ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 50(4): 391-406, December 2025

EVALUATION OF SELECTED GARLIC GENOTYPES FOR SALINITY TOLERANCE UNDER DIFFERENT MULCHING PRACTICES IN COASTAL SALINE SOIL*

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Abstract

An experiment was carried out at the farmer's field of Tildanga, Dacope, Khulna from November 2020 to April 2021, to identify high-yielding genotypes of garlic under different mulching practices in saline-prone areas of Bangladesh. In the present study, six selected genotypes, namely KSA-009, DRA-012, SAM-016, KJH-001, SGA-021, and GNA-032, were evaluated under four mulching treatments *viz.*, Control (no mulch) (M_0), rice straw mulch (M_1), black polythene mulch (M_2), and transparent polythene mulch (M_3). The experiment was laid out in a randomized complete block design (factorial) with three replications. Results revealed that mulching significantly influenced growth and yield traits, including plant height, leaf number plant^{-1}, fresh and dry weights of leaves and bulb, clove length and breadth, number of cloves bulb^{-1}, bulb length and breadth and bulb yield. Under mulching practices, genotype KSA-009 combined with rice straw mulch produced the highest bulb yield (8.21 t ha^{-1}), which was statistically similar to the yields of genotypes DRA-012 and SAM-016 under the same mulching treatment. While under non-mulched conditions genotypes KSA-009, DRA-012, and SAM-016 performed better in respect to growth, yield attributes, and bulb yield, indicating that these three garlic genotypes were relatively tolerant to salinity. The lowest bulb yield (4.56 t ha^{-1}) was recorded in GNA-032 under non-mulch condition. Results indicated that genotype KSA-009 is suitable for coastal saline soil when grown with straw mulch.

Keywords: Garlic, Genotypes, Salinity, Mulches, Growth and bulb yield.

Introduction

Coastal agriculture in Bangladesh is severely threatened by soil salinity, a problem that worsens as the soil dries and is exacerbated by climate-induced sea-level rise, cyclones, and salinity intrusion. This crisis affects a significant portion of the country's cultivable land, with salt-affected areas having increased from 83.3 million hectares in 1973 to 105.6 million hectares in 2009 (SRDI, 2019). Around

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*A part of PhD dissertation of the first author.

2.85 million hectares of coastal areas exist, of which 0.83 million hectares are cultivable, but salinity intrusion reduces soil fertility and irrigation water quality, hampering agricultural production and threatening the livelihoods of millions living in the coastal region. In this region, the dominant cropping pattern is 'Fallow-Fallow-*T. aman* rice', which leads to very poor agricultural land use intensity. A key issue within this system is the cycle of late rice harvests, which delays the planting of subsequent *rabi* crops and further diminishes their yields.

Salinity stress disrupts plant metabolism through ionic toxicity, osmotic stress, and nutritional disorders, which can stunt crops, reduce yields, or cause total failure (Zorb *et al*., 2019). Addressing this crisis is critical for national food security and aligns with global commitments like Sustainable Development Goal (SDG) 13 i.e. "Taking urgent action to combat climate change and its impacts" (FAO, 2021). Garlic (*Allium sativum* L.) is a strategically important *rabi* crop in Bangladesh, ranking second in production among bulb spice and is valued for its nutritional and medicinal properties. In our country this crop is also known as 'rashun'. Despite a steady increase in national production of garlic, 4.85, 5.02 and 5.27 lakh metric tons in 2019-20, 2020-21 and 2021-22, respectively (Anon., 2023), yields remain particularly limited in coastal saline regions, forcing heavy imports from countries like China, India, and Myanmar (Volza, 2024). A potential solution for low yield of this spice lies in an innovative management practice like mulching that conserves soil moisture during the critical dry period (Demo and Asefa, 2024). Mulching has emerged as an effective method not only to conserve soil moisture but also to reduce root-zone salinity and suppress weeds, thereby promoting healthier root systems and making cultivation more viable in saline soil (Cuevas *et al.,* 2019). Usage of salt tolerant garlic genotype/cultivar is also a good option for increasing garlic production in coastal saline soil. The experiment was, therefore, carried out to evaluate the performance of selected garlic genotypes under different mulching practices to identify the best combinations for enhancing garlic production and sustainability in this saline-prone environment.

Materials and methods

The experiment was conducted at a farmer's field in Tildanga, Dacope, Khulna (22°37′55″N, 89°30′10″E) during the 2020-2021 *rabi* season. After two consecutive years' screening of thirty-two genotypes under both non-saline and saline condition at three locations *viz.*, BARI, Gazipur; Amtali, Borguna and Dacope, Khulna six garlic genotypes, namely KSA-009, DRA-012, SAM-016, KJH-001, SGA-021 and GNA-032 were selected based on their yield performance to develop a suitable package of cultivation using different mulching practices. The experimental site was situated in the southern coastal belt of Bangladesh characterized by its vulnerability to salinity and other climatic stresses. Dacope, Khulna has a subtropical monsoonal climate with high humidity and ~1800 mm of annual rainfall (Fig. 1). The region is highly vulnerable to climate impacts, including cyclones, salinity intrusion, and rising temperatures, which threaten to significantly reduce crop production. Before commencement of the experiment, cropping history of the experimental field was studied and the 'Fallow–Fallow-*T. aman*' cropping pattern were found there. The experimental treatments consisted of six selected garlic genotypes viz. KSA-009, DRA-012, SAM-016, KJH-001, SGA-021and GNA-032 and four types of mulches *viz.* Control (no mulch), Rice straw mulch (5 - 7 cm), Black polythene mulch (0.01 mm) and Transparent polythene mulch (0.01 mm). The study was laid out in a factorial Randomized Complete Block Design with three replications. The combination of genotypes and mulch materials resulted in a total of twenty-four treatment combinations. The land was prepared by ploughing and harrowing to achieve a fine tilth. Subsequently, raised beds were constructed to facilitate essential drainage in the coastal environment. The soil was a silty clay loam, pre-planting analysis of which indicated low organic carbon, N, and K. Cloves were planted on 27 November at a spacing of 15 cm by 10 cm. Total 30 plants of garlic were planted in each plot and thus the unit plot area was 0.45 m^2. Rice straw mulch was applied to the soil at a dose of 10 t ha^{-1}. Straw mulch and polythene mulches were applied to the soil before planting of cloves or 15 days after clove emergence. A basal dose of fertilizers was applied at the time of planting, incorporating both organic and inorganic sources. Necessary intercultural operations, including irrigation and pest management, were performed uniformly. Initial soil data of the experimental site presented in the (Table 1). Final harvest of garlic cloves was done in the first week of April when the plants reached physiological maturity. Data on plant height, number of leaves $plant^{-1}$, fresh weight of leaves $plant^{-1}$, dry weight of leaves $plant^{-1}$, clove length and breadth, bulb length and breadth, bulb fresh weight and dry weight, number of cloves $bulb^{-1}$ and bulb yield $plot^{-1}$ were recorded from the inner rows of each plot.

Table 1. Initial soil data of the experimental site

Soil parameters	Tildanga, Dacope
Mechanical composition	Sand (5%), Silt (55%), Clay (40%)
Soil texture	Silty clay loam
Bulk density (Mg/m^3)	1.56
pH	7.8 (Slightly alkaline)
OC (%)	0.93
Total N	0.08
K (meq/100g)	0.68
P (ppm)	92.4
S (ppm)	28.7
B (ppm)	0.8
Zn (ppm)	0.92
CEC (meq/100g dry soil)	7.95
EC 1:5 (dS/m)	11.29

Weather data of the experimental site is presented in the Figure 1.

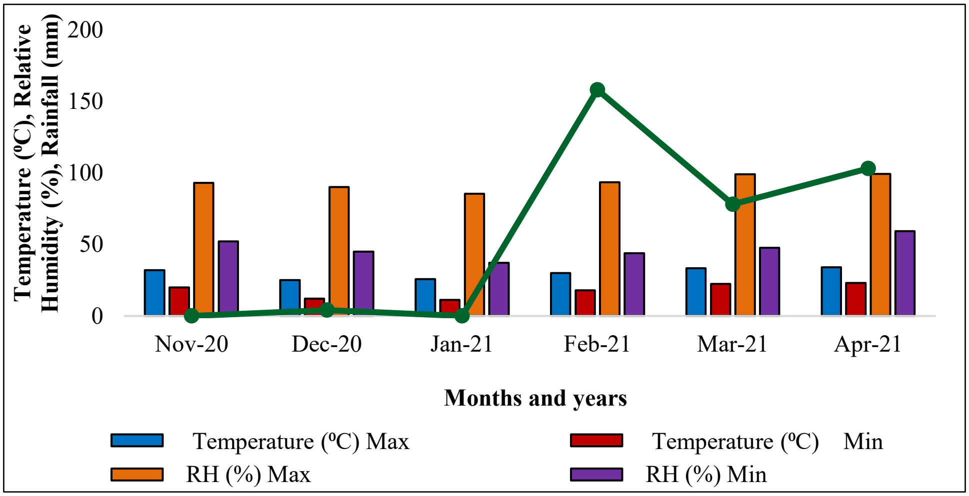

Fig. 1. Maximum and minimum (Temperature, Relative Humidity) and total rainfall during 2020-21 at Dacope, Khulna location.

Soil moister content data (Table 2) at 0-45 cm depth were also taken at 15 days interval after spreading mulch in the plot during the cropping season according to the treatments.

Table 2. Soil moisture content at different depth of soil (cm) during 2020-21 at Tildanga Dacope, Khulna.

Depth of soil (cm)	Days After Planting (DAP)	Soil moisture content (% w/w, dry basis)
0-15	Planting time	34
0-15	30	29
0-15	45	26
0-15	60	24
0-15	75	40
16-30	Planting time	56
16-30	30	47
16-30	45	39
16-30	60	44
16-30	75	49
31-45	Planting time	65
31-45	30	58
31-45	45	43
31-45	60	57
31-45	75	45

Soil and canal water (used for irrigation purpose) salinity data (Figure 2) were also taken at 7 days interval from the time of land preparation to 15 days before harvesting the crop.

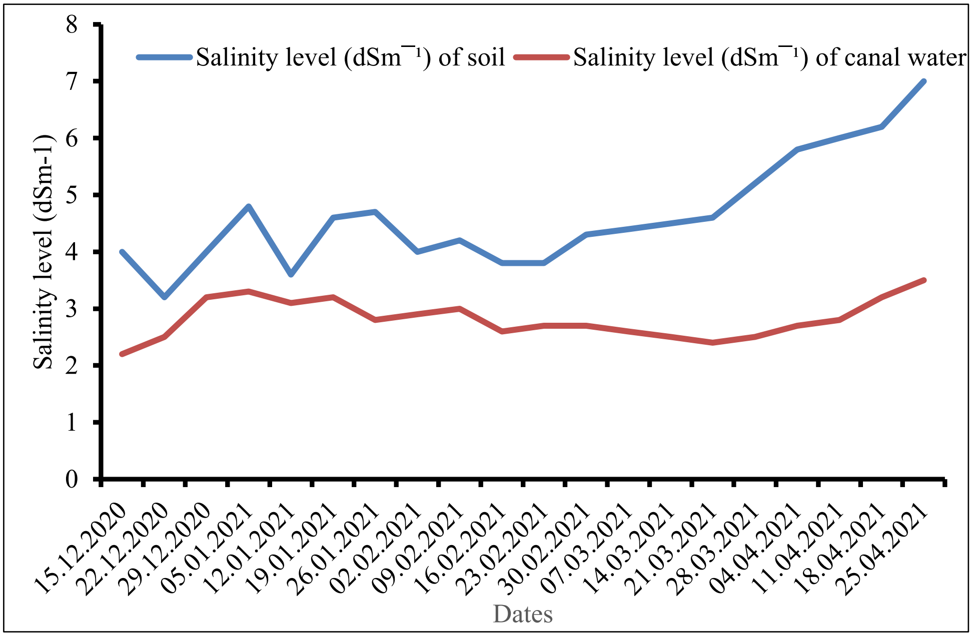

Fig. 2. Soil and canal water salinity level (dS m^{-1}) at different dates during 2020-21 in Tildanga.

The collected data were subjected to Analysis of Variance using R statistical software. Treatment means were compared using the Least Significant Difference (LSD) test at 1% or 5% level of significance according to necessity.

Results and discussion

Plant height at 110 days after planting

Genotype and mulch type significantly influenced garlic plant height at 110 days after planting (DAP). Genotypes KSA-009 and DRA-012 produced the tallest plants in combination with rice straw mulch (55.58 cm and 53.75 cm, respectively), while GNA-032 gave the shortest plants (43.00 cm) when no mulch was used (Table 3). Rice straw mulch (M_1) significantly increased plant height (53.61 cm) compared to the unmulched control (49.17 cm) (Table 3). The tallest plants were recorded in KSA-009 with M_1 mulch, whereas GNA-032 performed poorest in the unmulched control (M_0) (Table 3). These results highlight the importance of selecting salt-tolerant genotypes along with effective mulching practices to maximize growth and yield in saline conditions. The superior height of KSA-009 and DRA-012 reflects their genetic potential and adaptability, consistent with Sultana *et al.* (2022). Straw mulch has been reported to moderate soil temperature and improve growth parameters, supporting its role in enhancing garlic performance (Rafiuddin *et al.* 2023).

Number of leaves plant^{-1}

The number of leaves plant^{-1} was significantly affected by the interaction of genotype and mulching (Table 3). The highest leaf number plant^{-1} was fond in the combination KSA-009 × M_1 (8.33) which was statistically similar with KJH-001 × M_1 (8.00), DRA-012 × M_1 (8.00), SGA-021 × M_1 (8.00), GNA-032 × M_1 (8.00), KSA-009 × M_1, KJH-001 × M_3, KSA × M_3, DRA × M_3, SAM-016 × M_3 and SGA-021 × M_3 and the lowest leaf number was noticed in GNA-032 × M_0 combination identical with other five genotypes with non-mulch. It is evident that all genotypes with rice straw mulch gave statistically similar and maximum leaf number and all genotypes except GNA-032 with transparent polythene mulch recoded identical and second highest leaf number, whereas all genotypes under no-mulch condition produced similar and minimum leaf number plant^{-1}. These findings demonstrate the combined role of genotype and mulching in enhancing leaf development, photosynthesis, and yield. Similar results were reported by Rashid and Islam (2019) i.e. rice straw mulch can act as a temperature regulator and protect the plants from extreme level of heat or cold. This favorable microclimate can support leaf development and overall, the number of plants. Kaur and Bains (2023) also reported that vermicompost and rice straw mulch produced the highest number of leaves (6.13 and 6.50), while the control treatments with no manure and no mulch yielded the lowest (3.71 and 3.61). This superior performance is due to vermicompost providing essential nutrients and rice straw mulch regulating soil temperature, creating optimal conditions for leaf development.

Fresh weight of leaves plant^{-1}

Fresh leaf weight plant^{-1} was significantly influenced by the combination of genotype and mulching (Table 3). The interaction effect between genotype and mulching was found most pronounced in KSA-009 × M_1 (16.83 g) closely followed by KJH-001 × M_1 (16.26 g), DRA-012 × M_1 (15.95 g), SAM-009 × M_1 (15.53 g), SGA-021 × M_1 (15.53 g), GNA-032 × M_1 (15.26 g), KJH-001 × M_2, KJH-001 × M_2, KJH-001 × M_3, KJH-001 × M_0, KSA-009 × M_2, DRA-012 × M_2 and GNA-032 × M_2, whereas GNA-032 × M_0 produced the lowest (10.03 g), underscoring the synergistic role of genotype and mulching in vegetative growth. Previous studies support these findings such as Rahman *et al.* (2020) reported varietal differences in leaf weight, Yimer *et al.* (2020) demonstrated that mulching particularly rice straw and black polyethylene sheet enhances yield through improved moisture retention and stress mitigation. Rafiuddin *et al.* (2023) further emphasized the role of organic mulches in optimizing soil conditions and yield. These results collectively affirm that integrating high-performing genotypes with effective mulching strategies is vital for maximizing garlic productivity.

Table 3. Interaction effect of genotypes and mulches on plant height at 110 DAP, number of leaves plant^{-1}, fresh weight of leaves plant^{-1} and dry weight of leaves plant^{-1}

Genotypes × Mulches	Plant height at 110 DAP (cm)	Number of leaves plant^{-1}	Fresh weight of leaves plant^{-1} (g)	Dry weight of leaves plant^{-1} (g)
KJH-001 X M_0	47.00	7.00	12.03	1.67
KJH-001 X M_1	55.00	8.00	16.26	2.33
KJH-001 X M_2	50.33	7.33	14.90	1.91
KJH-001 X M_3	54.00	7.66	15.20	2.15
KSA-009 X M_0	48.33	7.33	14.36	1.66
KSA-009 X M_1	58.33	8.33	16.83	2.43
KSA-009 X M_2	52.66	7.33	15.16	1.90
KSA-009 X M_3	54.66	7.66	14.86	2.09
DRA-012 X M_0	48.00	7.33	14.06	1.63
DRA-012 X M_1	57.33	8.00	15.95	2.25
DRA-012 X M_2	51.66	7.33	14.83	1.82
DRA-012 X M_3	54.66	7.66	13.10	2.02
SAM-016 X M_0	47.00	7.00	13.13	1.58
SAM-016 X M_1	56.66	8.00	15.53	2.22
SAM-016 X M_2	50.66	7.33	14.76	1.79
SAM-016 X M_3	54.00	7.66	12.03	2.01
SGA-021 X M_0	46.00	7.00	12.56	1.58
SGA-021 X M_1	54.66	8.00	15.53	2.19
SGA-021 X M_2	50.00	7.33	14.06	1.73
SGA-021 X M_3	53.00	7.66	13.33	2.00
GNA-032 X M_0	43.00	7.00	10.03	1.44
GNA-032 X M_1	54.66	8.00	15.26	2.16
GNA-032 X M_2	48.66	7.33	14.26	1.68
GNA-032 X M_3	53.00	7.33	13.90	1.92
LSD $_{(0.05)}$	8.61	0.88	3.45	0.57
Level of sig.	*	*	**	**
CV (%)	10.11	7.18	12.19	13.39

* indicates significant at 5% and ** indicates significant at 1% levels of probability; NS = Not significant;

DAP: Days after planting, M_0 – No mulch (Control), M_1 - Straw mulch, M_2 - Black polythene mulch, M_3 – Transparent polythene mulch**;** Sig: significance.

Dry weight of leaves plant^{-1}

Dry weight of leaves plant^{-1} was significantly influenced by the interaction effect of genotype and mulching (Table 3). The highest dry weight of leaves plant^{-1} was observed in KSA-009 × M_1 (2.43 g) combination closely followed by KJH-001 × M_1 (2.33 g), DRA-012 × M_1 (2.25 g), SAM-016 × M_1 (2.22 g), SGA-021 × M_1 (2.19 g), GNA-032 × M_1 (2.16 g), KJH-001 × M_2 (1.91 g), KJH-001 × M_3 (2.15 g), KSA-009 × M_2 (1.90 g), KSA-009 × M_3 (2.09 g), DRA-012 × M_3 (2.02 g), SAM-016 × M_3 (2.01 g), SGA-021 × M_3 (2.00 g) and GNA-032 × M_3 (1.92 g), whereas GNA-032 × M_0 combination gave the lowest dry weight plant^{-1} (1.44 g). It revealed that all the genotypes under rice straw mulch condition performed better with regard to dry weight plant^{-1} followed by the same genotypes under transparent polythene mulch and all 6 genotypes under non-mulched condition gave the inferior result in respect of dry biomass plant^{-1}. The above results highlighted the synergistic role of genotype and mulch in biomass accumulation. Rafiuddin *et al.* (2023) emphasized varietal differences in mulch response, while Atif *et al.* (2019) demonstrated genotype-specific biomass enhancement under uniform ecological conditions. Collectively, the results underscore the importance of genotype selection and mulch application in optimizing garlic growth under saline environments.

Clove length

Clove length in garlic was significantly influenced by genotype and mulch interaction (Table 4). The KSA-009 × M_1 combination gave the maximum clove length (2.48 cm) which was identical with DRA-012 × M_1 (2.45 cm), SAM-016 × M_1 (2.39 cm), SGA-021 × M_1 (2.33 cm), GNA-032 × M_1 (2.32 cm), KJH-001 × M_1 (2.33 cm), KSA-009 × M_3 (2.31 cm) and DRA-012 × M_3 (2.31 cm) whereas GNA-032 × M_0 recorded the minimum (1.88 cm) closely followed by all other genotypes under no mulch. It was observed that all the genotypes under non-mulched and rice straw mulched condition, respectively performed worse and better in respect of clove length. These findings align with previous studies (Galgaye, 2023; Abreham, 2017; Rai and Negi, 2021) that highlight the role of mulching and genotype in enhancing clove size.

Clove breadth

Clove breadth in garlic was significantly influenced by the interaction of genotype and mulch (Table 4), The KSA-009 × M_1 combination recorded the maximum clove breadth (1.41 cm) which was identical with DRA-012 × M_1 (1.38 cm), SAM-016 × M_1 (1.35 cm), SGA-021 × M_1 (1.32 cm), GNA-032 × M_1 (1.32 cm), KJH-001 × M_1 (1.34 cm), KJH-001 × M_3 (1.28 cm), KSA-009 × M_3 (1.31 cm), DRA-012 × M_3 (1.31 cm) and SAM-016 × M_3 (1.28 cm), and GNA-032 × M_0 recorded the minimum (0.95 cm) closely followed by all other genotypes under no mulch.

It was observed that all the genotypes under non-mulched and rice straw mulched condition performed better in respect of clove length. It is evident that all the genotypes under rice straw mulch gave the best result with regard to clove breadth and when no mulch was applied, all genotypes gave inferior results. These results underscore the importance of genotype selection and mulching in improving clove development under saline stress. The findings align with Rai and Negi (2021), who reported significant improvements in clove dimensions due to mulching and genetic factors.

Table 4. Interaction effect of genotypes and mulches on clove length, clove breadth, bulb length and bulb breadth of garlic genotypes

Genotypes × Mulches	Clove length (cm)	Clove breadth (cm)	Bulb length (cm)	Bulb breadth (cm)
KJH-001 X M_0	2.03	1.00	2.36	2.13
KJH-001 X M_1	2.33	1.34	2.93	2.76
KJH-001 X M_2	2.08	1.10	2.60	2.43
KJH-001 X M_3	2.19	1.28	2.73	2.60
KSA-009 X M_0	2.05	1.00	2.50	2.30
KSA-009 X M_1	2.48	1.41	3.06	2.93
KSA-009 X M_2	2.16	1.25	2.63	2.46
KSA-009 X M_3	2.31	1.31	2.80	2.76
DRA-012 X M_0	2.04	1.00	2.46	2.30
DRA-012 X M_1	2.45	1.38	3.06	2.83
DRA-012 X M_2	2.15	1.20	2.60	2.43
DRA-012 X M_3	2.31	1.31	2.80	2.73
SAM-016 X M_0	2.03	1.00	2.43	2.20
SAM-016 X M_1	2.39	1.35	3.00	2.80
SAM-016 X M_2	2.12	1.18	2.60	2.43
SAM-016 X M_3	2.23	1.28	2.73	2.60
SGA-021 X M_0	2.00	0.99	2.20	2.13
SGA-021 X M_1	2.33	1.32	2.93	2.76
SGA-021 X M_2	2.07	1.10	2.56	2.33
SGA-021 X M_3	2.16	1.25	2.73	2.60
GNA-032 X M_0	1.88	0.95	2.13	2.10
GNA-032 X M_1	2.32	1.32	2.86	2.76
GNA-032 X M_2	2.06	1.08	2.53	2.33
GNA-032 X M_3	2.16	1.25	2.63	2.53
$LSD_{(0.05)}$	0.17	0.15	0.28	0.21
Level of sig.	**	**	**	**
CV (%)	4.94	7.66	6.51	5.30

* indicates significant at 1% levels of probability.

M_0 – No mulch (Control), M_1 - Straw mulch, M_2 - Black polythene mulch, M_3 - White polythene mulch. Sig.: Significance.

Bulb length

Bulb length in garlic was significantly affected by genotype and mulch interaction (Table 4). The highest bulb length (3.06 cm) was recorded in two combinations KSA-009 × M_1 DRA-012 × M_1 closely followed by DRA-012 × M_1(3.00 cm), KJH-001 × M_1 (2.93 cm), SGA-021 × M_1 (2.93 cm), GNA × M_1 (2.86 cm), KSA-0009 × M_3 (2.86 cm) and DRA-012 × M_1 (2.86 cm). Whereas GNA-032 × M_0 yielded the lowest (2.13 cm). Under no much condition, genotypes KSA-009, DRA-012 and SAM-006 gave statistically similar but lower result compared to mulch treatments. These findings align with Mulu *et al.* (2021), Galgaye and Deresa (2023) and Rai and Negi (2021), who reported significant varietal and mulch effects on bulb traits in. Under rice straw mulch those genotypes gave higher bulb length because rice straw mulched helped conserve soil moister (%) more (Table 2) and also reduce soil salinity (dS m^{-1}) (Fig. 2).

Bulb breadth

Bulb breadth in garlic was significantly influenced by interaction effect of genotype and mulch (Table 4). The maximum bulb breadth was recorded in KSA-009 × M_1 (2.93 cm) which was statistically similar to the combinations DRA-012 × M_1 (2.83 cm), SAM-016 × M_1 (2.80 cm), KJH-01× M_1 (2.76 cm), SGA-021 × M_1 (2.76 cm), GNA-032 × M_1 (2.76 cm), KSA-009 × M_3 (2.76 cm) and DRA-012 × M_3 (2.73 cm) indicating strong genotype-specific responses to rice straw mulching. Under no mulch condition, all genotypes gave inferior results with regard to bulb breadth. These findings align with Rahman *et al.* (2020), Rai and Negi (2021), who reported significant varietal and mulch effects on bulb diameter. Enhanced clove size and favorable soil conditions under mulching contribute to improved bulb breadth, reinforcing the importance of integrating genetic selection with effective mulching strategies for optimal garlic production.

Fresh weight of bulb

Fresh bulb weight in garlic was significantly affected by the interaction of genotype and mulch (Fig. 3). Rice straw mulch (M_1) in combination with KSA-009 (KSA-009 × M_1) produced maximum bulb weight (17.43 g) closely followed by DRA-012 × M_1 (16.5 g) and the lowest was obtained from GNA-032 × M_0 (11.66 g). It was seen that genotypes in combination with rice straw mulch performed best and the genotypes under unmulched condition gave the inferior result with regard to clove breadth highlighting the synergistic effect of genetic potential and mulching. These findings are consistent with Rahman *et al.* (2020) who reported significant varietal and mulch effects on bulb weight. Enhanced moisture retention, reduced nutrient loss, and improved soil conditions under rice straw mulch contribute to increased bulb biomass. The results underscore the importance of integrating genotype selection with effective mulching and tillage practices to optimize garlic yield under stress conditions.

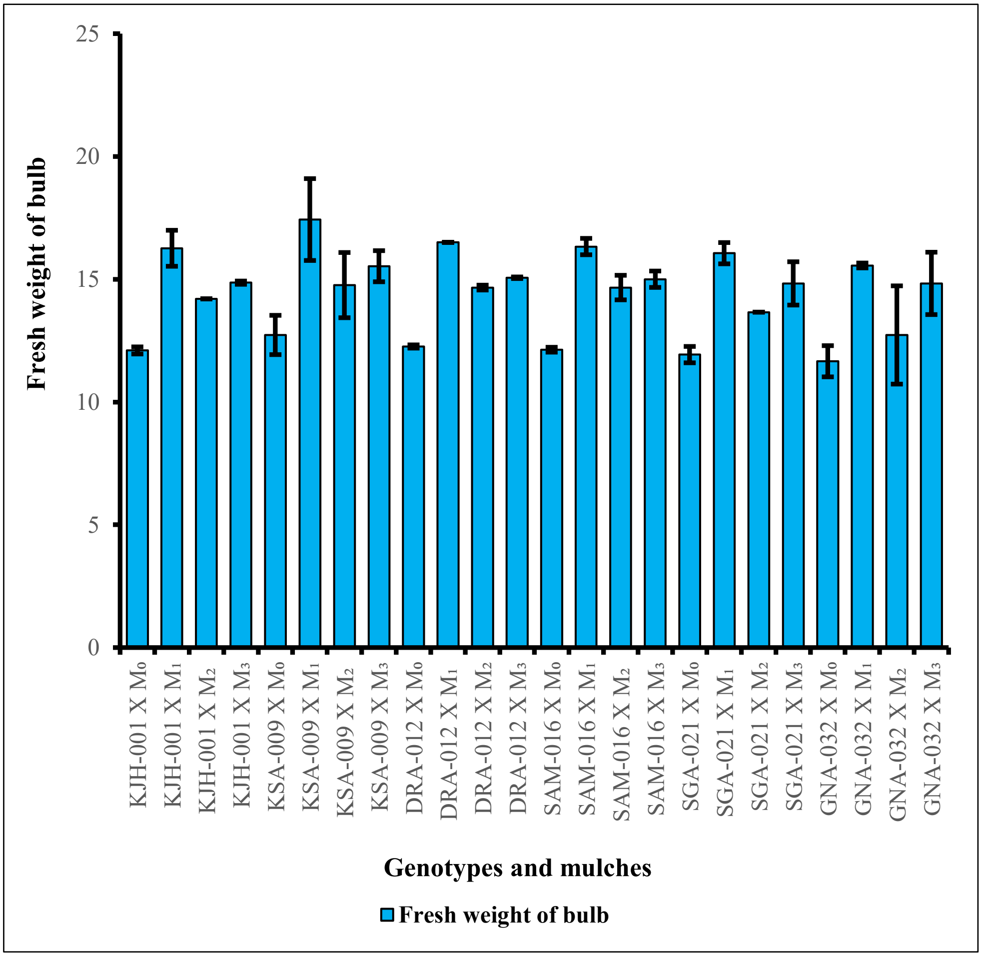

Fig. 3. Interaction effect of different genotypes and mulches on the Fresh weight of bulb. The vertical line (error bar) represents the Standard Error (SE) of the mean for specific genotypes × mulch combination.

M_0 – No mulch (Control), M_1 - Straw mulch, M_2 - Black polythene mulch, M_3 - White polythene mulch.

Dry weight of bulb

Dry bulb weight in garlic was significantly influenced by the genotype and mulch interaction (Figure 4). The most favorable combination was KSA-009 × M_1 (6.05 g) which was followed by DRA-012 × M_1 (4.90 g), SAM-016 × M_1 (4.83 g), whereas GNA-032 × M_0 yielded the minimum dry weight of bulb (3.93 g), highlighting the synergistic effect of genotype and mulching. These findings are in consonance with Rahman *et al.* (2020) who reported significant varietal and mulch effects on dry bulb weight. Improved soil moisture retention, reduced temperature stress, and weed suppression under rice straw mulch contributed to enhanced root development and nutrient uptake, ultimately boosting garlic yield.

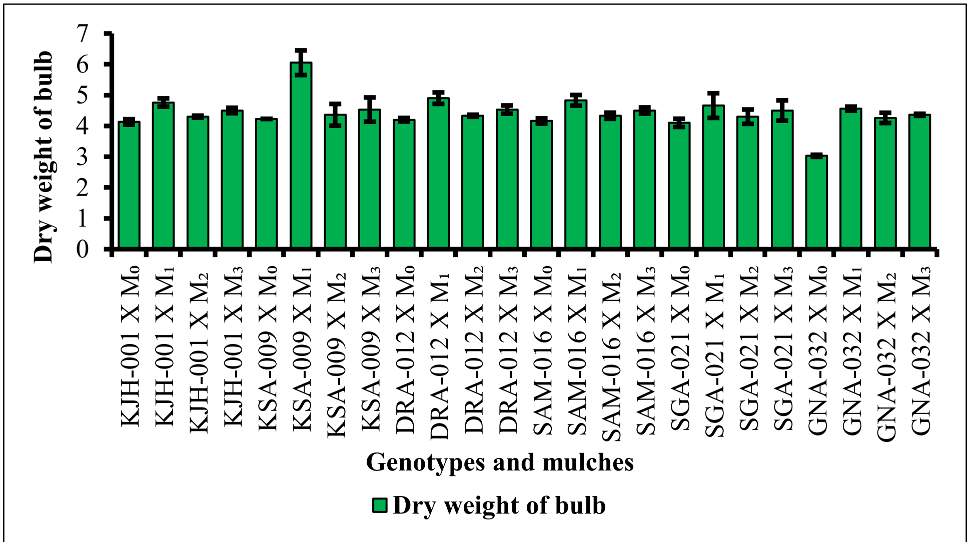

Fig. 4. Interaction effect of different genotypes and mulches on the dry weight of bulb. The vertical line (error bar) represents the Standard Error (SE) of the mean for specific genotypes × mulch combination.

M_0 – No mulch (Control), M_1 - Straw mulch, M_2 - Black polythene mulch, M_3 - White polythene mulch.

Number of cloves bulb^{-1}

The number of cloves bulb^{-1} was also significantly affected interaction of genotype and mulch type. The combination of KSA-009 and M_1 mulch maximized number of cloves bulb^{-1} (17.33) closely followed by DRA-012 × M_1, SAM-016 × M_1, KJH-001 × M_1, SGA-021 × M_1, GNA-032 × M_1 (Fig. 5), contrasting with the lowest count observed in GNA-032 under no mulch condition (12.00). These results underscore the importance of selecting compatible genotypes and mulching strategies to optimize garlic yield under saline conditions. Supporting studies by Rahman *et al.* (2020) similarly reported significant varietal and mulch effects on clove number with mulch treatments enhancing productivity, particularly when combined with specific cultivation practices such as zero tillage.

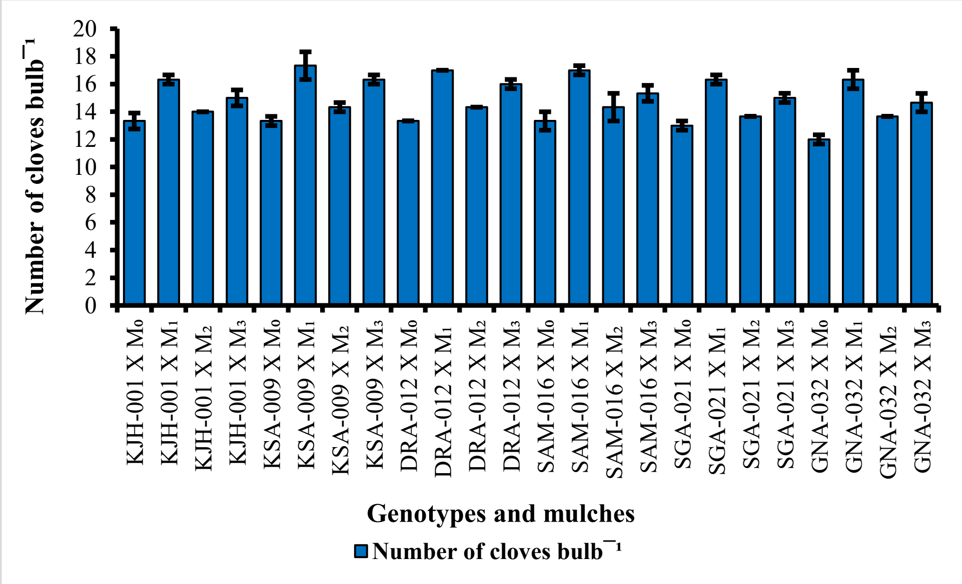

Fig. 5. Interaction effect of different genotypes and mulches on number of cloves bulb $^{-1}$. The vertical line (error bar) represents the Standard Error (SE) of the mean for specific genotypes × mulch combination

M_0 – No mulch (Control), M_1 - Straw mulch, M_2 - Black polythene mulch, M_3 - White polythene mulch.

Bulb yield

Both genotype and mulch type significantly influenced garlic bulb yield, exhibiting a strong synergistic interaction (Fig. 6). Notably, the combination of KSA-009 with rice straw mulch achieved the highest bulb yield of 8.21 t ha^{-1} followed by DRA-012 with rice straw mulch (6.99 t ha^{-1}), while the lowest yield (4.56 t/ha) was observed in GNA-032 without mulch. When no mulch was applied, other genotypes did not perform better than KSA-009, DRA-012, and SAM-016 in respect of bulb yield. The genotype KSA-009 in combination with rice straw mulch gave the maximum yield because this combination recorded highest clove length and breadth, bulb length and breadth, clove number bulb^{-1}, fresh and dry weight of bulb. Besides, under rice straw mulch soil moisture was conserved more and soil salinity was reduced in a considerable amount. These results emphasize that integrating high-yielding genotypes with effective mulching strategies optimizes garlic production under saline conditions. Supporting studies by Rahman *et al.* (2020) demonstrated significant varietal differences in yield, with BAU Garlic-3 outperforming other varieties. Furthermore, Rahman *et al.* (2020) confirmed that combined planting systems and variety choices critically affected yield, with zero-tillage plus BAU Garlic-3 delivering the greatest production (9.14 t ha^{-1}).

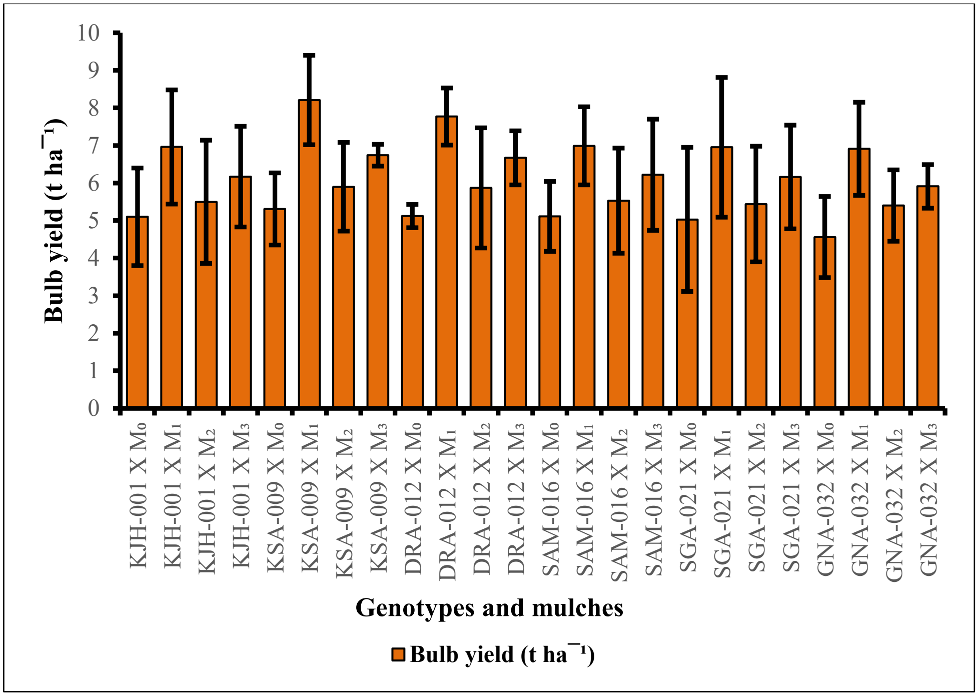

Fig. 6. Interaction effect of different genotypes and mulches on the yield of bulb (t ha^{-1}). The vertical line (error bar) represents the Standard Error (SE) of the mean for specific genotypes × mulch combination

M_0 – No mulch (Control), M_1 - Straw mulch, M_2 - Black polythene mulch, M_3 - White polythene mulch.

Conclusion

The experiment results revealed that the garlic genotypes KSA-009, DRA-012, and SAM-016 performed better with regard to growth, yield attributes and yield indicating promising salt-tolerant lines. These three genotypes under rice straw mulch significantly enhanced growth and bulb formation and thus produced higher yields by mitigating soil salinity. The combination of tolerant garlic genotypes and mulching practices with rice straw offers a strong strategy for improving garlic yield in salt-prone areas, though further validation trials are recommended.

Acknowledgements

The author gratefully acknowledges the invaluable guidance and continuous supervision of the supervisor, whose support was instrumental in completing both the research and the manuscript. Sincere appreciation is also extended to the co-supervisor for constant encouragement and mental support throughout the study.

The contributions of the personnel of BARI and BAU are deeply appreciated for their dedicated assistance. Acknowledgement is further made to the IWM, Soil Science, Plant Physiology, and ASICT divisions for their support in soil and plant sample analysis as well as data processing. The author also expresses gratitude to the ACIAR project for providing essential financial assistance.

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