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Fertilizer recommendation for sesame-fallow-T. aman cropping sequence in saline areas of Bangladesh

A. B. M. M. Hasan, S. M. Rasel, M. U. Ahmed, N. H. Khan, M. Mehnaz, M. E. Rahman, S. M. Shamsuzzaman*

Soil Resource Development Institute, Krishi Khamar Sarak, Dhaka, Bangladesh.

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Abstract

Balance use of fertilizer nutrients, soil test based (STB) fertilizer recommendation and monitoring the soil and water salinity is needed to enhance the crop production in saline soil. An experiment was conducted to determine the fertilizer requirement of Sesame (BARI Til-4) – Fallow - T. Aman (BR23 rice) cropping sequence in saline soils of coastal region. Eight Treatments were formulated by 25% increased or decreased of N, P and K with100% soil test based (STB) fertilizers. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The results revealed that seed yield of sesame (BARI Til-4) and grain yield of T. Aman (BR23 rice) were significantly influenced due to different treatments. The highest seed yield of sesame (3.07 t ha^{-1}) and grain yields of BR23 rice (5.26 t ha^{-1}) were obtained in the treatment of 25% more NPK with 100% STB fertilizers. Application of 100% STB fertilizers + 25%NPK were also increased capsule $plant^{-1}$, seeds $capsule^{-1}$, 1000 seed weight and stover yield of sesame(BARI Till-4) and effective tillers $hill^{-1}$, panicle length, filled grains $panicle^{-1}$ and 1000 grain weight and straw yield of BR23 rice in comparison to control and 100% STB fertilizers treatment. Considering the yield components, seed of BARI Til-4 and grain yields of BR23 rice, 25% increase of N, P and K chemical fertilizers in STB fertilizer doses might be recommended for Sesame (BARI Til-4) – Fallow - T. Aman (BR23 rice) cropping pattern in saline areas of coastal belt.

* **Corresponding Author:** S. M. Shamsuzzaman ✉ shamsuzzamansm@gmail.com

Introduction

In Bangladesh, out of 2.85 hectares of coastal and off-shore land, about 1.0 million hectares is affected by varying degree of salinity. These coastal saline soils are distributed unevenly in 120 upazilas of 18 coastal districts covering portions of eight Agro-ecological zones (AEZ) of the country. The larger portion of the saline area (0.65 million hectares) exists in the districts of Khulna, Satkhira, Bagerhat, Barguna, Patuakhali, Pirojpur and Bhola on the western coast (west of meghna) and the smaller portion (0.18 million hectares) in the districts of Chittagong, Coxs Bazar, Noakhali, Lakshmipur, Feni and Chandpur on the eastern coast (east of meghna) SRDI 2009). Salinity causes unfavorable environment and hydrological situation that restrict normal crop production through the year. Munns *et al. (*2006) reported that plant growth in saline soils is adversely affected because of reduced water uptake, salt toxicity, and nutrient imbalances. Beneficial effort of higher fertilizer doses of N, P and K has been reported in potato, tomato, brinjal and okra under saline soils (SRDI, 2009).

Salinity in the country received very little attention in the past. Increased pressure of growing population demand more food. Thus it has become increasingly important to explore the possibilities of increasing the potential of these saline lands for increased production of crops (SRDI, 2014). To address the problems of coastal belt scientists have developed several reclamatory management practices in recent years through inducing salt tolerance in different rice and vegetables crops of dry (rabi and kharif-1) seasons and various land and soil management practices including agronomical techniques for reducing the adverse effect of salts. Among the salt tolerant oil crops sesame (BARI Til-4) is popularly cultivated in different parts of coastal belt due to its high salt tolerance, low water requirement, favorable sowing time and farmers' income. At the same time Bangladesh Rice Research Institute (BRRI) introduced several high yielding rice varieties like BRRI Dhan 23, 30, 40, 41 and 47 in coastal belt which are salt tolerant and can overcome the flooding depth of the respective land situations (SRDI, 2009). Thereby, several new and suitable cropping patterns like Sesame – Fallow - T. Aman, Lady's Finger - Fallow-T. Aman, sweet gourd – Fallow - T. Aman, and Maize-Fallow - T. Aman etc. have been developed for coastal belt increasing cropping intensity in recent ages.

Information based on soils, crops and cropping pattern, Bangladesh Agricultural Research Council (BARC) prepared Fertilizer Recommendation Guide - 2012 to adopt balanced fertilization for sustaining crop production (FRG, 2012). Although often STB fertilizer dose cannot produce the optimum yield of the respective crops in different saline areas, slight increase of fertilizer doses may result optimum yields (Ali *et al.*, 2013). Hence, the present study was undertaken to the fertilizer requirements in the existing soil test based fertilizer recommendation for Sesame (BARI Til-4) – Fallow - T. Aman (BR23) cropping pattern.

Materials and methods

Location

The experiment was set up at the farmer's field of Kapalidanga village under Dumuria Upazila of Khulna district (N-22°43´44.7˝, E-89°25´54.4˝) belonging to Agro-ecological Zone (AEZ) 13 lying in the coastal belt.

Soil sample collection

Initial soil samples were collected from fallow plot and made free from the plant roots and unnecessary materials and dried under shade for four days. Then ground and mixed up thoroughly and sieved through 2mm sieve. Physical and chemical analyses were done for assessing soil fertility and STB fertilizer recommendation according to FRG-2012. Soil samples were also collected from the experimental plots on mid of the months for monitoring salinity. Soil salinity was classified according to ULSRUG, Dumuria upazilla, 2008.

Analysis of soil sample

Electrical conductivity (EC) and pH of the soil samples were determined from 1:1 and 1:2.5 soil-water extract respectively by glass-electrode method (Jackson 1962, Andersoen and ingram, 1966).

Total nitrogen (TN) was determined by Micro-kjeldahl distillation method (Bremner and Mulvany, 1982), available phosphorus (P) by revised Olsen method (Olsen *et al.*, 1954; Olsen and Sommers, 1982), percent organic matter (%OM) by wet oxidation method (Walkley and Black,1934.), available sulphur (S) by calcium biphosphate extraction method (Fox *et al.,* 1964), available zinc (Zn) by DTPA extraction method(Lindsay *et al.*, 1978), exchangeable potassium (K) by ammonium acetate extraction method (Coleman *et al.*,1959; Knudsen *et al.*, 1982), Soil texture according to USDA system by hydrometer method (Day, 1965).

Treatment combinations and experimental design

As sources for N, P, K, and Zn urea, triple super phosphate, muriate of potash, and zinc sulfate-heptahydrate were used. The treatments were T_1 = 100% of STB fertilizer ($N_{61.94}P_{31.28}K_{14.2}Zn_{3.73}$ Kg ha^{-1} sesame and $N_{71.47}P_{10.02}K_{9.65}Zn_{1.86}$ for T. Aman), T_2 = T_1 + 25%N of STB fertilizer, T_3 = T_1 + 25%NP of STB fertilizer, T_4 = T_1 + 25%NK of STB fertilizer, T_5 = T_1 + 25%PK of STB fertilizer T_6 = T_1 + 25%NPK of STB fertilizer, T_7 = 75% of T_1 and T_8 = Control. The land was prepared thoroughly by ploughing and cross ploughing with a power tiller. After uniform leveling, the experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The size of each unit plot was 5m x 4m and plots were separated from each other by drains (0.5m). The treatments were randomly distributed to the plots in each block.

Cultivation of BARI Til-4

For Sesame (BARI Til-4) Fertilizers were applied to each plot as per treatment. Except urea and zinc sulfate-heptahydrate, other fertilizers were applied to the individual plots during final land preparation. Urea was applied in four equal splits at15 (DAS), 5 DAS) and at 50 DAS. Healthy seeds of Sesame (BARI Til-4) were line-sowed along 2 cm deep furrows with 30cm line to line distance. Then the seeded area was covered with soil. After two weeks some seedlings were thinned out keeping 15cm plant to plant spacing. Intercultural operations like irrigation, weeding, and insect and pest control were done as and when necessary.

Data collection on BARI Til-4

Ten plants were randomly selected from each plot at maturity to record the yield contributing characters like, number of capsule /$plant^{-1}$, seeds $capsule^{-1}$ and 1000 seed weight (g). In each plot the ripe sesame plants were cut, bundled separately and stacked in sun for 10 days to make them ready for threshing.

Cultivation of BR23 rice

After three months of sesame harvesting the experimental plots were prepared for transplanting seedlings of BR23 rice. The Sesame plants were uprooted and the experimental plots were prepared thoroughly by puddling and cross puddling with a spade. Fertilizers were applied to each plot according to treatment. Except urea, other fertilizers were applied to the individual plots during final land preparation. Urea was applied in three equal splits at 15 days after transplanting (DAT), 30 DAT and 55 DAT. Thirty days old healthy seedlings of BR23 rice were transplanted. The spacing of transplanting was 25 × 20cm and three seedlings were transplanted in each hill. After one week of transplanting, all plots were checked for any missing hill, which was filled up with extra seedlings. Intercultural operations like irrigation, weeding and insect and pest control were done as and when necessary following standard procedures. After transplanting, 5 to 6cm water was maintained in each plot throughout the growing period.

Data collection on BR23 rice

Five hills were randomly selected from each plot at maturity to record the yield contributing characters like, number of effective tiller $hill^{-1}$, panicle length, number of filled grain $panicle^{-1}$ and weight of 1000-grains. The harvested crop of each plot was bundled separately and brought to the threshing floor. After threshing of the crop, grain and straw from each unit plot was dried and weighed. The results were expressed as t/ha on 14% moisture basis.

Statistical analysis

The variance analysis was done by M-State-C statistical software. We used Duncan's Multiple Range Test (DMRT) with 5% probability for Comparisons of average values.

Results and discussion

Physical and chemical properties of initial soil

Table 1 shows that soil pH and EC was slightly alkaline and slight saline, respectively. Available S and B was very high, Exchangeable K was optimum and %OM was medium. While, % TN and available Zn was low and Available P was very low.

Table 1. Properties of Initial soil of the experimental field.

Texture	pH	EC (dS/m)	OM (%)	Total N (%)	P (ppm)	K(meq/ 100gsoil)	S (ppm)	Zn (ppm)	B (ppm)
	7.5	7.46	2.52	0.146	3.97	0.28	127.72	0.56	0.93
Clay loam	Slightly Alkaline	Slightly Saline	Medium	Low	Very Low	Optimum	Very High	Low	Very High

Electrical conductivity (EC).

The EC ranged from 1.23 to 7.46 dS/m was recorded 3.02 dS/m (very slightly saline) in January which showed an overall sharp increasing tendency in the following months and reached at its peak during June (7.46 ds/m; slightly saline). After attainment of peak salinity, it significantly decreased in the following months was recorded 1.63dS/m (non- saline) in July. From July soil salinity gradually decreased in the following months attained its lower level 1.23 dS/m (non- saline) during October. After attaining lower level soil salinity again showed an overall sharp increase in the following months (Table 2).

Table 2. Soil salinity during the experimental period.

Month											
Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
EC (dS/m)											
3.02	3.44	6.84	5.15	7.03	7.46	1.63	1.71	2.15	1.23	1.56	2.12
VSS	VSS	SS	SS	SS	SS	NS	NS	VSS	NS	NS	VSS

Soil salinity data was interpreted according to ULSRUG (2008). VSS = very slightly saline, SS = slightly saline and NS = Non-saline.

The distribution pattern of soil salinity mostly depends on the rainfall pattern of the respective region. Similar distribution pattern of soil salinity in different months was also reported by SRDI (2014) through investigating several soils of Khulna region.

Yield contributing characters and yield of sesame (BARI Til-4).

Table 3 represents the yield contributing characters and seed yield of Sesame (BARI Til-4). The number of capsule plant^{-1}, seeds capsule^{-1} and 1000 seed weight due to different treatments varied 26.53 - 56.94, 26.72 to 52.75 and 2.15 to 2.77g, respectively. The highest number of capsule plant^{-1} 56.94 and seeds capsule^{-1} 52.75 was found in the treatment T_6 (T_1 + 25%NPK) was at par with T_3 and T_4 treatments. Whereas the highest 1000 seed weight 2.77g was found in the treatment T_4 (T_1+25 %NK) was same level with T_1, T_2, T_3, T_5 and T_6 treatments, respectively. Addition of 25% increased amount of N, P and K chemical fertilizers alone or in different combinations resulted an increase in number of capsule plant^{-1}, seeds capsule^{-1} and 1000 seed weight over 100% STB. While a decrease of chemical fertilizers (75% STB) resulted a decrease in number of capsule plant^{-1}, seeds capsule^{-1} and 1000 seed weight. All the treatments from T_1 to T_7 produced significantly higher number of capsule/plant over T_8 (control) treatment which produced the lowest capsule plant^{-1} (26.53), seeds capsule^{-1} (26.721) and 1000 seed weight (2.15g).

The significant response of yield parameters to different fertilizer doses obtained this study similar to the reports of Wayase *et al*. (2014) who reports that application of 120% RDF significantly influenced all the yield parameters of sesame. Mohamed *et al*. (2012) revealed that increasing level of the used mineral fertilizers induced significant increases in all investigated morphological and yield characters as well as in seed oil percentage of sesame cv. Shandaweel-3. Likewise, prominent increases in photosynthetic pigments of sesame leaves.

Table 3. Effect of different fertilizer combination on the yield contributing characters of BARI Till-4.

Treatment	Capsule/ Plant (No.)	Seeds/ capsule (No.)	1000 seed weight (gm)	Seed yield (kgha^{-1})	Stover yield (kgha^{-1})
T_1	51.09bc	51.17a	2.73a	1383bc	2595b
T_2	52.44b	51.31a	2.77a	1408bc	2602b
T_3	53.97ab	52.17a	2.71a	1435abc	2915ab
T_4	56.68a	52.75a	2.77a	1530a	3063a
T_5	52.53b	51.79a	2.73a	1474ab	2732b
T_6	56.94a	52.37a	2.76a	1539a	3068a
T_7	47.83c	46.19b	2.45b	1338c	2342c
T_8	26.53d	26.72c	2.15c	890d	1556d
CV (%)	4.46	4.42	2.77	4.27	7.21

*Means in a column followed by the same letter(s) are not significantly different at $P < 0.05$.

Seed and stover yields due to different treatments varied from 890 to 1539 kg ha^{-1} and1556 to 3068 kg ha^{-1}, respectively. The highest seed (1539 kg ha^{-1}) and stover (3068 kg ha^{-1}) yield was found in the treatment T_6 (T_1 + 25%NPK) was at par with T_3, T_4 and T_5 treatment, respectively. Addition of 25% increased amount of N, P and K chemical fertilizers alone or in different combinations over 100% STB fertilizer resulted an increase in seed yield. While a decrease of chemical fertilizers (75% STB fertilizer) resulted a decrease in seed yield. All the treatments from T_1 to T_7 significantly increased the seed yield over T_8 (control) treatment which produced the lowest seed (890kgha^{-1}) and stover (1556 kgha^{-1}) yield. Per cent seed yield increase under different treatments ranged from 2 to 11% over 100% STB fertilizers.

Table 4. Effect of fertilizer on the yield contributing characters of BR 23 rice.

Treatment	Effective tillers hill^{-1} (no.)	Panicle Length (cm)	Filled grains panicle^{-1} (no.)	1000-grain weight (gm)	Grain yield (tha^{-1})	Straw yield (tha^{-1})
T_1	13.67ab	25.29a	102.92b	25.80ab	4.77bc	5.79b
T_2	14.33ab	25.65a	112.07ab	25.57ab	5.11ab	5.87ab
T_3	14.33ab	25.67a	116.85ab	25.29ab	5.13ab	5.91ab
T_4	14.00ab	25.99a	116.39ab	25.33ab	5.22a	6.08a
T_5	14.00ab	25.95a	111.89ab	25.52ab	5.01ab	5.97ab
T_6	16.00a	26.34a	120.87a	26.20ab	5.26a	6.17a
T_7	12.33c	23.40b	89.22c	24.62ab	4.47c	4.84c
T_8	10.33d	21.06c	81.71d	23.97b	3.40d	3.95d
CV (%)	5.48	2.65	8.58	4.53	4.04	6.94

The present findings corroborated the findings of Wayase *et al*. (2014), who reported that 120% RDF gave more number of values like seed yield, straw yield and biological yield over 80% RDF and it was at par with 100% RDF. Similarly, Babajide and Oyeleke (2014) reported that total seed yield was significantly increasing from 20 - 80 kg N ha^{-1}.

Yield contributing characters and yield of BR23

The effect of different fertilizers doses on yield contributing characters and yield were statistically significant (Table 4).

Panicle length, number of filled grains panicle^{-1} and 1000-grain weight due to different treatments varied from 21.06 to 26.34cm, 81.71 to 120.87 and 23.97 to 26.20g. The longest panicle (26.34cm) and the highest number of filled grains panicle^{-1} (120.87) and1000-grain weight (26.20g) was found in the treatment T_6 (T_1+25%NPK) was at par with T_1, T_2, T_3, T_4 and T_5 treatments, respectively. The shortest panicle (21.06cm) and the lowest filled grain panicle^{-1} (81.71) and 1000 grain weight (23.97g) was found in the treatment T_8 (control) significantly lower than those recorded in all other treatments. All the treatments from T_1 to T_7 significantly increased panicle length, filled grain panicle-1 and 1000 grain weight over T_8 (control). Sarfaraz *et al.* (2002) found that the number of tillers m^{-2}, 1000-grain weight, grain and straw yields were significantly increased with the application of NPK and S fertilizers compared to the control. Bahmaniar *et al.* (2007) reported that nitrogen application increased number of tiller, length of panicle, number of grains/panicle and1000-grain weight. Potassium also had positive effects on all of above mentioned yield components.

The grain and straw yields of BR23 rice due to various treatments ranged from 3.40 to 5.26 tha^{-1} and 3.95 to 6.17 t ha^{-1}. The highest grain (5.26 tha^{-1}) and straw (6.17 t ha^{-1}) yield was found in the treatment T_6 was at par with 5.11, 5.13 and 5.22 tha^{-1} recorded in T_2, T_3 and T_5 treatments, respectively and significantly higher than T_1 treatment. All the treatments from T_1 to T_7 significantly increased the grain yield over control treatment which produced the lowest grain (3.40 tha^{-1}) and straw (3.95 tha^{-1}) yield. Percent grain and straw yield increase under different treatments ranged from 7 to 10% and 1.4 to 6.6% over 100% STB fertilizers. Addition of 25% increased amount of N, P, K chemical fertilizers alone or in different combinations over 100% STB resulted an increase in yield contributing characters and yield, while a decrease of chemical fertilizers (75% STB fertilizers) resulted a significant decrease in yield contributing characters and yield comparison to STB fertilizers (T_1). These types of findings of 1000-grain weight, grain and straw yield were also reported by Chaudhary *et al.* (2011). Hoshain (2010) observed that grain and straw yield were significantly increased with the increasing rates of N. Higher yield of rice with higher dose of K over the present recommended rate was reported by many workers (Krishnappa *et al.*, 2006; Bahmaniar *et al.*, 2007).

Conclusion

In view of yield and yield contributing parameters, best performance was shown by T_6 (T_1 + 25%NPK of STB fertilizer) treatment in both the crop which resulted 73 and 11% seed yield increase of sesame(BARI Till-4) and 56 and 6.6% grain yield increase of BR23 over control and T_1(100%STB) treatments, respectively. As a result 25% increased dose of N, P and K chemical fertilizers in soil test based fertilizer doses can be suggested for sesame- Fallow-T. Aman cropping pattern for saline soils of coastal region. Verification and updating the existing soil test based fertilizer recommendation of different cropping patterns is needed in other saline districts also.

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