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Effect of combination of inorganic fertilizer and seaweed extract on yield, yield attributes and economics of soybean crop

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Abstract
A field experiment was conducted during the rainy (kharif) season in Indian in 2017 at central farm vasantrao naik Marathwada Krishi vidyapeeth parbhani to study the effects of seaweed extract (prepared from *Ascophyllum nodosum*) on the growth and yield of soybean [*Glycine max* (L.) Merrl.] grown under rainfed conditions with combination of chemical fertilizers and seaweed extract. The granular application was applied at the time of sowing with two different concentrations (20 and 40 kg/ha^{-1}) and foliar spray was applied at the time of flowering (2 Ml SL lit^{-1}).Granular and Foliar applications of seaweed extract significantly enhanced yield and yield attributing parameters. The highest yield attributes, seed yield, GMR, NMR, was recorded with applications of 100% RDF + 40 Kg SG ha^{-1} + 2 Ml SL ha^{-1} (T_7) seaweed extract, followed by 100% RDF + 20 Kg SG ha^{-1} + 2 Ml SL ha^{-1} (T_6) seaweed extract. Highest B:C ratio is highest with T_6 it is due to high cost of fertilizer and dose of fertilizer given in treatment. The maximum straw yield was also achieved with T_7. Thus, under rainfed soybean production, applications of inorganic fertilizers with seaweed extracts could be a promising option for yield enhancement.

Keywords: Sea weed extract, GMR, NMR, B:C ratio *Ascophyllum nodosum*

Introduction
Soybean (*Glycine max* (L.) Merill) belong to the order Fabales, family Fabaceae (Leguminosae), and subfamily Faboidede (Papilionoideae). In India it is known by several names as *bhat, bhatman, bhatmas, kulthi, ramkulthi, bhut, kalitur, teliakulth* and *gerakalay*. It is an important crop worldwide, because it has a wide range of geographical adoption, unique chemical composition, good nutritional value, functional health benefits and variety of end uses (food, feed and non-edible). It is extremely climate resilient and performs even under severe water stress and wet conditions. It improves soil fertility by fixing atmospheric nitrogen to the extent of 50-300 kg/ha. Depending upon agro climatic conditions, variety, strain etc. (Keyser and Fudi, 1992) [1] it adds about 1.0-1.5 tonnes of leaf litter per season/ha. It generates employment through trading, processing, exports, and industrial uses i.e. value addition.
Among biostimulants, a special attention is given to seaweed extracts (Blunden, 1991; Cassan *et al.*, 1992; Calvo *et al.*, 2014) [2, 4, 3]. The brown seaweeds *Phaeophyceae* in particular, are employed in sustainable agricultural applications (Goñi *et al.*, 2016), and some of them like *Ascophyllum nodosum, Macrocystis pyrifera*, and *Durvillea potatorum* are widely used in food and industrial applications (Khan *et al.*, 2009). The beneficial effect of seaweed extract application is as a result of many components that may work synergistically at different concentrations, although the mode of action still remains unknown (Fornes *et al.*, 2002) [5]. In recent years, use of seaweed extracts have gained in popularity due to their potential use in organic and sustainable agriculture (Russo and Beryln, 1990) [6], especially in rainfed crops, as a means to avoid excessive fertilizer applications and to improve mineral absorption. Unlike, chemical fertilizers, extracts derived from seaweeds are biodegradable, non-toxic, non-polluting and non hazardous to humans, animals and birds (Dhargalkar and Pereira, 2005) [7].
Liquid extracts obtained from seaweeds have gained importance as foliar sprays and soil drench for many crops including various grasses, cereals, flowers and vegetable species. Also they apply to stimulate seedling germination and rooting. At present one of the most promising applications of seaweeds is their use as plant biostimulants. For example, aqueous extracts of *Sargassum johnstonii* at concentration from 0.1 to 0.8% (w/v) that is mL^{-1} equivalent 18 mg SW used as foliar spray and soil drench enhanced vegetative. Seaweed extracts exhibit growth motivating property on crop plants. Hence its formulation can be used as a bio-stimulant in agriculture.

Material and Method

The field experiment conducted during 2017 was conducted at balsa block Central Farm, VNMKV, Parbhani. The experimental field was leveled and well drained. The soil was clay in texture, low in nitrogen, medium in phosphorus and high in potassium and alkaline in reaction. Total rainfall received during crop growing season was 995.01 mm and distributed over 42 rainy days during the process of experimentation. The environmental conditions prevailed during experimental period was favourable for normal growth and maturity of soybean.

The experiment was laid out in Randomized block design with seven treatments viz., T1- Control, T2- 75% RDF (22.5:45:22.5 NPK kg ha-1), T3- 100% RDF (30:60:30 NPK kg ha-1), T4- 75% RDF + 20 kg SG ha-1 (Seaweed extract in granular form) + 2 ml SL lit-1 (Seaweed extract in liquid form), T5- 75% RDF + 40 kg SG ha-1 + 2 ml SL lit-1, T6- 100% RDF + 20 kg SG ha-1 + 2 ml SL lit-1, T7- 100% RDF + 40 kg SG ha-1 + 2 ml SL lit-1 and 3 replications. Sowing of soybean variety MAUS-71 was done on 14th July, 2017 by dibbling the seeds at spacing 45 cm × 05 cm. The recommended cultural practices and plant protection measures were taken. Fertilizer viz., nitrogen, phosphorus and potassium were applied to respective plots by using urea, SSP and muriate of potash uniformly in the lines opened for sowing as per the treatments.

Result and Discussion

1. Effect of seaweed extract on yield and yield parameters of soybean

The chemical constituents of the of *Ascophyllum nodosum* extract of see weed extract in granular form are taken for treatments with different doses of fertilizer. AThe highest number of mean number of pods plant^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, number of seeds pod^{-1}, test weight, seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) of soybean observed at 100% RDF + 40 Kg SG ha-1 + 2 Ml SL lit-1 (T7) twice during flowering (45 DAS) and pod filling stage (60 DAS) recorded significantly highest yield and yield attributing character but it was at par with the 100% RDF + 20 Kg SG ha-1 + 2 Ml SL lit-1 (T6) and 75% RDF + 40 Kg SG ha-1 + 2 Ml SL lit-1 (T5). Significantly minimum growth parameters recorded in treatment (T1) Control. It is due to sea weed extract on different aspect of plant *ie* surface area for high photosynthetic rate as well as maximum translocation of photosynthesis from source to sink, subsequently resulted in improvement of all yield attributes. Because of synergetic effect among the yield attributes they benefited each other. These findings are in accordance with those of Rathore *et al.* (2009) [8], Zodape *et al.* (2009) [9], Sridhar and Rengasamy (2010)[b].

Table: Mean number of pods plant^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, number of seeds pod^{-1}, test weight, seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) of soybean as influenced by different treatments.

Sr. No.	Particulars	Treatments						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
1.	Number of pods plant^{-1} at harvest	17.93	19.23	24.60	22.73	26.30	28.97	30.47
2.	Weight of pods plant^{-1} (g)	4.76	5.48	6.79	6.35	7.53	8.13	8.58
3.	Weight of seed plant^{-1} (g)	3.12	3.78	4.98	4.43	5.79	6.20	6.64
4..	Number of seeds plant^{-1}	37.08	42.49	52.67	48.65	60.17	65.40	69.61
5.	Seed yield (Kg ha^{-1})	1183	1453	1783	1770	2015	2120	2232
6..	Straw yield (Kg ha^{-1})	1576	1957	2354	2355	2635	2782	2879
7.	Biological yield (Kg ha^{-1})	2759	3410	4137	4125	4650	4902	5111

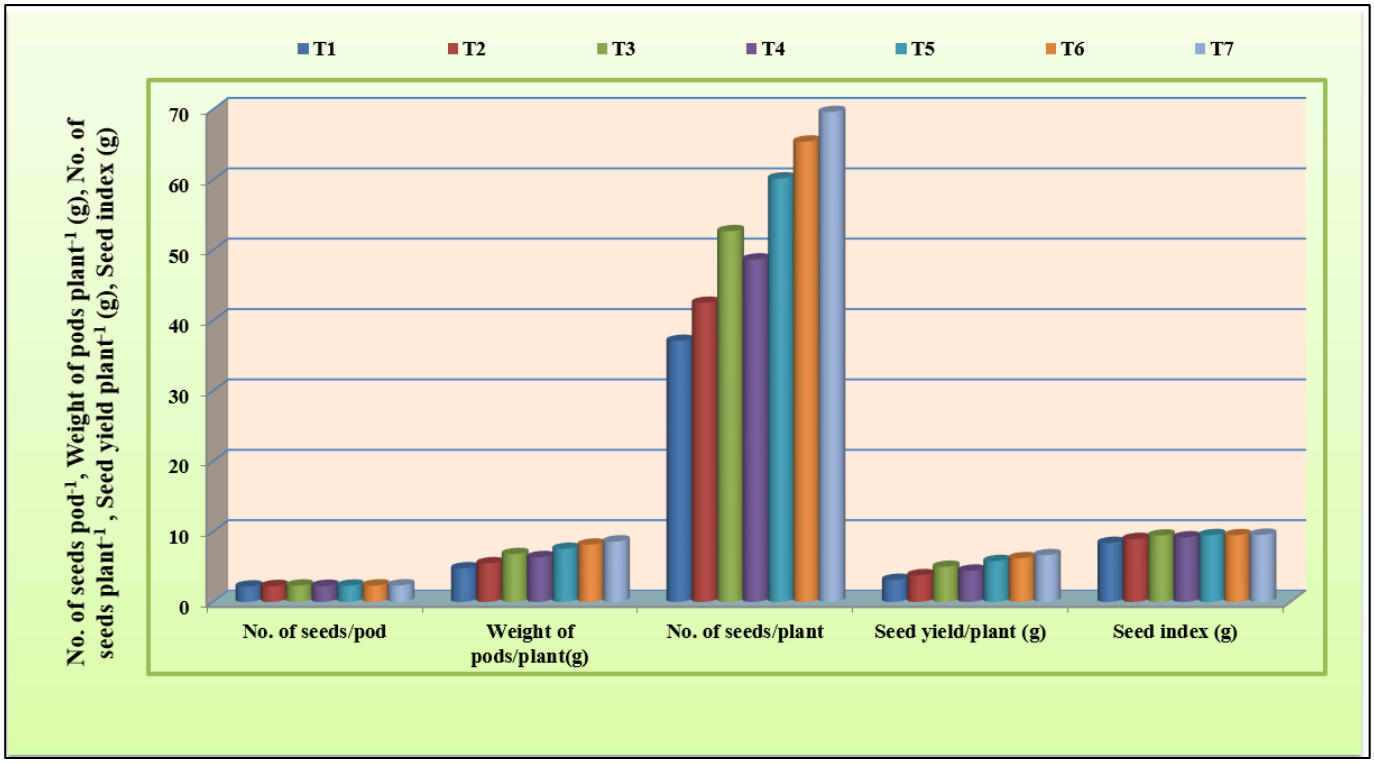

Fig 1: Yield attributes of soybean as influenced periodically by various treatments

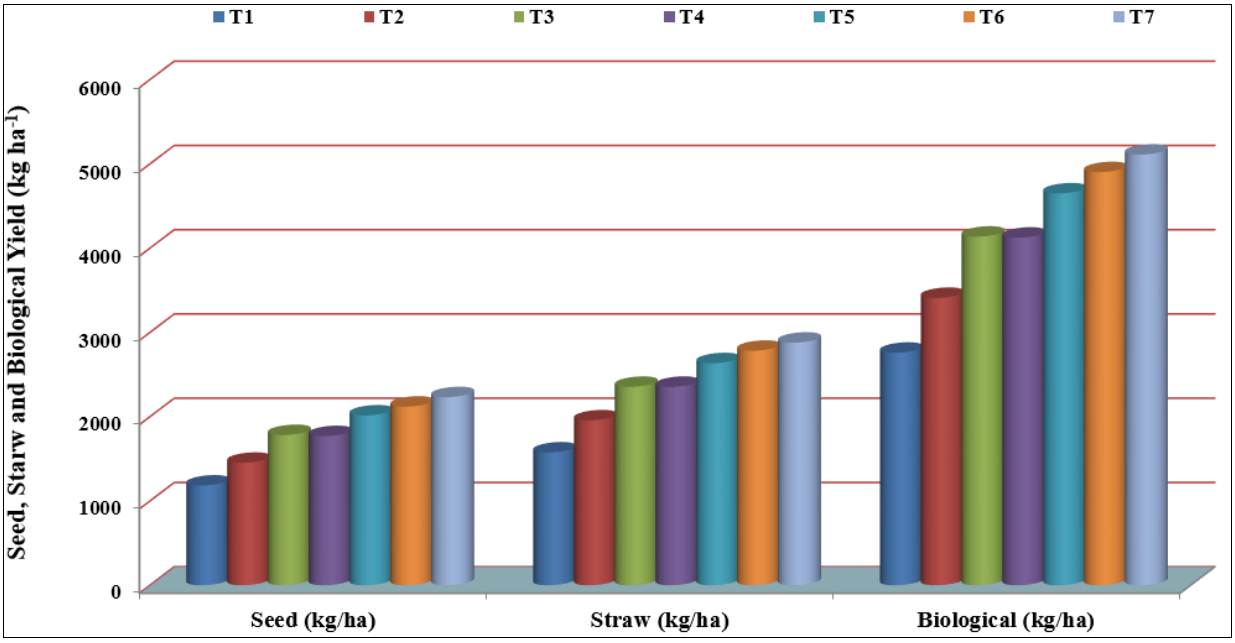

Fig 2: Seed, straw and biological yields (Kg ha^{-1}) of soybean as influenced by different treatments

Table 2: Economics of soybean production as influenced by different treatments

Treatments	Gross monetary returns (ha^{-1})	Cost of cultivation (ha^{-1})	Net monetary returns (ha^{-1})	B:C ratio
T_1- Control	37668	22500	15168	1.67
T_2- 75% RDF	46283	26509	19774	1.75
T_3- 100% RDF	56726	27655	29071	2.05
T_4- 75% RDF + 20 kg SG + 2 ml SL	56320	30329	25991	1.86
T_5- 75% RDF + 40 kg SG + 2 ml SL	64093	32529	31564	1.97
T_6- 100% RDF + 20 kg SG + 2 ml SL	67442	31475	35967	2.14
T_7- 100% RDF + 40 kg SG + 2 ml SL	70955	33675	37280	2.11
S.E.(m) ±	2408	-	2408	-
C.D at 5%	7419	-	7419	-
General mean	57070	29239	27831	1.93

2. Effect of seaweed extract on Economics of soybean production soybean

Economics of soybean producton depends on several factors such as input cost, labour requirement and above all weather condition prevailing durig the crop growth period. Economics of maize (sweet corn): It is revealed from the data present in table 2, that the cost of cultivation of Soybean varied from Rs. 22,500 to 33,675 ha^{-1} owing to the use of different doses of seaweed extract and fertilizers. The data recorded for yield showed that the maximum yield (22.32 q ha-1) was observed under treatment T_7- 100% RDF + 40 kg SG + 2 ml SL, hence, as compared with other treatment it gave maximum gross return (Rs. 70,955 ha^{-1}), net return (Rs. 37,280 ha^{-1}) but B:C ratio (2.14), is highest in treatment T_6- 100% RDF + 20 kg SG + 2 ml SL with net return (Rs. 35,967 ha^{-1}) it is due to higher rate of fertilizer and cost of fertilizer. Application of seaweed extract enhanced the early growth and yield attribute properties in legume plants and yield return of 12-25% more than that of control (Sethi and Adhikary, 2008).

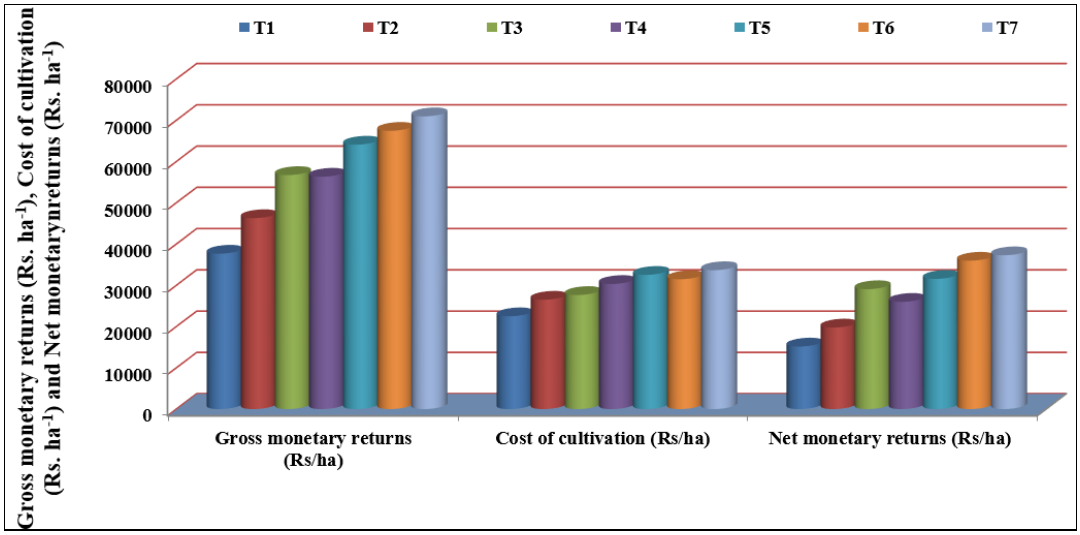

Fig 3: Economics of soybean as influenced by different treatments

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