**Guideline for Preparing Research Report**

**Following guidelines should be followed in preparing Research Report:**

* The report should be written as a Scientific Article, which should contain following chapters
  + Abstract (should be within 200-300 words)
  + Introduction
  + Materials and Methods
  + Results and Discussion
  + Conclusion/Recommendation

Under these chapters there will be Headings and Sub-headings

Following format should be followed in writing the reports:

* **Font:** “Times New Roman” throughout the report
* **Font size:** 12 throughout the report; but might be reduced up to 10 in tables, in case of space problem.
* **Spacing:** Should be 1.15 in the text and 1.00 in headings/captions of tables and graphs, figures, titles etc.
* **Title of Report:** Should be in CAPITAL LETTER**, Bold,** Single spacing, Centre aligned
* **Use of** CAPITAL LETTERs/small caps: Universal rules should be followed in using CAPITAL LETTERs and small caps.
* **Author(s):** Should be written as in the attached report, **Bold**, Single spacing, Centre aligned
* **Chapter headings (Abstract, Introduction etc.):** Centre aligned (As attached report), **Bold**
* **Headings/Sub-headings:** Should be left aligned, **Bold**, Single spacing
* **The Report should contain** “Initial soil analysis” along with critical level values for each nutrients/Interpretation
* **Table and Figure number:** Should be on single report basis. Table and Figure caption should be single spacing and **Bold**.
* **The Tables** should be stretched untilboth side margins. Use of many lines in Table makes it clumsy. Please follow the Table format as of the attached report for lining style.
* **Reference:** Latest related references should be used in the report, which must be enlisted in the “Reference” Chapter
* **Conclusion/Recommendation:** Continuation/discontinuation/modification/suggestion for the future should be mentioned in “Conclusion”. For conclusive results (for >3 years study) there should be clear cut Recommendation.
* **Paper Size:** A4; Margins: Top- 1.6 cm, Bottom- 0.45 cm, Left- 2 cm, Right- 2cm
* **Page number:** Bottom-Centre

These are the major guidelines for preparing the Report. For any confusion or for the case which have not been mentioned please follow the format of the attached Report.

**Effect of raised bed planting and potassium application on the mitigation of soil salinity and yield of maize**

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**Abstract**

A field experiment on hybrid maize (cv. BARI maize-9) was conducted in coastal saline areas at Hazirhatt, Noakhali under Young Meghna Estuarine Floodplain (AEZ 18) and at Kuakata, Patuakhali (AEZ 13) during late rabi 2014-15. The objectives were to test the possibility that salinity damage can be reduced by elevating K fertilization rate; To study the effects of planting method and K fertilization interactions on maize yield and nutrient uptake under salt stress condition; and to study K dynamics in soil as a function of soil salinity. Four rates of K (Native K, 100% STB K, 125% STB K and 150% STB K) were tested under two planting methods (Flat land and raised bed) in a randomized complete block design with three replications. Prior to seed sowing the salinity level was low (EC: 2.5 to 2.78 dS m-1). But salinity level reached at the peak in April (EC: 8.78 and 8.96 dS m-1 for flat lat and raised bed plot, respectively) at Hazirhat. But at Kuakata, the salinity level was much higher 1(2.16 and 12.46 dS m-1) for flat land and raise bed, respectively. The higher rates of K contributed to 31- 44.2% increased yield over control as against 16% with STB dose which implies the necessity of higher dose of K in salt affected soil in augmenting yield. At Kuakata, K application contributed 14.4-29.2% increased yield over K control. Different combinations contributed 16.7-47.7% and 15.6- 34.1% yield benefit over K control for Hazirhat and Kuakata, respectively where raised bed with higher dose of K (K4 x M2) gave numerically better result over other combinations. Thus application of 25-50% higher rates of K over present STB dose under raised bed method of cultivation could be useful in minimizing salt stress and optimizing yield of hybrid maize in the study area.

**Introduction**

Salinity is one of the most detrimental factors limiting the productivity of agricultural crops, with adverse effects on germination, plant vigor and crop yield (Munns & Tester, 2008). In Bangladesh, salinization is one of the major natural hazards hampering crop production. Coastal area in Bangladesh constitutes about 20% of the country of which about 53% are affected by different degrees of salinity (Haque, 2006). A study conducted by Miah *et el.,* (2009) shows that the salt-affected areas in the coastal region of Bangladesh increased sharply, by 26.71 percent, to 950,780 hectares in 2009 from 750,350 hectares in 1973.

High salt content affects the physiology of plants at the cellular and whole-plant levels. Ionic imbalance occurs in cells due to excessive accumulation of Na+ and Cl− ions that reduce uptake of K+, Ca2+, and Mg2+ (Bayuelo-Jimenez *et al*., 2003). Excess sodium ions in cells cause enzyme inhibition and degradation of photosynthetic pigments (Chaves *et al*., 2009).

Potassium uptake by plants can be affected by high salinity and the Na concentration in the soil solution. There is abundant evidence that Na and the Na/Ca ratio affects K uptake and accumulation within plant cells and organs and that salt tolerance is correlated with selectivity for K uptake over Na. This provides the basis for hypothesis which exists in the literature and was examined in this study, that K application can reduce salinity damage to plants. A hypothesis that K application can reduce the deleterious effects of salinity on plant development has been proposed (Ben-Hayyim *et al.,* 1987; Kafkafi 1984; Khalil *et al*., 1967).

Potassium significantly increased yield at all salinity levels only in the sandy soil which had a low natural level of K, but there was no difference in the relative yield decrease with salinity increase between the lowest and highest K application rates. Potassium fertilization did not eliminate the deleterious effects of salinity on corn yield despite its beneficial effect of increasing K content and reducing the Na: K ratio in plant tissue (Bar-Tal *et al*., 1991). Such studies under field conditions are scarce under Bangladesh situations. Maize grows well under Bangladesh agro climatic situations and its area and production are gradually increasing due to its diversified uses. For prolific growth maize requires higher rates of nutrients especially N and K but K nutrition is impaired due excess availability of Na in coastal saline soil. Elevated level of K is may be helpful in diluting the dominancy of Na by increasing its absorption by roots. The present study was therefore undertaken in context of following objectives:

1. To test the possibility that salinity damage can be reduced by elevating K fertilization rate
2. To study the effects of planting method and K fertilization interactions on maize yield and nutrient uptake under salt stress condition;
3. To study K dynamics in soil as a function of soil salinity.

**Materials and Methods**

A field experiment was conducted to observe the effect of raised bed planting and potassium application on the minimization of salinity stress to hybrid maize grown in salt affected soil. The experiment was conducted in coastal saline at Hazirhat, Noakhali under Young Meghna Estuarine Floodplain (AEZ 18) during rabi 2013-14. Soil of the study site is Calcareous Alluvium and loamy in texture having 1.43 g cm-3 bulk density. The initial soil moisture content was 23.74% while field capacity was 24.26% (Table 1a). The soil is alkaline in reaction (pH 7.8) initially non saline and low in organic matter content. Exchangeable Ca, Mg and Na contents were high while K content was low (0.16 cmol kg-1). The available S status was high, zinc was medium while total-N content was low (Table 1b). There were two sets of planting methods flat land and raised bed and four levels of potassium (0, 100% STB, 125% STB and 150% STB), which formulated 8 treatment combinations. This experiment was simultaneously conducted at Kuakata, Patuakhali under Ganges Tidal Floodplain (AEZ 13).The initial soil properties of Kuakata are presented in Table 1c.The experiment was conducted in two factors RCB design with three replications. Potassium dose was estimated based on the soil test value as 89, 111 and 134 kg K ha-1 and 54, 68 and 81 kg ha-1 for Noakhali and Patuakhali, respectively. The requirement of other nutrients was also estimated following STB approach as N274P57S3Zn1B1 kg ha-1 forNoakhali and N293P68S0Zn4B1 kg ha-1 for Patuakhal. The plot size was 4m x 5m for both raised bed and flat land. The seeds of hybrid maize (cv. BARI HM 9) were sown on 15 December, 2014 at Hazirhat and 27 November, 2014 at Kuakata maintaining a spacing of row to row 75 cm and seed to seed 25 cm. Entire amount of P, Zn, B and 2/3rd K was applied at basal prior to sowing. Nitrogen as urea was applied in 3 equal splits at 5 days after germination, stem elongation and teaseling stage. The rest 1/3rd K was applied with second dose of N at stem elongation stage. All intercultural operations were done as per requirement of the crop following prescribed protocols. Soil salinity was monitored at 15 days interval staring from sowing to just before harvest. The crop was harvested in its maturity on 12 April and 27 April 2015 at Kuakata and Hazirhat, respectively. Data on yield components like plant height, cobs plant-1, grains cob-1, 100 seed weight etc and grain yield were recorded from 10 randomly selected plants as per treatments and replication. After collection, the samples were analyzed statistically following MSTAT-C software.

**Table 1. Physical and chemical properties of initial soil at Hazirhat, Noakhali**

1. **Physical**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample Type | Depth (cm) | Sand | Silt | Clay | Textural Class | Bulk density | Moisture | Field capacity |
| (%) | | | g cm-3 | (%) | |
| Composite | 0-20 | 38.54 | 42.21 | 19.45 | Loam | 1.47 | 24.84 | 25.18 |

b. **Chemical**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pH | EC  dS m-1 | OM | Total-N | Ca | Mg | K | Na | P | | S | Zn |
| (%) | | cmol kg-1 | | | | mg kg-1 | | | |
| 7.8 | 2.84 | 1.18 | 0.07 | 12.5 | 5.34 | 0.14 | 5.19 | 13.2 | 28.7 | | 1.2 |
| Alkaline | Non saline | Low | Low | High | High | Low | V. high | Low | High | | Medium |

**Table 1c. Chemical properties of initial soil at Kuakata, Patuakhali**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pH | EC  (dS/m) | OM | Total N | K  cmol kg-1 | P | S | Zn | B |
| (%) | | (µg/g soil) | | | |
| 6.7 | 2.58 | 0.77 | 0.05 | 0.24 | 9.6 | 43.3 | 0.52 | 0.39 |
| Neutral | Non saline | Low | Very low | Medium | Low | High | Low | Medium |

**Results and Discussion**

The yield and yield components of hybrid maize as influenced by potassium application and planting method are presented in Table (1-4).

**Effect of potassium**

Higher rates of K application in salt affected soil increased the yield of hybrid maize to a great extent. In K control soil, the grain yield was 7.39 t ha-1, which increased significantly to 8.57 t ha-1 due to 89 kg ha-1 (STB dose) of K application. The grain yield further increased with the increasing dose K where the highest yield (10.66 t ha-1) was recorded with 135 kg K ha-1 (150% STB dose), which was statistically similar to 111 kg K ha-1 (125% K) but significantly higher over rest of the K doses (Table 2). The higher rates of K contributed to 31-44.2% increased yield over control as against 16% with STB dose which implies the necessity of higher dose of K in salt affected soil in augmenting yield. The K fertility of the initial soil was low (0.14 cmol kg-1) but not too bad in comparison to its critical level (0.12 cmol kg-1), which might have generated reasonable yield (7.39 t ha-1) in control soil despite medium level of salt stress. But such practice may deplete the K level in soil resulting in drastic yield reduction in near future. The scenario was almost similar at Kuakata, Patuakhali as well (Table 2a). Although K fertility in Patuakhali was in medium level but still the crop responded significantly with the elevated level of applied K might be due to intense of salinity. The yield at Kuakata was somewhat lower than the Hazirhat might be due to changes in agro-ecology. In this site K application contributed 14.4-29.2% increased yield over K control. In presence of higher level of Na in soil, the K uptake by plant might have restricted which could be minimized with the higher level of K application in soil to minimize the Na dominancy in soil solution. This interpretation could be well interpreted in the next report upon completion of chemical analysis of soil plant samples.

**Table 2. Effect of potassium on the yield components and yield of hybrid maize at Hazirhat, Noakhali**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Treatment | | Plant height | Cobs length | Grains cob-1  (number) | 1000 grain  weight  (g) | Grain yield  (t ha-1) | Yield increase (%) |
| K levels | Required K (kg ha-1) |
| (cm) | |
| Native K | 0 | 136.8 c | 14.68 | 389.1 b | 290.5 c | 7.39 c | - |
| 100% STB K | 89 | 150.5 b | 15.32 | 452.7 a | 305.8 b | 8.57 b | 16.0 |
| 125% STB K | 111 | 161.0 a | 15.55 | 461.7 a | 315.9 ab | 9.68 ab | 31.0 |
| 150% STB K | 134 | 166.6 a | 15.80 | 462.9 a | 323.4 a | 10.66 a | 44.2 |
| F test |  | \*\* | NS | \*\* | \*\* | \*\* |  |
| CV(%) | | 5.3 | 5.4 | 5.8 | 4.0 | 10.1 |  |

Figure(s) in a column having same letter do not differ significantly at5 % level of probability by LSD

**Table 2a. Effect of potassium on the yield components and yield of hybrid maize at Kuakata, Patuakhali during 2014-15**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Treatment | | Plant height | Cobs length | Grains cob-1  (number) | 1000 grain  weight  (g) | Grain yield  (t ha-1) | Yield increase (%) |
| K levels | Required K (kg ha-1) |
| (cm) | |
| Native K | 0 | 175.5 b | 15.58 b | 428.9 c | 272.3 c | 7.01 c | - |
| 100% STB K | 54 | 187.8 a | 16.07 ab | 461.2 b | 288.3 b | 8.02 b | 14.4 |
| 125% STB K | 68 | 192.0 a | 16.55 a | 476.4 ab | 297.7 ab | 8.65 ab | 23.4 |
| 150% STB K | 81 | 193.2 a | 16.75 a | 486.5 a | 303.2 a | 9.06 a | 29.2 |
| F test |  | \*\* | NS | \*\* | \*\* | \*\* |  |
| CV(%) | | 3.4 | 4.5 | 5.9 | 3.6 | 7.7 |  |

Figure(s) in a column having same letter do not differ significantly at5 % level of probability by LSD

**Effect of planting method**

There was no significant effect of planting method irrespective of K doses on the yield components and yield of hybrid maize grown in salt affected soil (Table 3 and 3a). Although raised bed planting method exerted better results over flat land planting for all the studied characters. For instance, the flat land method of cultivation at Noakhali gave 8.94 t ha-1 grain yield which increased to 9.20 t ha-1 for raised bed method contributing to 2.6% yield benefit. In case of Patuakhali too, the contribution of raised bed was little (2.85%), showing 8.03 and 8.30 t ha-1 grain yield for flat land and raised bed, respectively.

**Table 3. Effect of planting method on the yield components and yield of hybrid maize at Hazirhat, Noakhali**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Planting Method | Plant height  (cm) | Cobs length  (cm) | Grains cob-1  (number) | 1000 grain weight (g) | Grain yield  (t ha-1) |
| Flat land | 152.7 | 15.28 | 442.2 | 307.3 | 8.94 |
| Raised bed | 154.8 | 15.39 | 441.0 | 310.5 | 9.20 |
| F test | NS | NS | NS | NS | NS |
| CV(%) | 5.3 | 5.4 | 5.8 | 4.0 | 10.1 |

**Table 3a. Effect of planting method on the yield components and yield of hybrid maize at Kuakata, Patuakhali during 2014-15**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Planting Method | Plant height  (cm) | Cobs length  (cm) | Grains cob-1  (number) | 1000 grain weight (g) | Grain yield  (t ha-1) |
| Flat land | 185.8 | 16.1 | 457.8 | 286.3 | 8.07 |
| Raised bed | 188.4 | 16.4 | 468.8 | 294.5 | 8.30 |
| F test | NS | NS | NS | NS | NS |
| CV(%) | 3.4 | 4.5 | 5.9 | 3.6 | 7.7 |

**Interaction effect**

The interaction effect between planting method and potassium level on hybrid maize grown in salt affected soil was statistically non-significant (Table 4 and 4a). This result suggest that K acted independently and planting method had no significant attraction on K doses either higher or lower while interpretation is made using F test. Nevertheless, different combinations contributed 16.7-47.7 % and 15.6- 34.1% yield benefit over K control for Hazirhat and Kuakata, respectively where raised bed with higher dose of K (K4 x M2) gave numerically better result over other combinations (Table 4). The contribution of raised bed in combination found to be 2.6 and 5.1 % for Hazirhat and Kuakata, respectively. Thus raised bed with elevated level of K appeared as remunerative in augmenting the yield in salt affected soil.

**Table 4. Interaction effect between potassium and planting method on the performance of hybrid maize in salt affected soil at Hazirhat, Noakhali during 2014-15**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Interaction | Plant height  (cm) | Cob  length  (cm) | Grains  cob-1  (No.) | 1000 grain wt. (g) | Grain  yield  (t ha-1) | Yield increase  (%) |
| (KxM) |
| K1M1 | 136.1 | 14.6 | 391.8 | 289.7 | 7.29 | - |
| K2M1 | 149.8 | 15.3 | 450.3 | 304.2 | 8.51 | 16.7 |
| K3M1 | 160.2 | 15.5 | 458.8 | 312.4 | 9.44 | 29.5 |
| K4M1 | 164.5 | 15.7 | 463.6 | 322.7 | 10.54 | 44.6 |
| K1M2 | 137.5 | 14.7 | 386.4 | 291.4 | 7.48 | 2.6 |
| K2M2 | 151.2 | 15.4 | 455.1 | 307.3 | 8.63 | 18.4 |
| K3M2 | 161.8 | 15.6 | 462.2 | 319.3 | 9.91 | 35.9 |
| K4M2 | 168.7 | 15.8 | 464.5 | 324.1 | 10.77 | 47.7 |
| F test | NS | NS | NS | NS | NS |  |
| CV(%) | 5.3 | 5.4 | 5.8 | 4.0 | 10.1 |  |

**Table 4a. Interaction effect between potassium and planting method on the performance of hybrid maize in salt affected soil at Kuakata, Patuakhali during 2014-15**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Interaction | Plant height  (cm) | Cob  length  (cm) | Grains  cob-1  (No.) | 1000 grain wt. (g) | Grain  yield  (t ha-1) | Yield increase  (%) |
| (KxM) |
| K1M1 | 184.6 | 15.5 | 425.8 | 269.7 | 6.84 | - |
| K2M1 | 186.2 | 15.9 | 458.3 | 285.3 | 7.92 | 15.6 |
| K3M1 | 190.7 | 16.3 | 467.4 | 292.7 | 8.55 | 25.0 |
| K4M1 | 191.6 | 16.6 | 479.7 | 300.3 | 8.96 | 31.0 |
| K1M2 | 186.3 | 15.6 | 432.1 | 278.0 | 7.19 | 5.1 |
| K2M2 | 189.3 | 16.3 | 464.1 | 291.3 | 8.10 | 18.4 |
| K3M2 | 193.3 | 16.7 | 485.4 | 302.7 | 8.76 | 28.1 |
| K4M2 | 194.7 | 16.9 | 493.3 | 306.0 | 9.17 | 34.1 |
| F test | NS | NS | NS | NS | NS |  |
| CV(%) | 3.4 | 4.5 | 5.9 | 3.6 | 7.7 |  |

**Soil salinity level**

The soil salinity level at sowing (end of November) was low (EC: 2.5 dS m-1 for Hazirhat and 2.6-2.7 dS m-1 for Kuakata) which gradually increased with the progress of growing period as the rise of temperature observed from 15 days interval of salinity monitoring (Fig. 1 and 1b). Upon gradual increase the salinity level reached at the peak in April (EC: 8.78 and 8.96 dS m-1 for flat lat and raised bed plot, respectively) at Hazirhat. But at Kuakata, the salinity level was much higher 1(2.16 and 12.46 dS m-1) for flat land and raise bed, respectively. At initial level salinity was lower, which may not affect the crop to germinate and establishment but in later the intense of salinity increased, which might have been suppressed due to the elevated level of applied K. Higher level of K did not show noticeable effect on the changes in EC over the growing period and thus the benefit of elevated level of K application might due to its dominancy in absorption through the root negating the activity of Na but that deserve through investigation before conclusion.





**Conclusion**

It may be concluded that higher level of K (25-50% over STB dose as per the present recommendation) is beneficial in obtaining significantly higher yield from salt affected soil of Hazirhat, Noakhali (AEZ-18) and Kuakata, Patuakhali (AEZ13). The benefit of raised bed planting method in terms of yield is not so encouraging but elevated level of K under raised bed method of cultivation could be useful in minimizing salt stress and optimizing yield of hybrid maize in the study area. Further study is needed before drawing of final conclusion.

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