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Integrated nutrient management on yield and quality parameters of rapeseed (*Brassica Campestris* L.) grown in a typic Haplaquept soil

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Abstract

A field experiment was conducted in a Typic Haplaquept soil of West Bengal, India to study the influence of combined application of inorganic and organic fertilizers on yield and quality parameters of Rapeseed (*Brassica Campestris* L. Var. Yellow Sarson). Recommended doses of N, P and K were applied to all the treated plots (5m X 4m). FYM was applied at 5 ton ha⁻¹ to all the plots except control. Two doses of S (20 and 40kg ha⁻¹) and two doses of B (0.5 and 1.0 kg ha⁻¹) were included in the treatment combinations. Rhizosphere soil and plant samples were collected at branching, pod formation and harvesting stages of rapeseed. Rhizosphere soil were analyzed for available S and B content. Plant samples were also analyzed for S and B uptake following standard methods. Results of the present investigation revealed that in general, the amount of S and B in soil decreased with increase in the period of crop growth. Comparatively higher uptake of S and B were recorded by rapeseed crop which received recommended doses of N, P and K (RDF) along with organic matter as well as higher doses of S and B (T₉). Highest seed yield (13.79%) as well as oil (42.57%) and protein contents (21.76%) over control were recorded in rapeseed which received RDF along with organic matter as well as higher doses of S and B (T₉). Furthermore, it is noteworthy to mention that the application of organic matter along with S and B increased oil and protein content in rapeseed significantly.

Keywords: FYM, oil and protein content, RDF, sulphur, boron, rapeseed crop

Introduction

Integrated nutrient management (INM) implies the maintenance or adjustment of soil fertility to an optimum level for sustaining the desired crop productivity on one hand and to minimize nutrient losses to the environment on the other (Singh *et al.*, 2000) [1]. It is achieved through efficient management of all nutrient sources. Nutrient sources to a plant growing on a soil include soil minerals and decomposing soil organic matter, mineral and synthetic fertilizers, animal manures and composts, by products and wastes, plant residues, and biological nitrogen fixation (BNF). Therefore, the INM combines organic and mineral methods of soil fertility management with physical and biological measures of soil and water conservation. It integrates technologies that are site specific to agronomists and socio-economic conditions to reduce nutrient imbalance.

Indian rapeseed (*Brassica Campestris* L. var. Yellow sarson) is the 2nd most important oil-yielding crop after mustard [*Brassica* (L.)] followed by toria (*Brassica Campestris* var. toria) (Rai *et al.*, 2016) [2]. Rapeseed is the principal oil crop of India especially in West Bengal state. However, the average yield of rapeseed in West Bengal is very low (1.0 t ha⁻¹), which is about 50% lower than world average (Mandal *et al.* 2006) [3].

Sulphur plays an important role in enhancing the yield and quality of crops specially oil seeds crops. It improves the crop growth and yield attributes by regulating the metabolic and enzymatic processes including photosynthesis and respiration (Rao *et al.*, 2001) [4]. Sulphur improves the quality of food crops particularly of oil seeds. It has a role to play in increasing chlorophyll formation and aiding photosynthesis. Sulphur also plays a role in the activation of enzymes, nucleic acids and forms a part of biotin and thiamine. Brassica has the highest sulphur requirement owing to the presence of sulphur-rich glucosinolates (Karthikeyan and Shukla, 2014) [5]. Similarly boron also plays a vital role in cell wall synthesis, root elongation, glucose metabolism, nucleic acid synthesis and tissue differentiation.

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Since meagre information is available on the interaction between sulphur and boron in relation to response of oilseed crops (Ameta *et al.*, 2014) [6].

Soils of West Bengal are deficient in S and B (AICRP-MSPE, 2015) [7] and as such these nutrients must be incorporated in any INM practice particularly in rice-mustard cropping sequence. Realizing the importance of sulphur, and Boron in integrated nutrient management for mustard in general, the present investigation would be carried out in the future research programme. Therefore, it is felt necessary to study the influence of integrated nutrient management (especially FYM, S and B) on soil fertility build up as well as yield and quality improvement of rapeseed.

Materials and Methods

The investigation was conducted with rapeseed (B9 / Binoy variety) in the farmers field situated at Gotra mouza, Chakdah block, Nadia, West Bengal, India (23.08N, 88.53E, 11m above MSL) during November, 2015 to February, 2016. In the present investigation, both organic (FYM) and inorganic fertilizers (N, P, and K) were applied including sulphur and boron as treatment combinations. Initial composite soil samples (0-15 cm) of the field was collected and analyzed for different physical, chemical and physico-chemical properties using standard methodologies. The characteristics of the initial soil samples were pH 7.45, EC 0.21 dSm⁻¹, Organic C 0.51%, Clay 64.98%, Textural class Clay loam, CEC 24.20 Cmol(p+)⁻¹kg⁻¹, Available N 150.58 kg ha⁻¹, Available P₂O₅ 45.6 kg ha⁻¹, Available K₂O 147.24 kg ha⁻¹, Available SO₄⁻² 9.12 mg kg⁻¹, Available B 0.42 mg kg⁻¹, Soil Taxonomy Typic Haplaquept.

Both organic (FYM) and inorganic fertilizers (N, P, and K) were applied including sulphur and boron as treatment materials. There were total 10 treatments with 3 replications. The treatments details were: T₀=Control, T₁=T₀+FYM, T₂=T₀+FYM+B₁, T₃=T₀+FYM+B₂, T₄=T₀+FYM+S₁, T₅=T₀+FYM+S₂, T₆=T₀+FYM+B₁+S₁, T₇=T₀+FYM+B₁+S₂, T₈=T₀+FYM+B₂+S₁, T₉=T₀+FYM+B₂+S₂. N, P₂O₅ and K₂O at 80:40:40 kg ha⁻¹ were applied through Urea, SSP and MOP respectively for all the treatments. The full dose of FYM at 5t ha⁻¹ was applied at the time of primary land preparation as per treatment combination. Sulphur as Elemental S (S₁ @ 20 kg ha⁻¹ and S₂ @ 40 kg ha⁻¹) and B as Borax (B₁ @ 0.5 kg ha⁻¹ and B₂ @ 1 kg ha⁻¹) were applied as per treatment combinations. The full doses of P₂O₅, K₂O, S, B and half of N were applied at the time of final land preparation and the remaining half of the N was applied at about 21 days after sowing and just after final weeding and thinning. The FYM used as treatment material contain N, P₂O₅, K₂O, S and B about 0.58%, 0.26%, 0.40%, 0.02% and 2.8 mg kg⁻¹, respectively. Augmented Strip plot design was adopted for the experiment. Two irrigation, first after 30 days and second after 60 days of sowing, were applied during crop growth. Manual weeding was done twice to keep the plots free from weeds. Plants were harvested on 90th day after sowing.

Collection and Analysis of soil and plant samples

Rhizosphere soil samples were collected from five to six randomly selected locations in each plot of 30 plots (15-30 cm) at Branching (30DAS), pod formation (60DAS) and harvesting stage (90DAS) of the yellow Sarson. The samples were air dried for removal of moisture and analyzed for available SO₄⁻², and available B following standard methods. Available Sulfur in the soil was extracted using 0.15% CaCl₂ solution (Chesnin and Yien, 1951) [8]. Boron was determined

spectrophotometrically using modified Azomethine-H method (Wolf 1971) [9] after extracting the soil with hot CaCl₂ solution. Seed and stover yield was determined after harvest. The plant samples were also collected at branching, pod formation and harvesting stage of rapeseed. Then the plant samples were oven dried and were analyzed for total S (Chesnin and Yien 1951) [8] after digesting the samples with di-acid mixture (Jackson, 1973) [10] and total B content by Azomethine-H method (Wolf, 1971) [9] after digesting the samples with triacid mixture (HNO₃: HClO₄: H₂SO₄::10:4:1; Jackson, 1973 [10]), Mustard seeds were analyzed for oil content with the help of Soxhlet's extraction method (Soxhlet, 1879) [11] and protein content by Lowry's soluble protein determination method (Lowry et al 1951) [12].

Statistical analysis

Data of soil and plant samples were analyzed statistically at different growth stages of yellow sarson using Microsoft Office Excel.

Results and discussion

Available B

Hot CaCl₂ solution -extractable B tended to decrease slightly in soils with time which are amended either with B or S fertilizer along with FYM from branching to harvesting stage of rapeseed (Mandal and Das, 2011) [13] (Fig 1). Soils treated combinedly with B and S fertilizer along with FYM also showed a decreasing trend of Hot CaCl₂ solution extractable B in soils. This is probably due to proper growth of crop in presence of inorganic and organic fertilizers (Aswal and Yadav, 2007) [14].

Available Sulphur

Irrespective of treatments, available SO₄-S tended to decrease significantly with increase in the period of crop growth (Fig 2). Furthermore addition of S-fertilizer increased SO₄ content of soils. Addition of lower and higher doses of S-fertilizer along with FYM but in absence of B increased SO₄ content of the soil by about 18 kg ha⁻¹ and 22 kg ha⁻¹ compared to control at the branching stage. However, addition of either doses of S fertilizer further increase SO₄ content in soils in presence of either doses of B at the branching stage of rapeseed. However, the increment is maximum in soils which received higher dose of S and B. The increase of SO₄-S in soils treated with elemental S is obvious. Higher amount of accumulation of SO₄ in FYM treated system is due to mineralization of organic S present in FYM (Saren and Das., 2018) [15]. The decrease in SO₄ with advancement of growth of rapeseed is due to its utilisation by the growing crop. Higher amount of utilization of SO₄ by the rapeseed crop treated combinedly with higher doses of S and B along with RDF is due to supply of balanced and higher amount of available nutrients which lead to result higher dry matter production.

S and B content in plant and its Uptake by rapeseed

S and B percentages in plant and S and B uptake by stover and seeds of rapeseed differ significantly grown under different treatment combinations (Table 1 and 2). Addition of FYM along with recommended doses of N, P and K in combination with either B or S or together not only increased dry matter production but also increased uptake of both the nutrients by crops. Treatment (T₉) which received combined application of B and S along with FYM and recommended doses of N, P and K fertilizers showed higher values of S and

B uptake by stover and seed. Besides, combined application of B and S with FYM further improved uptake of nutrients mainly due to better growth and dry matter accumulation (Singh and Pal, 2011) ^[16]. The balanced nutrition also exerted the synergistic effect on uptake data which are obtained by multiplying percentage data with that of dry matter yield, so where dry matter production is higher, uptake will be of higher order.

The results (Table 1) reveal that the S content in mustard increased from branching to harvesting stage of the crop. S-uptake has also been increased gradually from branching to harvesting stage. However, irrespective of treatments, S content in stover was lower compared to seed at harvest. It is due to the accumulation of sulphur in seeds as S is the principle component of oil. Many workers, have reported that oil seed crop required fairly large quantity of S for synthesis and conversion of amino acids into protein and glucosides into oil in seed (Karthikeyan and Shukla 2014) ^[15].

Data in Table 2 reveal that irrespective of treatments, B content in the plant Biomass gradually decreased with progress of crop growth this is might be due to the dilution effect resulting from the increased biomass. However, the magnitude of B content varied with the treatments. Comparing the results of different treatment, it was found that the amount of B content has been recorded a significant increase with the different treatment combination with B, S and FYM along with recommended doses of NPK fertilizers, being a greater magnitude with B application at 1kg ha^{-1} as borax with others nutrients. The research findings of (Mondal and Das, 2011) ^[14] also confirmed the results of present study. The results (Table 2) further showed that the amount of B content and its uptake by rapeseed has increased significantly in all the treatments over the control. Highest B content 14.07mg kg^{-1} and uptake 19.40 g ha^{-1} was recorded in the T₉ treatment compared to others treatments. This might be explained by the higher yield and biomass production resulting from the highest number branches and siliquae.

Mandal *et al* (2009) ^[17] reported that the B content in the plant was recorded highest when integrated application of 1kg B ha^{-1} as borax and organic manure, FYM at 5t ha^{-1} were made.

Combined application of recommended doses of fertilizers along with FYM, S and B significantly increased oil and protein content as well as seed yield and stover yield compared to alone application of any of the chemical and organic fertilizer (Tables 3 and 4). Similar increase in seed, and stover yields due to increase in levels of fertilizers have been reported earlier by Sayan *et al.* (2018) ^[18]. However, the highest protein and oil content as well as seed yield were recorded in rapeseed crop grown in soils treated with recommended doses of N,P and K along with FYM as well as higher doses of S and B fertilizers i.e. treatment T₉. The increase in oil content under treatment (T₉) might be due to the increased availability of S and B. Lu *et al.* (2000) ^[19] and Salroo *et al.* (2002) ^[20] also reported the integrated nutrient management practices increased the yield of brown sarson. The percent increase of rapeseed yield in the treatment T₉ over control was 45.15% followed by the treatment T₈ (41.26%). S and B performs many physiological functions and most of the S in plants occurs as amino acids which are important components of plant protein and B also a play vital role in cell wall synthesis, root elongation, glucose metabolism, nucleic acid synthesis lignifications and tissue differentiation (Koshiba *et al.*, 2009) ^[21]. Again, application of higher levels of chemical fertilizer improved N availability that helped in higher protein production and made potential deficiency of carbohydrates (Shukla *et al.*, 2002) ^[22]. The increase in oil content with Sulphur fertilization may be attributed due to its role in oil synthesis. The application of S might have favoured the synthesis of CoA and lipoic acid resulting in increased oil content (Mathew and George, 2013) ^[23]. The highest percent in oil content (42.57%) and protein content (21.76%) in rapeseed was recorded in the T₉ treatment.

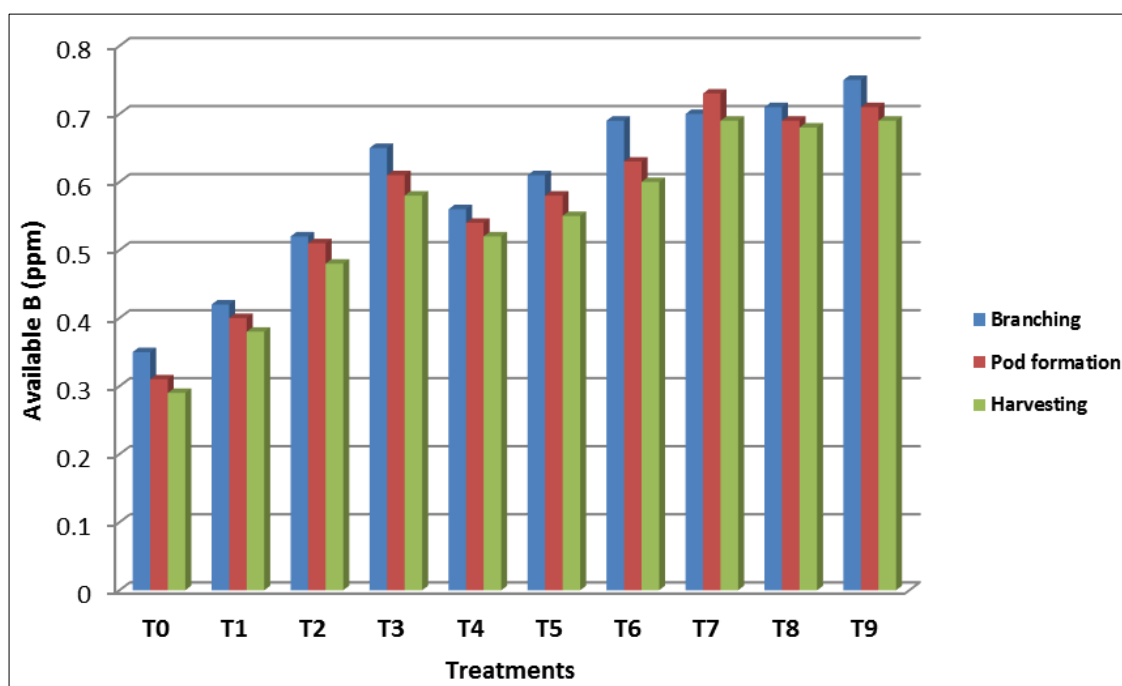


Fig 1: Changes in the amount of available B mg kg^{-1} in soil Cropped with rapeseed and amended with different treatment combinations

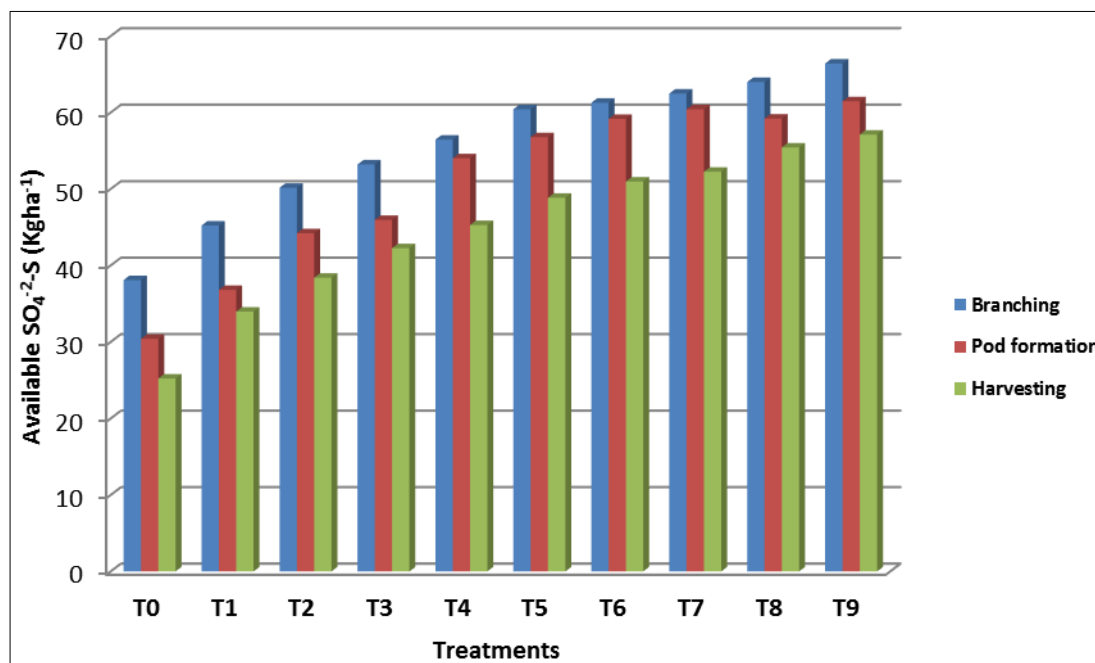


Fig 2: Changes in the amount of available SO_4^{2-}S (kg ha^{-1}) in soil cropped with rapeseed and amended with different treatment combinations

Table 1: Changes in S content (%) and S uptake (kg ha^{-1}) by stover and seeds at different growth stages of rapeseed grown under different treatment combinations (Mean of three replicates)

Treatment	Stages of crop growth															
	Branching				Pod formation				Harvesting							
	S (%)		S uptake (kg ha^{-1})		S (%)		S uptake (kg ha^{-1})		Stover				Seeds			
	S (%)	S uptake (kg ha^{-1})	S (%)	S uptake (kg ha^{-1})	S (%)	S uptake (kg ha^{-1})	S (%)	S uptake (kg ha^{-1})	S (%)	S uptake (kg ha^{-1})	S (%)	S uptake (kg ha^{-1})	S (%)	S uptake (kg ha^{-1})	S (%)	S uptake (kg ha^{-1})
T ₀ =Soil+NPK	0.16	0.85	0.35	4.22	0.08	1.84	0.34	3.26								
T ₁ =T ₀ +FYM	0.18	1.09	0.42	5.53	0.11	2.74	0.39	4.11								
T ₂ =T ₁ +B ₁	0.19	1.29	0.43	6.27	0.12	3.50	0.40	4.48								
T ₃ =T ₁ +B ₂	0.20	1.46	0.46	7.34	0.14	4.43	0.41	4.90								
T ₄ =T ₁ +S ₁	0.22	1.66	0.50	8.78	0.15	4.87	0.41	5.02								
T ₅ =T ₁ +S ₂	0.23	2.03	0.49	9.14	0.15	5.14	0.42	5.27								
T ₆ =T ₂ +S ₁	0.24	2.19	0.52	10.41	0.15	5.24	0.45	5.72								
T ₇ =T ₂ +S ₂	0.26	2.62	0.57	11.99	0.16	5.74	0.45	5.95								
T ₈ =T ₃ +S ₁	0.27	3.00	0.57	12.25	0.16	5.86	0.49	6.57								
T ₉ =T ₃ +S ₂	0.28	3.44	0.59	13.03	0.17	6.36	0.51	7.03								
	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD
Treatments	0.001	0.003	0.01	0.03	0.003	0.006	0.05	0.11	0.001	0.001	0.02	0.05	0.001	0.003	0.01	0.03
S	0.01	0.05	0.27	0.75	0.01	0.03	0.25	0.70	0.003	0.009	0.20	0.56	0.009	0.02	0.14	0.41
B	0.01	0.04	0.18	0.50	0.1	0.03	0.23	0.64	0.003	0.003	0.12	0.34	0.01	0.03	0.18	0.49
S at diff. level of B	0.01	0.02	0.12	0.30	0.01	NS	0.31	0.69	0.005	0.005	0.17	NS	0.009	0.02	0.10	0.24
B at diff. level of S	0.01	0.02	0.10	0.30	0.01	NS	0.32	0.72	0.005	0.005	0.16	NS	0.01	0.02	0.11	0.26

Table 2: Changes in B content (mg kg^{-1}) and B uptake (g ha^{-1}) by stover and seeds at different growth stages of rapeseed grown under different treatment combinations (Mean of three replicates)

Treatment	Stages of crop growth															
	Branching				Pod formation				Harvesting							
	B (ppm)		B uptake (g ha^{-1})		B (ppm)		B uptake (g ha^{-1})		Stover				Seeds			
	B (ppm)	B uptake (g ha^{-1})	B (ppm)	B uptake (g ha^{-1})	B (ppm)	B uptake (g ha^{-1})	B (ppm)	B uptake (g ha^{-1})	B (mg kg^{-1})	B uptake (g ha^{-1})	B (mg kg^{-1})	B uptake (g ha^{-1})	B (mg kg^{-1})	B uptake (g ha^{-1})	B (mg kg^{-1})	B uptake (g ha^{-1})
T ₀ =Soil + NPK	7.97	4.21	6.96	8.39	6.47	14.86	9.90	9.40								
T ₁ =T ₀ +FYM	8.61	5.22	7.21	9.49	6.79	16.91	11.32	11.94								
T ₂ =T ₁ +B ₁	11.71	7.97	10.76	15.68	9.94	28.97	11.65	12.94								
T ₃ =T ₁ +B ₂	12.68	9.24	11.34	18.09	10.44	33.04	11.88	14.31								
T ₄ =T ₁ +S ₁	10.43	7.87	8.86	15.56	8.15	26.44	10.2	12.20								
T ₅ =T ₁ +S ₂	11.16	9.84	9.16	17.09	8.77	30.05	10.42	13.20								
T ₆ =T ₂ +S ₁	13.31	12.13	12.44	24.89	11.69	40.81	12.18	15.59								
T ₇ =T ₂ +S ₂	15.08	15.22	13.91	29.25	12.70	45.53	13.57	17.80								
T ₈ =T ₃ +S ₁	15.75	17.48	13.76	29.57	13.07	47.94	13.88	18.62								
T ₉ =T ₃ +S ₂	16.20	19.91	14.73	32.53	13.89	51.93	14.07	19.40								
	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD
Treatments	0.006	0.01	0.003	0.007	0.003	0.007	0.003	0.008	0.008	0.01	0.01	0.03	0.004	0.01	0.03	0.08

S	0.134	0.37	0.06	0.18	0.09	0.27	0.09	0.26	0.11	0.31	0.34	0.96	0.10	0.26	0.43	1.21
B	0.08	0.24	0.04	0.12	0.02	0.07	0.10	0.29	0.12	0.33	0.07	0.20	0.07	0.21	0.67	1.86
S at diff. level of B	0.06	0.15	0.02	0.07	0.03	0.09	0.03	0.10	0.06	0.15	0.14	0.36	0.04	0.10	0.26	0.62
B at diff. level of S	0.05	0.12	0.02	0.06	0.02	0.05	0.04	0.10	0.06	0.15	0.08	0.20	0.03	0.09	0.31	0.78

Table 3: Changes in stover and Seed yield (Kgha⁻¹) at different growth stages of rapeseed grown under different treatment combinations (Mean of three replicates)

Treatments	Stages of crop growth							
	Branching		Pod formation		Harvesting			
	Dry matter yield		Dry matter yield		Stover Yield		Seed Yield	
T ₀ =Soil+NPK	529		1205		2296		950	
T ₁ =T ₀ +FYM	607		1316		2490		1055	
T ₂ =T ₁ +B ₁	681		1457		2914		1111	
T ₃ =T ₁ +B ₂	729		1595		3165		1205	
T ₄ =T ₁ +S ₁	755		1756		3244		1235	
T ₅ =T ₁ +S ₂	882		1866		3427		1267	
T ₆ =T ₂ +S ₁	911		2001		3491		1280	
T ₇ =T ₂ +S ₂	1009		2103		3585		1312	
T ₈ =T ₃ +S ₁	1110		2149		3668		1342	
T ₉ =T ₃ +S ₂	1229		2209		3739		1379	
	SE(d)	CD	SE(d)	CD	SE(d)	CD	SE(d)	CD
Treatments	0.8	1.7	0.74	1.66	0.70	1.57	0.57	1.28
S	14.5	40.30	6.29	17.48	7.22	20.04	3.02	8.40
B	13.6	37.87	4.93	13.69	7.21	20.02	9.87	27.4
S at diff. level of B	6.81	17.07	4.96	11.54	4.87	11.51	3.60	8.18
B at diff. level of S	6.61	16.43	4.78	10.97	4.87	11.50	4.77	11.88

Table 4: Yield and quality parameters of rapeseed grown under different treatment Combinations (Mean of three replicates)

Treatments	Oil content (%) in seeds		Protein content (%) in seeds	
	Content	% increase over control	Content	% increase over control
T ₀ =Soil + NPK	33.41		16.83	
T ₁ =T ₀ +FYM	35.29	5.62	18.22	8.25
T ₂ =T ₁ +B ₁	37.32	11.70	19.17	13.90
T ₃ =T ₁ +B ₂	40.23	20.41	19.8	17.64
T ₄ =T ₁ +S ₁	40.28	20.56	19.73	17.23
T ₅ =T ₁ +S ₂	40.7	21.81	20.15	19.72
T ₆ =T ₂ +S ₁	41.19	23.28	20.83	23.76
T ₇ =T ₂ +S ₂	41.67	24.72	21.25	26.26
T ₈ =T ₃ +S ₁	42.32	26.66	21.46	27.51
T ₉ =T ₃ +S ₂	42.57	27.41	21.76	29.29
	SE(d)	CD	SE(d)	CD
Treatments	0.004	0.009	0.01	0.04
S	0.06	0.16	0.12	0.33
B	0.07	0.20	0.07	0.21
S at diff. level of B	0.03	0.07	0.12	0.28
B at diff. level of S	0.03	0.08	0.12	0.27

Conclusions

Combined application of higher doses S (40kgha⁻¹) and B (1 kg ha⁻¹) along with recommended doses of N, P and K as well as FYM not only increased S and B content in seed by 44.11% and 42.12% (over that of control) but also enhanced the seed yield by 45.15% (over that of control) and quality parameters (protein content by 29.29% and oil content by 27.41% (over that of control) in yellow sarson.

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