

**GERMINATION RESPONSE OF COMMON BEANS (*Phaseolus vulgaris*)  
UNDER INDUCED STRESS USING SALTS; SODIUM CHLORIDE  
(NaCl), POTASSIUM CHLORIDE (KCl) AND SODIUM BICARBONATE  
(NaHCO<sub>3</sub>)**

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**ABSTRACT:** In this study, the effects of salt stress on the germination of common beans (*Phaseolus vulgaris*), a major source of affordable plant protein and an important staple in Nigeria were examined. The three salts that were applied at concentrations of 100 ppm, 500 ppm and 1000 ppm were sodium chloride (NaCl), potassium chloride (KCl) and sodium bicarbonate (NaHCO<sub>3</sub>). Distilled water was utilised as the control in this study. To find out how well they responded in terms of germination, growth, and nutritional value, white and brown bean cultivars were evaluated. Priming of 200 healthy seeds in the respective prepared salt solutions was done using a completely randomised design. Growth metrics such biomass, shoot length and root length, germination

rate and leaf spread were measured and moisture content was ascertained by the germination. The results showed that salinity stress significantly affected both growth performance and proximate composition. Sodium chloride (NaCl) had the most detrimental effect, particularly at higher concentrations where it reduced biomass and overall plant development. Sodium bicarbonate (NaHCO<sub>3</sub>) was comparatively less harmful, while potassium chloride (KCl) exhibited moderate effects with some treatments maintaining relatively better growth performance. In addition, analysis of seed nutritional composition revealed that crude protein content remained relatively stable across all treatments, ranging from approximately 11.96% to 13.31%, indicating that protein levels were not significantly influenced by salt type or concentration. However, carbohydrate content varied noticeably with NaCl treatments showing minimal change, NaHCO<sub>3</sub> causing moderate increases and KCl leading to a progressive rise in carbohydrate levels, reaching the highest values at increased concentrations. The control sample showed moderate nutritional values, while untreated sowing seeds exhibited the highest carbohydrate content reflecting their natural composition prior to treatment. Also, white bean cultivars demonstrated greater tolerance to moderate salinity stress compared to brown beans, particularly during germination and early shoot development. Overall, the study concludes that salinity stress reduces both growth and nutritional quality of common beans, with sodium chloride being the most harmful and sodium bicarbonate the least. It is therefore recommended that salt-tolerant cultivars be introduced alongside improved soil and water management practices to prevent sodium accumulation, as well as further research into the biochemical and molecular mechanisms of salt tolerance to support sustainable bean production in saline-prone regions.

**Keywords:** *Germination, Common Beans, Salts*

## INTRODUCTION

Beans has a longstanding position as a staple of the Nigerian diet due the fact that it is an accessible and affordable source of nutrition for a wide range of people as it is the cheapest plant protein in Nigeria and most parts of Africa. Beans is also significant in the Nigerian diet because it has a potent combination of its high nutritional content, historical use as a financial stabilizer and fixed cultural importance. Consuming beans in Nigeria is not a straightforward dietary decision, rather it is a calculated reaction to a complicated

interaction between inherited customs, economic realities and public health requirements. Beans has high-quality protein and fiber composition that act as a vital defense against chronic illnesses and also solve the pervasive protein shortage.

Food legumes belonging to the genus *Phaseolus*, family Leguminosae, subfamily Papilionoideae, tribe Phaseoleae, and subtribe Phaseolinae are commonly referred to as beans. About 50 wild-growing species of *Phaseolus* are found only in the Americas; Asian *Phaseolus* has been reclassified as *Vigna*. Life histories (annual to perennial), growth patterns (bush to climbing), reproductive systems and adaptations (from cool to warm and dry to wet) are all represented by these species. Common beans (*Phaseolus vulgaris* L.), lima beans (*Phaseolus lunatus* L.), runner beans (*Phaseolus coccineus* L.), tepary beans (*P. acutifolius* A. Grey), and year beans (*P. polyanthus* Greenman) are among the five domesticated species in the genus. These species have different adaptations and reproductive systems: mesic and temperate, mostly self-pollinated; warm and humid, cool and humid, outcrossing; cleistogamous; and cool and humid, outcrossing, in that order. The other domesticated species, which form a syngameon and are sibling species, are phylogenetically closer to the lima bean. In terms of science and economics, the common bean is the principal species. Its wild ancestor, *P. vulgaris* var. *mexicanus* and var. *aborigineus*, is widely distributed throughout Latin America, from northern Mexico to northwest Argentina. The USDA in Pullman, Washington, USA, and CIAT in Cali, Colombia, both have sizable germplasm collections of both domesticated and wild types. The National Botanical Garden in Meise, Belgium, is home to the Phaseolinae reference collection. The most significant legume for direct human consumption worldwide is the common bean (Gepts, 2001).

The most significant grain legume for direct human consumption globally is the bean (*Phaseolus* spp.), especially the common bean *P. vulgaris* L. Because of their biological nitrogen fixation, effects on the soil, and weed control, they are a major source of highly valuable plant protein and micronutrients, they offer health benefits associated with regular consumption, and they help to improve the environment in a sustainable way when grown in agricultural rotation or with intercropping (Bitocchi *et al*, 2017).

Legumes, commonly called pulses, belong to the Leguminosae or Fabaceae family, which includes around 690 genera and 18,000 species. The term "legume" comes from the Latin

word *legere*, meaning "to gather," while "pulse" traces back to the Latin *puls*, referring to a porridge-like bean dish enjoyed by the ancient Romans. Within the family, there are three main subfamilies Papilionoideae, Caesalpinioideae, and Mimosoideae distinguished largely by their flower structure. Most edible legumes, including soybeans, chickpeas, beans, and peas, fall under Papilionoideae, while lesser-known members include clover, lentils, licorice, and peanuts, the latter of which are botanically legumes but not always treated as such in culinary contexts (Allaire and Brady, 2010).

A defining feature of Fabaceae plants is their unique flowers and fruit. These flowers are hermaphroditic, containing both stamens and pistils, which makes them self-fertile but also capable of cross-pollination. This duality often blurs distinctions among subspecies. The flowers typically have five petals arranged in a butterfly-like, or papilionaceous, shape: a large protective "banner," two lateral "wings," and two fused petals forming the "keel," which encloses the reproductive organs. After pollination, the flower withers to reveal the ovary, which matures into the characteristic pod of the legume plant (Allaire and Brady, 2010).

There are numerous common names for beans in various languages. Various bean classes, seed kinds, growth behaviours and, of course, particular varieties are distinguished by descriptive and common names, as are *Phaseolus vulgaris* L. and other edible seed legume species. The numerous agronomic, physical, and consumer traits of beans are also used to categorise them. Certain bean classes have relatively limited production and acceptability, which varies by nation and location.

In the English language, the generic term "beans" is often used not only for *P. vulgaris* but also for other species, such as *P. coccineus*, and it may even refer to other genera, such as *Vigna*. For this reason, descriptive adjectives, such as the following, are often used to distinguish *P. vulgaris* from other grain legumes: French beans, dry beans, food beans, field beans, beans, common beans, kidney beans, haricot beans, *Phaseolus* beans, and dry edible beans. Common bean or haricot bean are perhaps the most common species descriptors in English, but they are not of universal usage. These and other descriptors may be employed as a species description in one country and be used to describe a specific class of beans in another.

Beans usually refers to food legumes of the genus *Phaseolus*, family Leguminosae, subfamily Papilionoidea, tribe Phaseoleae, subtribe Phaseolinae. The genus *Phaseolus* contains some 50 wild-growing species distributed only in the Americas (Asian *Phaseolus* have been reclassified as *Vigna*). These species represent a wide range of life histories (annual to perennial), growth habits (bush to climbing), reproductive systems, and adaptations (from cool to warm and dry to wet). The genus also contains five domesticated species: in decreasing order of importance, common bean (*Phaseolus vulgaris* L.), lima bean (*P. lunatus* L.), runner bean (*Phaseolus coccineus* L.), tepary bean (*P. acutifolius* A. Gray), and year bean (*P. polyanthus* Greenman).

Beans rank among the world's most important and widely farmed legume crops, due to being a staple for hundreds of millions of people around the world because of its nutrition, versatility, and low price. The family Fabaceae, or Leguminosae, covers a great variety of species, each with unique and particular attributes (Smith, 2020).

The term "**beans**" broadly refers to the seeds of various genera and species within the **Fabaceae family**, encompassing a wide range of common and economically significant types. These include the **Common Bean** (*Phaseolus vulgaris*), which is the most widely cultivated and includes varieties like kidney, pinto, navy, black, cannellini, and green beans. Other notable types are the **Lima Bean** (*Phaseolus lunatus*), also known as butter beans; the **Fava Bean** (*Vicia faba*), or broad beans; and botanically distinct but commonly grouped legumes such as the **Chickpea** (*Cicer arietinum*) and **Lentil** (*Lens culinaris*). Additionally, the **Soybean** (*Glycine max*) stands out for its extensive industrial uses and high protein content, while the **Mung Bean** (*Vigna radiata*) is popular in Asian cuisine, and the **Cowpea** (*Vigna unguiculata*), including black-eyed peas, is widely grown in Africa and Asia. This diverse array of species underscores the broad genetic base within the "bean" category (Jones and Davis, 2021).

Most brown and white beans fall under the species ***Phaseolus vulgaris* L.**, commonly known as the **common bean**. This species is highly diverse, with numerous cultivars exhibiting a wide array of seed colors, shapes, and sizes, including various shades of brown and white. Some white beans can also be varieties of *Phaseolus lunatus* or *Vigna unguiculata*.

## Botanical Classification:

- **Kingdom:** Plantae (Plants)
- **Phylum:** Tracheophytes (Vascular plants)
- **Class:** Magnoliopsida (Dicotyledons)
- **Order:** Fabales
- **Family:** Fabaceae (Leguminosae)
- **Subfamily:** Faboideae
- **Genus:** *Phaseolus*
- **Species:** *Phaseolus vulgaris* L.

Beans (*Phaseolus vulgaris* L.) are not only a dietary staple but also a critical component in sustainable agriculture and rural livelihoods. Their nutritional profile is impressive, containing 20–30% crude protein, 40–60% carbohydrates, 5–15% dietary fiber, 1–2% fat, and an abundance of essential minerals such as calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn) (Nwadike *et al.*, 2018).

In many African countries, especially Nigeria, beans serve a dual role as a food security crop and a source of income. They are widely cultivated by smallholder farmers across diverse agro-ecological zones, including the savanna, rainforest, and middle belt regions, due to their adaptability and relatively short growing cycle (Aremu *et al.*, 2016).

Salt stress significantly reduces **crop biomass, flowering, fruit set, and yield**. In beans, high salinity affects **germination rates, pod development, and seed quality**. Salinity inhibits nutrient uptake (particularly nitrogen and phosphorus), causing metabolic imbalances and disrupting hormonal signals involved in flowering and seed development (Khan *et al.*, 2021).

## Materials And Methods

### Study Area

This project work was carried out in the laboratory at the National Space Research Laboratory at the early stages of germination and while it was in the nursery. It was later transferred outside to a nearby empty field where it grew to maturity.

## Experimental Groups And Design

- Control Group: This group contained only water and was used as a baseline for the experiment.
- NaCl Treatment Groups: This group consisted of different concentrations of NaCl which were 100ppm, 500ppm and 1000ppm respectively.
- KCl Treatment Groups: This group consisted of different concentrations of KCl; which were 100ppm, 500ppm and 1000ppm respectively.
- NaHCO<sub>3</sub> Treatment Groups: This group consisted of different concentrations of NaHCO<sub>3</sub> which were 100ppm and 100ppm, 1000ppm respectively.

The experimental design was completely randomized. Seeds were treated with different concentrations of growth stimulators (100 ppm, 500 ppm, and 1000 ppm) and distilled water as control.

Number of seeds used: 200 (20 seeds per treatment). The beans seeds was carefully selected and separated accordingly for each stimulator.

Priming method: Each batch of seeds was primed in 20ml of the respective prepared concentration for 1 hour before sowing.

The solutions were prepared.

Each growth stimulator was separately weighed and dissolved in 1000 ml of distilled water, prepared into 100 ppm, 500 ppm, and 1000 ppm concentrations, and labelled accordingly.

Planting: Cotton wool was placed at the base of sterilized petri dishes, and primed seeds were planted on them.

Replicates: Each treatment was replicated in 3 petri dishes, while distilled water treatment (control) was maintained in 1 petri dish.

## Materials

100 healthy white beans, 100 healthy brown beans, 10 clean cans of bottle water, Beakers, Volumetric cylinder, 10 Petri dishes, Razor blade, Cotton wool, Disposable hand gloves, Face mask, Loamy soil, Masking tape, Marker, Forceps

## **Equipment**

Weighing balance

## **Reagents**

Sodium chloride (NaCl), Potassium chloride (KCl), Sodium bicarbonate (NaHCO<sub>3</sub>),  
Distilled water

## **METHODS**

### **Sample Collection**

The sample was purchased on the 6th of July from Ring-road in Benin City, Edo State, Nigeria. The reagents were provided by the laboratory.

### **Cultivation: Sample Preparation And Pot Preparation**

Healthy, viable and undamaged beans were selected. It was then soaked in the respective solutions of salt concentrations for an hour, after which it was sowed in the respective Petri dish containing cotton wool and little amount of the prepared salt solution was added to the Petri dish.

The seedlings were transferred to the nursery after five days(120 hours). The pot used for the nursery were clean plastic pots which were gotten from cut up water bottles. These plastics were cleaned and loamy soil was added to fill these cut up plastic pots. Water was then added to loosen the soil up a bit before transferring the seedlings.

### **Maintenance And The Appropriate Growth Conditions**

The plastic pots containing the growing seedlings were placed in an incubation room under controlled conditions. Maintaining appropriate temperature, humidity and photoperiod (about 12hours of sunlight daily). Watering or irrigation was done using the prepared salt solutions and watering was done every two days (every 48hours) until the seedlings were transferred to the field.

### **Reagent Preparation**

To prepare 100ppm of each salt solution

100mg (0.1g) of each salt is dissolved in 1000ml of distilled water

So the required milligram or gram (mg/g) of salt to be dissolved in 250ml of distilled water will be,

$$\underline{0.1\text{g}} = 1000\text{ml}$$

$$x = 250\text{ml}$$

Cross multiply

$$x = \underline{25}$$

$$1000$$

$$x = 0.025\text{g}$$

To prepare 500ppm of each salt solution

500mg (0.5g) of each salt is dissolved in 1000ml of distilled water

So the required milligram or gram (mg/g) of salt to be dissolved in 250ml of distilled water will be,

$$\underline{0.5\text{g}} = 1000\text{ml}$$

$$x = 250\text{ml}$$

Cross multiply

$$x = \underline{125}$$

$$1000$$

$$x = 0.125\text{g}$$

To prepare 1000ppm of each salt solution

1000mg (1g) of each salt is dissolved in 1000ml of distilled water

So the required milligram or gram (mg/g) of salt to be dissolved in 250ml of distilled water will be,

$$\frac{1g}{1000ml}$$

$$x = 250ml$$

Cross multiply

$$x = \frac{250}{1000}$$

$$1000$$

$$x = 0.25g$$

### **Seed Priming**

1. A total of Ten (10) beakers where prepared and labelled
2. (KCl 100ppm, 500ppm, 1000ppm, NaCl 100ppm, 500ppm and 1000ppm, and NaHCO<sub>3</sub> 100ppm, 500ppm and 1000ppm and Water (H<sub>2</sub>O)).
3. A total of 200 viable seeds, (100 of brown and 100 of white beans) where picked and set apart and 20 seeds (10 of each variety), where placed in each beaker.
4. 20ml of each concentration (100ppm, 500ppm, 1000ppm) of the Reagents (KCl, NaCl and NaHCO<sub>3</sub>) where poured into the beaker containing the seeds, and the seeds were left to prime for 30 minutes.
5. While the seeds where priming Ten (10) Petri dishes where prepared and labelled with each growth regulator and concentration respectively. Afterwards an appropriate amount of cottonwool was spread in each Petri dish to act as the base for the plant and a source of Carbon.
6. At the 30mins mark the seeds where implanted into the
7. Petri dished containing the cotton wool and the variety was separated in the Petri dishes.
8. Afterwards the growth was observed for a total of 120 hours.

## **Transplanting Into Nursery**

Growing crops in a nursery is crucial because it offers a regulated setting where young plants may be closely tended to during their formative years. In the nursery, seedlings are given enough nutrients and water to support healthy growth while being shielded from inclement weather, pests, and illnesses. In addition to lowering the initial land and resource requirements, this approach guarantees consistent and robust seedlings and allows farmers to choose just the healthiest plants for field planting. In order to produce consistent and healthy bean seedlings for this experiment, a nursery was necessary. This allowed for a more precise evaluation of the effects of various growth regulators on germination and early growth.

1. A total of Ten (10) plastic bottles were cut in half and filled with sand to act as the nursery.
2. Water was used to soak the sand in the Nursery to prevent dryness and to aid the growth of the plant
3. Two seedlings each from each of the Concentration were transplanted into the nursery and allowed to grow for a total of 4 days before transferring into the Field.

## **Field Preparation And Transplanting**

Transplanting seedlings from the nursery to the main field is crucial because it allows plants to grow in wider spaces with adequate access to soil nutrients, water, and sunlight. This step ensures proper plant population, reduces competition among crops, and encourages stronger root establishment. By transplanting only healthy and well-developed seedlings, farmers increase the chances of better crop survival, higher yields, and improved overall productivity in the field. For this project, transplanting to the field was necessary to observe how the bean seedlings responded to natural conditions after initial nursery growth, and to evaluate the overall effect of the applied growth regulators on their survival, establishment, and performance under field conditions.

1. The field was first prepared by clearing and tilling the soil,
2. Each of the nursery bottle were watered before uprooting to soften the soil and reduce root damage.

3. Holes were dug and prepared in the field, and the seedlings were placed into the holes and soil was added to cover the roots and make ridges to prevent water logging.
4. Regular aftercare practices such as irrigation, weeding, and pest control were carried out to ensure proper growth and development.

## RESULTS

The results of the germination of common beans (*Phaseolus vulgaris*) stressed by several salt treatments; sodium bicarbonate ( $\text{NaHCO}_3$ ), potassium chloride (KCl), and sodium chloride (NaCl) are arranged to show how each salt affects the nutritional makeup of the beans, as well as how much of each salt is present. For clarity, the results are displayed in tables, together with statistical analysis to assess the importance of the discrepancies that were noticed.

**Table 1.1** A Table Showing The Germination Rate Results

Samples	No of germinated seeds	Shoot length(cm)	Root length(cm)	No of roots	Wet weight(g)	Biomass(g)	Moisture content
Water(CTR)bb	7	4.3	2.2	18	2.15	0.52	1.63
Water(CTR)wb	8	6	5.6	13	2.93	0.53	2.4
Kcl100ppm bb	10	6.1	6.8	13	2.8	0.69	2.11
Kcl100ppm wb	10	6	6.1	14	0.9	0.15	0.75
NaCl100ppm bb	10	7	2.3	13	1.31	0.37	0.94
NaCl100ppm wb	9	7.8	2.5	12	1.35	0.38	0.97
NaHCO <sub>3</sub> 100ppm bb	10	4.3	4.2	21	2.03	0.78	1.25
NaHCO <sub>3</sub> 100ppm wb	10	9.1	2.24	1	1.55	0.2	1.35
KCl1500ppm bb	9	5.5	2.5	14	2.37	0.8	1.57
KCl1500ppm wb	10	4.2	3	14	2.16	0.43	1.73
NaCl1500ppm bb	8	6.4	3.3	25	1.46	0.47	0.99
NaCl1500ppm wb	10	6	6.3	9	0.54	0.06	0.48

NaHCO <sub>3</sub> 500ppm bb	10	4.3	5	14	0.89	0.18	0.71
NaHCO <sub>3</sub> 500ppm wb	10	9.1	4.8	10	1.37	0.3	1.07
KCl1000ppm bb	10	3.4	1.7	15	1.13	0.23	0.9
KCl1000ppm wb	10	6.6	3.9	14	0.96	0.3	0.66
NaCl1000ppm bb	9	6.1	2.5	18	1.53	0.5	1.03
NaCl 1000ppm wb	9	6.8	4.4	9	0.61	0.19	0.42
NaHCO <sub>3</sub> 1000pp m bb	10	3.3	1.4	14	0.52	0.14	0.38
NaHCO <sub>3</sub> 1000pp mwb	9	4.2	3.2	11	2.23	0.05	2.18

**KEY WORDS:**

CTR= Water

KCl= Potassium chloride

NaCl= Sodium chloride

NaHCO<sub>3</sub>= Sodium bicarbonate

bb = Brown beans

wb =White beans

**NOTE:** To get moisture content:

Wet weight – Biomass = Moisture content

For example;

In KCl100ppm bb, the moisture content will be

$$2.8 - 0.69 = 2.11$$

Thus, 2.11 is the moisture content in KCl100ppm bb

Also,

Biomass = Shoot dry weight + Root dry weight

## Observations

1. At the 30 hours mark, 100ppm of KCl, 100ppm of NaCl, 100ppm of NaHCO<sub>3</sub> and 1000ppm of KCl showed significant increase in growth compared to the other seedlings.
2. At the 48 hours mark, leaves were visible in across all salt solutions and even water but the seedlings in Kcl had the most leaves. In KCl 6 seedlings sprouted and had leaves(5 white and 1 brown).
3. At the 120 hours mark, leaves were observed across all the salt concentrations except in 1000ppm of NaCl.

**Table 1.2** A Table Showing The Parameters Gotten From The Field Observation

Samples	No of leaves	No of branches	Length of spread(cm)	Wet	Dry	Moisture content
				weight of spread	weight of spread	
Water	88	3	217	20.1	9.3	10.8
KCl	125	4	215.2	29.86	10.26	19.6
NaCl	36	1	126	16.92	4.68	12.24
NaHCO <sub>3</sub>	66	3	196	14.94	2.78	12.16

### KEY WORDS:

CTR= Water

KCl= Potassium chloride

NaCl= Sodium chloride

NaHCO<sub>3</sub>= Sodium bicarbonate

## Observations

The table above presents the results of field observations comparing how different treatments {water (CTR), potassium chloride (KCl), sodium chloride (NaCl), and sodium bicarbonate (NaHCO<sub>3</sub>)} affect plant growth and biomass characteristics using several parameters. The control sample treated with water shows moderate growth with 88 leaves, 3 branches, and the widest spread length of 217 cm, indicating healthy natural development without salt interference; its wet weight (20.1) and dry weight (9.3) give a moisture content of (10.8), suggesting balanced water retention. In contrast, the KCl-treated plants exhibit the most vigorous growth overall, producing the highest number of leaves (125) and branches (4) along with a large spread (215.2 cm) which is very close to the control. Also, KCl results in the highest wet weight (29.86) and dry weight (10.26), as well as the highest moisture content (19.6), indicating that potassium chloride significantly enhances vegetative growth, biomass accumulation and water retention in the plant. On the other hand, NaCl-treated plants show the poorest performance across nearly all parameters with only 36 leaves, 1 branch, and a much smaller spread length (126 cm) alongside lower wet and dry weights (16.92 and 4.68 respectively), suggesting that sodium chloride has a strong inhibitory or toxic effect on plant growth and development. Similarly, NaHCO<sub>3</sub>-treated plants perform better than NaCl but still below the control and KCl treatments with 66 leaves, 3 branches, and a spread of 196 cm. However, despite a moderate spread, the wet weight (14.94) and especially the dry weight (2.78) are quite low, indicating reduced biomass accumulation even though moisture content (12.16) remains relatively moderate. Overall, the table clearly demonstrates that potassium chloride (KCl) promotes the best growth and yield-related parameters, water (control) supports normal growth, sodium bicarbonate (NaHCO<sub>3</sub>) has a mild negative effect and sodium chloride (NaCl) significantly suppresses plant growth and productivity.

**Table 1.3** A table showing the number of pods produced from each sample of common beans

Samples	No of Pods
Water(CTR)	2
Kcl 100ppm	0
KCl 500ppm	1
KCl 1000ppm	1
NaCl 100ppm	0
NaCl 500ppm	1
NaCl 1000ppm	0
NaHCO <sub>3</sub> 100ppm	1
NaHCO <sub>3</sub> 500ppm	1
NaHCO <sub>3</sub> 1000ppm	1

**KEY WORDS :**

CTR= Water

KCl= Potassium chloride

NaCl= Sodium chloride

NaHCO<sub>3</sub>= Sodium

bicarbonate

bb = Brown beans

wb =White beans

**Observations**

The table presents the effect of different salt treatments and concentrations on pod production in common beans, using water as the control (CTR) for comparison. The control sample produced two pods which is the highest yield in the table, indicating that natural conditions without salt stress favor pod formation. Under potassium chloride (KCl) treatments, no pods were produced at 100 ppm while only one pod was recorded at both 500 ppm and 1000 ppm, suggesting that low concentrations of KCl may inhibit pod formation while higher concentrations allow minimal production but still do not

outperform the control. Similarly, sodium chloride (NaCl) shows a generally negative effect with no pods at 100 ppm and 1000 ppm and only one pod at 500 ppm, indicating that NaCl especially at higher or lower extremes, suppresses reproductive development. In contrast, sodium bicarbonate (NaHCO<sub>3</sub>) treatments show more consistent results, with one pod produced at all concentrations (100 ppm, 500 ppm, and 1000 ppm), suggesting that while it does not enhance pod production beyond the control, it maintains a stable but reduced yield under varying concentrations. Overall, the table demonstrates that all chemical treatments tend to reduce pod production compared to the control, with water giving the best result, NaHCO<sub>3</sub> maintaining consistent but moderate production and KCl and NaCl generally having inhibitory effects depending on concentration.

## **DISCUSSION, CONCLUSION AND RECOMMENDATIONS**

### **Discussion Of Findings**

This study investigated the effect of three different salt stressors on the germination of common beans (*Phaseolus vulgaris*): sodium bicarbonate (NaHCO<sub>3</sub>), potassium chloride (KCl), and sodium chloride (NaCl). The principal aim was to ascertain and contrast the effects of these distinct salts, in differing concentrations, on the nutritional content of beans. Wide-ranging effects on food security and agriculture in saline-prone areas may result from the findings of this study, which provide important insight into how soil salinity (a major abiotic stressor) may alter the nutritional content of this staple crop.

To give a thorough grasp of the observed occurrences, the results in this discussion section are carefully reviewed and compared with the corpus of existing scientific literature. The fundamental processes by which these salts affect plant metabolism by combining the biochemical data on plant growth (shoot and root length, germination rate, and biomass) with the physiological data on plant germination (crude protein, crude fat, etc.) can be determined. The comparative effects of each salt will be carefully highlighted in the discussion, indicating whether osmotic stress, specific ion toxicity, or a mix of the two are principally responsible for the detrimental effects on nutritional quality. This section will conclude whether each goal was accomplished and offer a solid foundation for further research by interpreting the results in light of the study's initial aims and objectives.

## Interpretations Of Result

1. Seed Germination: In all treatments, both brown and white beans sprouted with 9–10 seeds sprouting in the majority of treatments. Although salts did not significantly hinder germination in certain instances, greater doses (such as NaCl1000 ppm Wb = 9) marginally decreased germination.
2. Shoot Length: For the control (water), the shoot lengths were moderate (Bb = 4.3 cm; Wb = 6 cm). In fact, several treatments (such as NaCl100 ppm Wb = 7.8 cm and NaCl1000 ppm Wb = 6.6 cm) lengthened the shoots in comparison to the control. On the other hand, shoot length decreased in several high-salt environments (such as KCl1000 ppm Bb = 3.4 cm). The Conclusion is dependent on the type of salt and bean variety, the effects of salt stress vary. At moderate stress levels, white beans appear to be more resilient.
3. Root Length: With the exception of a few instances (e.g., NaCl1000 ppm Wb = 3.9 cm, higher than some lower levels), root development generally declined as salt concentration increased. This shows that salt stress inhibits root extension; controls had greater root lengths (2.2–5.6 cm) than several stressed samples.
4. Number of Roots: The number of roots, which ranged from 11 to 25 among treatments, was not significantly impacted. Extreme values, however, imply variation based on bean type and salt.
5. Wet and Dry Weight: The biomass of the control plants was higher (wet weight: 2.15-2.93 g). Biomass was often decreased by high salt stress, particularly dry weight (e.g., NaHCO<sub>3</sub> ppm Wb = 0.05g). Wet weight (NaHCO<sub>3</sub>1000 ppm Bb = 0.52 g) was maintained or slightly increased by some treatments, indicating potential stress adaption.

### Note:

Wb = White Beans

Bb = Brown Beans

### Overall conclusion of result

Beans under salt stress have decreased biomass and root and shoot growth. Although white beans (wb) lose biomass under high stress but exhibit somewhat improved tolerance in terms of shoot length and germination under moderate stress. Under higher salt levels, brown beans (bb) are more susceptible, particularly in terms of shoot/root elongation. The effects of various salts vary:

- Dry weight was more significantly decreased by NaCl stress.
- Shoot length was significantly decreased by KCl stress at high concentrations.
- The effects of NaHCO<sub>3</sub> stress were less severe, and some biomass was preserved. This implies that under the measured conditions, NaHCO<sub>3</sub> is comparatively less toxic, whereas NaCl is the most hazardous salt.

**Table 1.4** A table showing the proximate analysis result after harvest

Code	Code	Moist ure Contt %	ASH CONTE NT %	CRUDE FIBRE CONTEN T %	CRUD E FAT %	CRUDE PROTEI N %	CARBOHYDRA TE %
YA 01	NaCl 100	34	9.2	1	1.15	12.34	42.31
YA 02	NaCl 1000	34.8	8.2	0.6	1.2	13.31	41.89
YA 03	NaHCO <sub>3</sub> 100	25.6	9.8	1.4	1.22	12.42	49.56
YA 04	NaHCO <sub>3</sub> 1000	31.4	9.4	1	1.18	11.96	45.06
YA 05	KCl 100	37.4	6.8	0.8	1.21	12.19	49.8
YA 06	KCl 500	24.4	8.2	1	1.17	12.25	52.98
YA 07	KCl 1000	19.6	5	1.2	1.25	12.27	60.68
CTR		34	8	0.8	1.16	12.93	43.11
Sowin g Seed		13.6	4.6	0.4	1.25	12.69	67.46

## Observations

The table presents the effect of different salt treatments specifically varying concentrations of sodium chloride (NaCl), sodium bicarbonate (NaHCO<sub>3</sub>), and potassium chloride (KCl) on the nutritional composition of the seeds. Each sample is identified by a unique code (YA 01 to YA 07), alongside a control (CTR) and an untreated “sowing seed” sample used as a baseline. From the table above, crude protein values remain relatively stable across all treatments, fluctuating only slightly between approximately 11.96% and 13.31%, which suggests that protein content is not significantly influenced by the type or concentration of salt used. In contrast, carbohydrate content shows more noticeable variation depending on the treatment applied. Samples treated with NaCl (YA 01 and YA 02) have carbohydrate values close to the control, indicating minimal impact, while NaHCO<sub>3</sub> treatments (YA 03 and YA 04) show a moderate increase in carbohydrate levels. The most significant change is observed in KCl-treated samples (YA 05 to YA 07), where carbohydrate content increases progressively with concentration, reaching as high as 60.68% at the highest level, suggesting that potassium chloride may enhance carbohydrate accumulation or retention. The control sample (CTR) provides a reference point with moderate protein and carbohydrate values, while the sowing seed sample exhibits the highest carbohydrate content overall (67.46%), indicating the natural composition before any treatment or experimental manipulation. Overall, the table demonstrates that while protein content remains largely unaffected by these chemical treatments, carbohydrate levels are sensitive to both the type and concentration of salts with KCl having the most pronounced effect.

## Conclusion

This study examined how common beans (*Phaseolus vulgaris*) responded to salt stress caused by sodium chloride (NaCl), potassium chloride (KCl), and sodium bicarbonate (NaHCO<sub>3</sub>) in terms of germination, growth and proximate composition. The results showed that the effects of salinity stress on seed germination, shoot and root development, biomass accumulation, and nutritional content were quantifiable. The most harmful stress was discovered to be NaCl, particularly at higher doses, which resulted in notable declines in biomass and proximate quality. Even while KCl stress was not as bad as NaCl stress, it nevertheless had a deleterious effect on shoot and root elongation at high

concentrations. On the other hand, some treatments seemed to preserve biomass and proximate balance better than NaCl and KCl, suggesting that NaHCO<sub>3</sub> had somewhat weaker impacts. Differences across the varieties were also noted that white beans, especially in terms of germination and shoot growth, showed a comparatively higher tolerance to moderate salt concentrations than brown beans. This implies that managing bean cultivation in saline environments may be significantly influenced by varietal selection. In conclusion the conditions examined, salt stress has a detrimental effect on common bean productivity and nutritional quality, with NaCl being the most detrimental, KCl being somewhat detrimental, and NaHCO<sub>3</sub> being the least detrimental.

### **Recommendations**

1. **Varietal Selection:** Although white bean varieties have demonstrated a comparatively higher tolerance to salt stress than brown bean types, farmers in saline-prone locations should give priority to growing them.
2. **Soil and Water Management:** Since sodium chloride was one of the most hazardous salt, steps should be made to prevent sodium buildup in soils. Some of them include diluting irrigation water to minimise salinity levels, adding gypsum as a soil amendment and ensuring correct drainage.
3. **Seed Priming:** Since moderate salt concentrations seemed to preserve or even enhance some growth factors, seed priming with lower concentrations of salts especially NaHCO<sub>3</sub> may be investigated as a management tactic.
4. **Futher Research:** To gain a better knowledge of the mechanisms underlying beans ability to withstand salt, future research should go beyond the germination factors to include micronutrients, anti-nutritional factors and biochemical reactions (e.g., enzyme activity, gene expression).
5. **Policy and Extension Services:** To maintain productivity, agricultural extension programs should inform farmers about the dangers of salinised soil and encourage adaptable techniques such crop rotation using salt-tolerant species and soil amendment techniques.
6. **Scaling Up:** Before widespread adoption, field-based experiments in Nigeria's various agro-ecological zones are advised to confirm these results in actual farming settings.

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