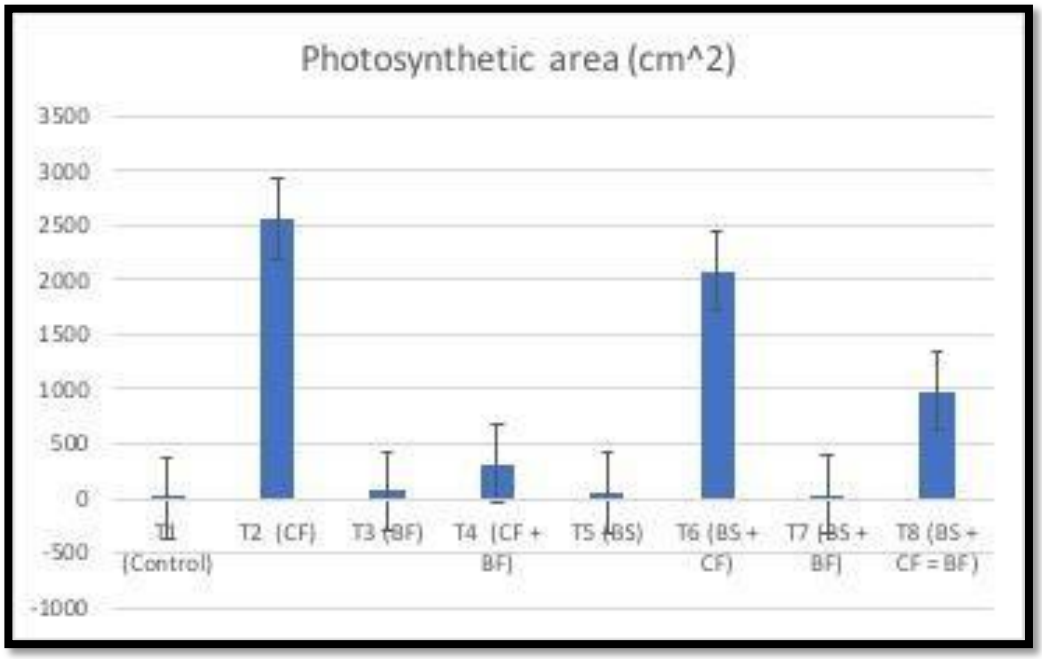
Photosynthetic area is defined as the product of the individual leaf surface area and the totalnumber of leaves.

Table 8: Photosynthetic area (in cm^2)

Treatment	Photosynthetic area
T1	4.08
T2	2562.2
T3	67.9
T4	317.53
T5	55.625
T6	2082.32
T7	35.825
T8	984.965

The highest photosynthetic area is observed in T2 (CF), followed by T6 (BS+CF).

Figure 8: Graph representing photosynthetic area vs treatments



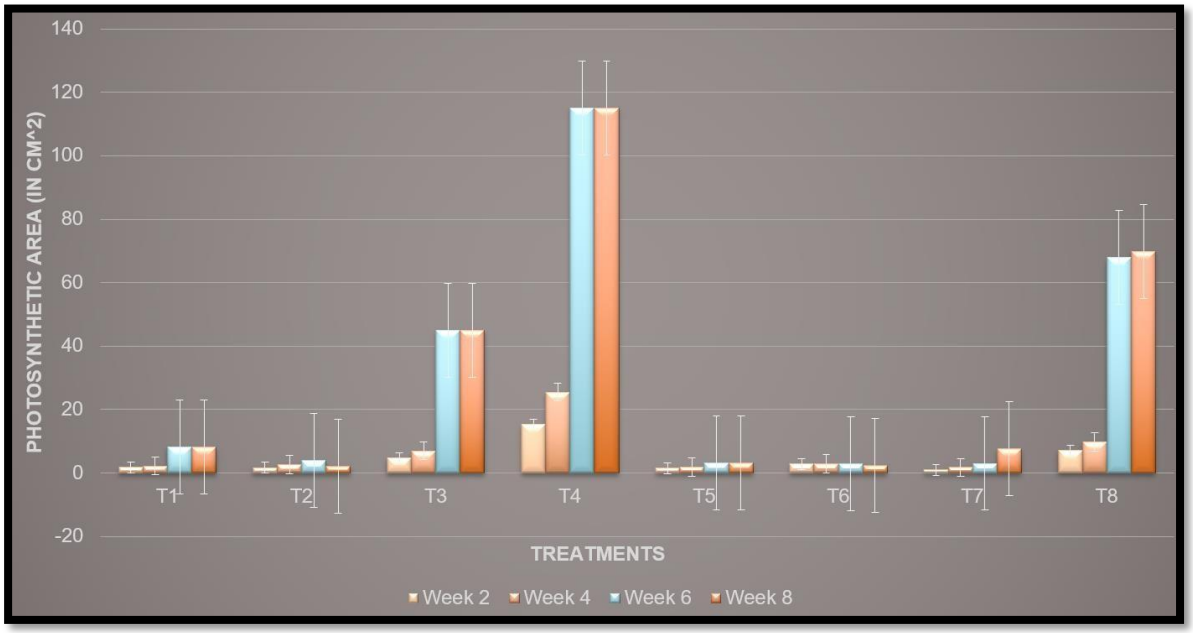
Week wise comparison of photosynthetic area (in cm^2)

Table 9: Week wise comparison of photosynthetic area (in cm^2)

	Week 2	Week 4	Week 6	Week 8
T1	1.83	2.25	8.14	8.16
T2	1.64	2.70	3.90	2.20
T3	4.73	7.02	45.05	45.08
T4	15.34	25.50	115.10	115.06
T5	1.56	1.95	3.20	3.25
T6	2.82	2.84	2.87	2.32
T7	1.06	1.75	3.06	7.65
T8	7.06	9.87	67.92	69.93

T4 shows the highest photosynthetic area in week 8.

Fig 9: Graph representing week wise comparison of photosynthetic area.



ROOT SPREAD (cm)

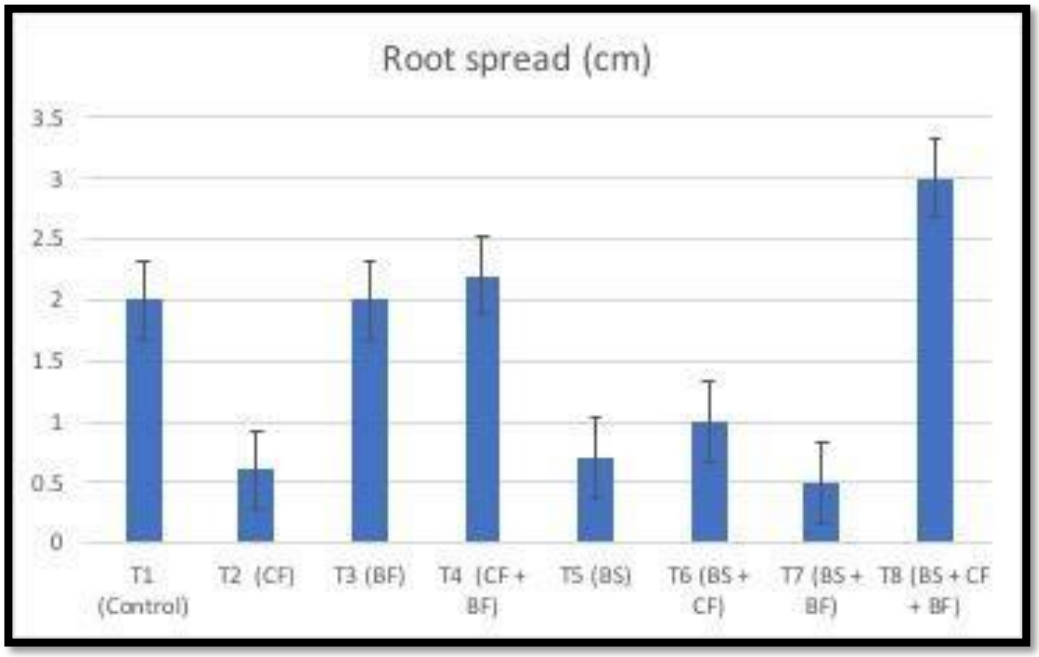
Root spread is the length which determines how far the roots spread in the soil.

Table 10: Root spread (in cm)

Treatment	Root spread
T1	2 ± 0.2
T2	0.6 ± 0.2
T3	2 ± 0.2
T4	2.2 ± 0.2
T5	0.7 ± 0.2
T6	1 ± 0.2
T7	**0.5 ± 0.2**
T8	**3 ± 0.2**

T8 (CF+BF+BS) shows the most root spread, followed by T4 (CF+BF).

Fig 10: Graph representing root spread vs treatments



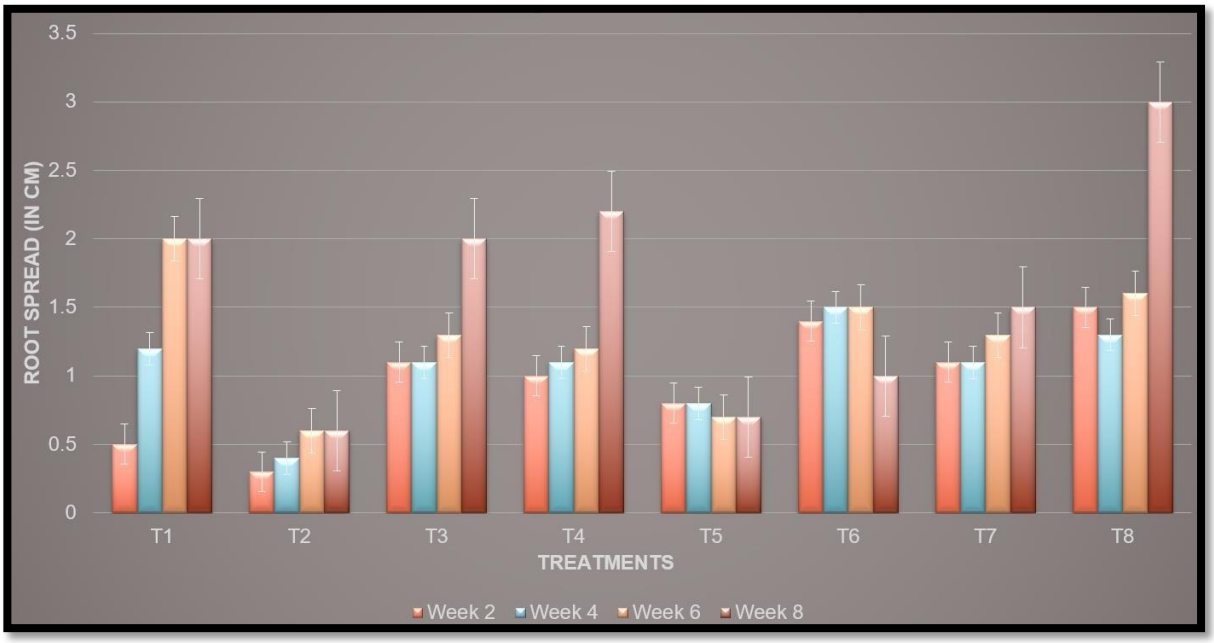
Week wise comparison of root spread (in cm)

Table 11 : Week wise comparison of root spread (in cm)

	Week 2	Week 4	Week 6	Week 8
T1	0.5	1.2	2.0	2.0
T2	0.3	0.4	0.6	0.6
T3	1.1	1.1	1.3	2.0
T4	1.0	1.1	1.2	2.2
T5	0.8	0.8	0.7	0.7
T6	1.4	1.5	1.5	1.0
T7	1.1	1.1	1.3	1.5
T8	1.5	1.3	1.6	3.0

In week 8, T8 (CF+BF+BS) shows a rapid increase in the root spread as compared to week 6.

Fig 11: Graph representing week wise comparison of root spread (in cm)



T4 (CF+BF) shows an increase in root spread in week 8.

DISCUSSION

A perusal of the data presented in this paper clearly indicates that the important vegetative features like plant length, number of leaves, internode length and root spread are significantly affected by the application of chemical fertilizer, biofertilizer and bio sap. After 8 weeks of germination, the soil treated with both the fertilizers and bio sap showed the maximum plant length (37.05 ± 0.2 cm), maximum number of leaves (52), maximum internode length (5.05 ±
0.2 cm) and maximum root spread (3 ± 0.2 cm) which were 527.96%, 1633.33%, 741.67% and 500% more as compared to the control setup with no additives. The maximum photosynthetic area was however found to be maximum for T2 (2562.2 cm^2) where only chemical fertilizer was added to the soil. It was found to be 62699% more than the control.

In our experiment as mentioned earlier, 3g bio sap was used for the treatments T5, T6, T7 and T8 but in other research where 1g bio sap was used for the same treatments a different result was obtained. According to that research after 8 weeks of germination, the soil containing bio sap along with bio fertilizer that is T7 showed the maximum plant length (25.75 ± 2.0 cm), number of leaves (33) and photosynthetic area (13.57 ± 2.34 cm^2) which are 19.99%, 120% and 57.06% more than the control, whereas the maximum internode length (3.00 ± 1.85 cm) being 5.63% more than the control was obtained in T2 containing only chemical fertilizer.

CONCLUSION

From an economic point of view, it can be said that in spite of Treatment 2 (chemical fertilizer only) giving the maximum photosynthetic area, which is very important considering the fact that the crop *Amaranthus dubius* is a leafy vegetable, Treatment 8 (biofertilizer, chemical fertilizer infused biosap) gives satisfactory results as well. This is because all parts of the crop except the roots are consumed.

The highest length of the plants that was obtained in Treatment 8 is indicative of higher nutrient uptake. This was in all probability possible because of the collective effect of all the components of the treatment that were utilized to yield a result such as this.

In conclusion, we can say that *Amaranthus dubius* has a future as an important source of nutrients, especially in regions with prevalent malnutrition. The presence of plant-based proteins, unsaturated fatty acids, micronutrients and many bioactive compounds like antioxidants and anthocyanins gives this crop tremendous potential. Hence indirectly, for large scale growth of this crop the best combination will be utilised for not only good produce but minimum negative impacts on the environment.

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