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Effects of Bay Leaf (*Laurus nobilis* L.), Potato (*Solanum tuberosum* L.) Peel and Banana (*Musa* Species) Peel Extracts on Physiological Performance of Some Upland (Ahu) Rice (*Oryza sativa* L.) Crop under Higher Iron in Acid Soil Condition

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Abstract— *A pot experiment (CRBD with three replications) was carried out to investigate the effects of Bay leaf, Potato peel, and Banana peel extracts on the physiological performance of some upland (Ahu) rice crop (varieties: Inglongkiri, Dehangi (Fe tolerant), Lachit (Fe susceptible), and Luit) under higher iron in acid soil conditions during the Autumn season (March-September, 2024). The five treatments were: (1) 100 ppm $FeSO_4$ as basal at vegetative stage (control), (2) 100 ppm $FeSO_4$ as basal at vegetative stage plus root dip treatment before transplanting and foliar spray with bay leaf extract at 20 days after transplanting, (3) 100 ppm $FeSO_4$ as basal at vegetative stage plus root dip treatment before transplanting and foliar spray with banana peel extract at 20 days after transplanting, (4) 100 ppm $FeSO_4$ as a basal at the vegetative stage, plus root dip treatment before transplanting and foliar spray with potato peel extract at 20 days after transplanting; (5) Natural soil without root dip treatment and without spray with bay leaf, banana peel, and potato peel extracts at 20 days after transplanting (Absolute control). In general, as compared to the control (100 ppm $FeSO_4$), there were significant increases in the morpho-physiological and yield-attributing parameters under other treatments. Among the treatments, 100 ppm $FeSO_4$ as basal at vegetative stage plus aqueous bay leaf (10 g in 100 ml) was found to be the most useful against the damaging effects of higher iron pertaining to the physiological parameters. In the study, Dehangi emerged as the prominent variety in terms of the various physiological parameters viz., SLW at maximum tillering (6.753 mg cm^{-2}) and heading stage (8.673 mg cm^{-2}), shoot biomass (35.513 g $plant^{-1}$) at harvest, numbers of tillers (12.707) and number of leaves (24.040 per plant) at maximum tillering stage, effective tillers (11.487 per plant), root biomass (20.413 g $plant^{-1}$) at harvest, panicle length (28.607 cm), panicle weight (8.960 g $plant^{-1}$), number of panicle (9.300/plant), seeds per panicle (85.313), test weight (26.893 g), HD grains (75.460%), sterility (22.460%), economic yield (16.593 g $plant^{-1}$), biological yield (45.007 g $plant^{-1}$), GHI (48.547) and plant height (3.81-8.25%) at harvest.*

Keywords— Banana peel, Bay leaf, HD grains, Iron, Potato peel, Rice.

I. INTRODUCTION

Rice is one of the staple food crops in Assam grown as kharif (70%), Rabi (upland) 23% and Boro (7%) covering 2.54 million hectares. The higher iron content in the acid soil (80% of geographical area i.e. 25 Mha) of the region is one of the factors for lower productivity (< 3 t ha^{-1}). The high rainfall (>2000 mm) makes the soil acidic in nature (pH<5.0) due to leaching of basic cations (Mandal, 1995; Mandal et al., 2019). So, the ground water contains higher iron (0.25 - 67.0 ppm), where its absorption by the plant roots enriches the concentration of iron in plants. The symptoms of iron toxicity appear in plants as per the dynamics of iron in soil viz., potassium deficiency (at 150-450 ppm), yellowing of green leaves (at 350-450 ppm), dark brown or bronze spots (at 450-780 ppm) and plants eventually die at >800 ppm iron in soil (Baruah et al., 1983; Bora and Borkakati, 1997). In the past, measures like applying potassium fertilizer (Singh and Singh, 1987), managing water (Borah and Nath, 1979), using growth hormones, organic acids, coconut milk, varietal screening (Bey, 2022) failed to ameliorate the physiological aberrations caused by higher iron. No noteworthy information on how to reduce iron toxicity in rice crop using bay leaf, banana and potato peels are available yet.

Bay leaf contains important nutrients viz., Ca (377 mg/100g), P (112 mg/100g), K (550 mg/100g), Fe (45 mg/100g), Cu (0.63 mg/100g), Mg (112 mg/100g), Mn (7.313 mg/100g), and Zn (2.90 mg/100g), and compounds like glycosides, terpenoids, tannins, and a variety of fatty acids (Batool et al., 2020; Cakmak et al., 2013). Banana peel contains a high concentration of natural phenolic compounds, antioxidants such as vitamins, flavonoids (Lee et al., 2010). A medium-sized banana has 450-467 mg of potassium. Banana peel contains dietary fibre, proteins, essential amino acids, polyunsaturated fatty acids, and potassium (Emaga et al., 2007), vitamin A as beta carotene, vitamin C, amino acids, particularly tryptophan, protein, carbohydrate, macro and micronutrients, phenolic compounds, fat, and fibre (Nguyen et al., 2003; Sidhu and Zafar, 2018). The minerals with the highest concentrations in raw potato are potassium (564 mg/g f.w.), phosphorus (30-60 mg/g f.w.), and calcium (6-18 mg/g f.w.) as reported by Burton, (1989); Buckenhüskes, (2005) and Karan, 2023). Furthermore, potatoes are low in fat and high in nutrients like vitamin C. It also contains the vitamins B1, B3, and B6, as well as folate, pantothenic acid, riboflavin, and minerals like potassium, phosphorus, and magnesium. Potatoes also contain antioxidants (Bharali et al., 2016), which may help prevent age-related diseases (FAO, 2008). Therefore, it was attempted to rectify the adverse effects of higher iron using bay leaf, potato peel and banana peel extracts studying the physiological performance of some upland (Ahu) rice crop in presence of higher iron condition in acid soil.

II. MATERIALS AND METHODS

2.1 Experimental site and design:

A pot experiment was carried out in the Plant Stress Physiology Laboratory of Assam Agricultural University (topography: 26°45' N Latitude, 94°12' E Longitude, 87 meters above mean sea level), during March-September of 2024. Four upland (Ahu) cultivars (Inglongkiri, Dehangi (tolerant), Lachit (susceptible), and Luit) were collected from the Assam Rice Research Institute, Titabor and KVK, Diphu. The experiment was laid out in Completely Randomized Block Design (CRBD) with three replications.

2.2 Soil and pot preparation:

The cultivars were planted in pots using a mixture of sand and loam soil. Before sowing the seeds in the pots, the soil was well soaked and combined with farm yard manure in a 50:50 ratio. Twenty-five to 30 days old seedlings were transplanted into the pots. NPK fertilizers were applied @ 60:40:40 kg/ha (10.7 g of muriate of potash (MOP) as a basal application, 80.3 g of single super phosphate (SSP), and 20.9 g of urea (the first dosage of nitrogen). The calculations for the amount of fertilizers required were based on the volume of soil per hectare (e.g., 46 kg N is present in 100 kg Urea, for 1 kg N = 100/46 = 2.17 kg Urea is required, for 30 kg N (first split as basal dose) = 30 × 2.17 kg = 65.1 kg Urea is required. In 1 ha area = 2.24×10^6 kg soil is present. Now, for 720 kg soil (72 pots × 10 kg soil) = [65.1 × 720 kg] / 2.24×10^6 = 20.9 gram of Urea required). Water level (2–3 cm) had been maintained throughout the period from transplanting to a week before harvest. Intercultural operations including weeding and prophylactic measures against insect pests were taken up when necessary.

2.3 Iron solution preparation and application:

Iron solution of 100 ppm strength was prepared using $FeSO_4$ (MW: 151.908 g). As 36.2 g of Fe is present in 100 g of $FeSO_4$, 276 mg of $FeSO_4$ was dissolved in 1000 ml of distilled water to create a 100 ppm solution. Each pot received a basal application of the solutions throughout the rice crop's vegetative state (10 days prior to transplanting). The holes at the bottom of the pots were made leak proof with mud.

2.4 Preparation of plant extracts:

Ripe bananas, matured bay leaves, and harvested potatoes were collected from the neighbourhood market, cleaned, peeled off, and dried at 55°C in a hot air oven. In order to get ready aqueous extracts, 10 g each of dried and ground bay leaf potato, banana peel separately were mingled with 100 ml of distilled water, and then the mixtures were heated to 50°C for 60 minutes in a thermostatic bath. The extracts were cooled, filtered (with a pore size of 0.45 mm) into flasks, and kept in dark at 4°C (Gebre Christos et al., 2020). Prior to transplanting of seedlings to pots, overnight root dip treatments (RDT) with extracts (10% w/v basis) was given to the 30-day-old seedlings (100 seedlings per litter solution), including spray of the extracts (analogous concentration to RDT) of banana, potato, and bay leaf after twenty days after transplanting.

2.5 Treatment Details:

The five treatments were:

- **T1:** 100 ppm $FeSO_4$ as basal at vegetative stage (control)
- **T2:** 100 ppm $FeSO_4$ as basal at vegetative stage + root dip treatment before transplanting + foliar spray with Bay leaf extract (10 g/100 ml) at 20 days after transplanting
- **T3:** 100 ppm $FeSO_4$ as basal at vegetative stage + root dip treatment before transplanting + foliar spray with Banana peel extract (10 g/100 ml) at 20 days after transplanting
- **T4:** 100 ppm $FeSO_4$ as basal at vegetative stage + root dip treatment before transplanting + foliar spray with Potato peel extract (10 g/100 ml) at 20 days after transplanting
- **T5:** Natural soil without root dip treatment and without spray with bay leaf, banana peel, and potato peel extracts at 20 days after transplanting (Absolute control)

2.6 Parameters Recorded:

A digital pH meter was used to measure the soil pH as suggested by Jackson (1973). Morpho-physiological parameters viz., specific leaf weight (SLW: mg cm^{-2}) as suggested by Amanullah, (2015), plant height, shoot biomass (g $plant^{-1}$), number of tillers per plant, number of effective tillers per plant, number of leaves per plant, root biomass at harvest, yield and yield attributing parameters viz., panicle length, panicle weight, panicle number per plant, number of seeds per panicle, 'Test' weight, HD grains and sterility per cent (Provinch, 1967), economic yield, biological yield and harvest index (HI) at harvest were recorded following standard protocol.

2.7 Statistical Analysis:

Data were analyzed using the ANOVA technique following Panse and Sukhatme (1967). The "F" value was calculated and critical difference between a pair of means was compared to the tabulated value at 5% significance level.

III. RESULTS AND DISCUSSION

The indigenous upland Ahu rice genotypes (Inglongkiri, Dehangi, Lachit and Luit) were raised in pots. The soil in the pots was acidic in nature. Even though the soil pH increased by 20.1% at the time of harvest (pH 5.60) of the crop as compared to the initial soil pH (4.93), the acidity remained constant during the course of the experiment. NPK fertilizers @ 60:40:20 kg ha^{-1} as Urea, SSP, and MOP were administered to the soil to correct the deficit of initial N (200.35 kg ha^{-1}), P (33.08 kg ha^{-1}), and K (133.03 kg ha^{-1}) status of the soil (Baruah and Borthakur, 1977). The total exchangeable Iron (Fe^{2+}) level in the soil fluctuated during the stages of crop growth (from initial: 200 ppm to 106 ppm at harvest) which indicated that plants absorbed the iron during growth period. For the growing season (March 2024 – September 2024), the monthly weather and climatic conditions viz., temperature (17.4 - 35.1°C), rainfall (14.8 - 83.6 mm) and BSS (2.4 - 7.2 hours) were favourable for the growth and development of rice crop.

3.1 Specific Leaf Weight (SLW):

The results revealed significant variations of SLW at maximum tillering stage (Table 1a) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the SLW increased by 10.63% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (9.73%) > 100 ppm $FeSO_4$ plus aqueous Potato peel (8.57%) > Natural soil (4.15%). Overall, the SLW decreased in the variety Lachit (13.03%) > Inglongkiri (5.12%) > Luit (3.74%) as compared to the Dehangi (iron tolerant).

TABLE 1
EFFECT OF BAY LEAF, POTATO PEEL, AND BANANA PEEL EXTRACTS ALONG WITH IRON TREATMENTS ON SPECIFIC LEAF WEIGHT (mg cm^{-2})

(a) SLW at maximum tillering stage

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	6.067	6.633	6.7	6.467	6.167	6.407
Dehangi	6.267	7.1	7.067	7	6.533	6.753
Lachit	5.367	6.1	6	6.1	5.8	5.873
Luit	6.1	6.8	6.6	6.467	6.333	6.5
Mean	**5.95**	**6.658**	**6.592**	**6.508**	**6.208**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.05	0.14				
Treatment (T)	0.04	0.12				
V × T	0.1	0.25				

(b) SLW at heading stage:

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	8.067	8.7	8.667	8.533	8.267	8.447
Dehangi	8.267	9.167	9.033	8.567	8.333	8.673
Lachit	6.433	8.067	8.033	8.067	7.033	7.527
Luit	8.133	8.733	8.6	8.533	8.367	8.473
Mean	**7.725**	**8.667**	**8.583**	**8.425**	**8**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.06	0.19				
Treatment (T)	0.06	0.16				
V × T	0.13	0.33				

At the heading stage (Table 1b), the results revealed significant variations of SLW among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the SLW increased by 10.86% at 100 ppm $FeSO_4$ application plus aqueous Bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (9.99%) > 100 ppm $FeSO_4$ plus aqueous potato peel (8.30%) > Natural soil (3.43%). Overall, the SLW decreased in the variety Lachit (13.21%) > Inglongkiri (2.60%) > Luit (2.30%) as compared to the Dehangi.

The bioactive qualities of bay leaf and its high potassium level, which include high phenolic and flavonoid content, essential oils, and antioxidant potential, can improve physiological processes that contribute to higher SLW. Phenols have antioxidant characteristics and can quench free radical reactions (Foti, 2007; Bozin et al., 2008). Potassium is necessary for enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomatal movement, energy transfer, phloem transport, cation-anion balance, and stress tolerance (Marschner, 2012). Lindhauer (1985) found that fine K feeding not only enhanced plant total dry mass and leaf area, but also improved water retention in plant tissues during drought stress. Improved plant K supply can reduce ROS generation under drought stress by inhibiting NADPH oxidase activity while maintaining photosynthetic electron transport (Cakmak, 2005). In addition to K, micronutrients such as Zn, B, Cu, and Mn have been demonstrated to help detoxify oxygen radicals (Marschner et al., 1989).

3.2 Number of tillers and effective tillers:

The results revealed significant variations of number of tillers at maximum tillering stage (Table 2a) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the number of tillers increased by 34.32% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (27.58%) > 100 ppm $FeSO_4$ plus aqueous Potato peel

(23.20%) > Natural soil (10.71%). Overall, the number of tillers decreased in the variety Lachit (29.27%) > Luit (20.35%) > Inglongkiri (13.17%) as compared to the Dehangi.

TABLE 2
EFFECT OF BAY LEAF, POTATO PEEL, AND BANANA PEEL EXTRACTS ALONG WITH IRON TREATMENTS ON NUMBER OF TILLERS AND EFFECTIVE TILLERS

(a) Number of tillers at maximum tillering stage

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	9.4	13.3	11.467	11.333	9.667	11.033
Dehangi	10.8	15.4	13.633	12.6	11.1	12.707
Lachit	6.467	11.267	9.833	9.7	7.667	8.987
Luit	7.2	11.833	11.467	10.467	9.5	10.12
Mean	**8.467**	**12.892**	**11.692**	**11.025**	**9.483**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.18	0.54				
Treatment (T)	0.16	0.47				
V × T	0.37	0.93				

(b) Number of effective tillers at flowering stage

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	7.567	11.7	10.433	9.233	7.733	9.333
Dehangi	9.6	13.267	12.367	12.267	9.933	11.487
Lachit	6.8	10.3	8.633	7.467	7.1	8.06
Luit	7.1	12.967	10.933	10.6	8.667	10.053
Mean	**7.767**	**12.058**	**10.592**	**9.892**	**8.358**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.2	0.58				
Treatment (T)	0.18	0.5				
V × T	0.39	1				

The effective tillers (Table 2b) varied significantly among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the number of tillers increased by 35.58% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous banana peel (26.67%) > 100 ppm $FeSO_4$ plus aqueous potato peel (21.48%) > Natural soil (7.07%). Overall, the number of effective tillers decreased in the variety Lachit (29.83%) > Inglongkiri (18.75%) > Luit (12.48%) as compared to the Dehangi.

The current study on phenolic and potassium-rich plant extracts (bay leaf) shows a considerable improvement in tiller numbers and other growth indices. In plants, phenolic chemicals are necessary for structural support, constitutive and induced protection, and defence against weeds, pathogens, and insects (Jones and Hartley, 1999). The flavonoids and phenolics in bay leaf extracts may increase cytokinin activity, a hormone directly associated to the stimulation of axillary bud expansion, hence boosting the number of tillers. Phenolic molecules have high antioxidant capabilities that assist plants fight oxidative stress. They scavenge reactive oxygen species (ROS) produced by many physiological activities, preventing oxidative damage to cell membranes, proteins, and DNA. Potassium plays a role in intracellular osmotic control and membrane protein transport by activating different enzymes. Furthermore, K aids glucose transport in rice and benefits plant metabolism and stress resistance (Wang and Wu, 2013; Nieves-Cordones et al., 2019).

3.3 Number of leaves and root biomass:

There were significant variations of number of leaves (Table 3a) at maximum tillering stage among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the number of leaves increased by 36.79% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (32.99%) > 100 ppm $FeSO_4$ plus aqueous potato peel (25.39%) > Natural soil (12.18%). Overall, the number of leaves decreased in the variety Lachit (45.06%) > Inglongkiri (30.86%) > Luit (24.01%) as compared to the Dehangi.

Bay leaf promotes vegetative development, which includes leaf formation. Magnesium (Mg) and flavonoids in bay leaf extract promote chlorophyll production, resulting in increased photosynthetic activity. Bay leaves' high polyphenolic and flavonoid contents aid in the detoxification of excess iron from rice leaves, reducing chlorosis and oxidative damage. Phenolics serve a vital function in plant development, particularly in the lignin and pigment production. They also provide structural integrity and scaffolding support to plants. Potassium is essential for photosynthesis, glucose translocation, and metabolism, which ultimately boost crop output and improve grain quality (Pettigrew, 2008; Zörb et al., 2014; Lu et al., 2016). When a plant is lacking in K, both the number and size of its leaves decrease. Similarly, foliar application of potassium oxide in onion has increased plant growth (plant length, number of leaves per plant, and fresh weight of leaves), as well as yield and quality (Xu et al., 2020; Marschner, 2012). Potassium spray boosted leaf potassium concentration while also increasing photosynthesis, photorespiration, and RuBP carboxylase activity. As a result, even in saline conditions, growth improved significantly in the current study (Jabeen and Ahmad, 2011). Similarly, Milford et al. (2007) proposed that K is essential for stomatal opening and closure, as well as plant cell transpiration and photosynthesis.

TABLE 3
EFFECT OF BAY LEAF, POTATO PEEL, AND BANANA PEEL EXTRACTS ALONG WITH IRON TREATMENTS ON NUMBER OF LEAVES AND ROOT BIOMASS

(a) Number of leaves per plant at maximum tillering stage

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	12.667	20	18.733	17.033	14.667	16.62
Dehangi	22.333	26.733	25.767	24	21.367	24.04
Lachit	9.667	17.333	15.333	13.033	10.667	13.207
Luit	10.367	23	22.3	19.7	15.967	18.267
Mean	**13.758**	**21.767**	**20.533**	**18.442**	**15.667**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.43	1.25				
Treatment (T)	0.38	1.09				
V × T	0.85	2.17				

(b) Root biomass (g plant⁻¹) at harvest

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	13.167	22.867	20.7	18.733	15.267	18.147
Dehangi	14.633	24.933	23.2	21.667	17.633	20.413
Lachit	11.567	16.933	15.233	14.133	12.3	14.033
Luit	11.767	19.667	19.367	19.167	15.8	17.153
Mean	**12.783**	**21.1**	**19.625**	**18.425**	**15.25**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.4	1.18				
Treatment (T)	0.36	1.03				
V × T	0.81	2.05				

The results revealed significant variations of root biomass (Table 3b) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the root biomass increased by 39.41% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (34.86%) > 100 ppm $FeSO_4$ plus aqueous Potato peel (30.62%) > Natural soil (16.17%). Overall, the root biomass decreased in the variety Lachit (31.25%) > Luit (15.97%) > Inglongkiri (11.10%) as compared to the Dehangi.

Bay leaf contains bioactive chemicals, nutrients such as potassium, essential oils, and antioxidants, all of which can have a substantial impact on root growth, nutrient uptake, and rice stress tolerance. Bay leaf, when used as a soil supplement, root dip, or extract, increases root biomass, root architecture, and biochemical activity, hence boosting overall plant health and productivity. Phenolics cause redox reactions in soils and preferentially affect the growth of soil microorganisms that populate the rhizosphere. These alter hormonal balance in plants, enzymatic activity, phytonutrient availability, and competition between nearby plants (Hättenschwiler and Vitousek, 2000; Kraus et al., 2003; Northup et al., 1998). Extracts with higher phenolic contents had a higher antioxidant capacity than extracts with lower phenolic contents (Liyana-Pathirana et al., 2006). Stressed rapeseed with adequate K supply not only showed an improved potential for elongating root length, increasing root density, and balancing root-shoot ratio to increase water uptake, but also stimulated organic acid secretion to improve nutrient acquisition and utilization (Xu et al., 2021).

3.4 Panicle length and panicle weight:

The results revealed significant variations of panicle length (Table 4a) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the panicle length increased by 36.50% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous banana peel (31.11%) > 100 ppm $FeSO_4$ plus aqueous potato peel (25.86%) > Natural soil (12.41%). Overall, the panicle length decreased in the variety Lachit (26.28%) > Inglongkiri (11.39%) > Luit (7.52%) as compared to the Dehangi (iron tolerant).

TABLE 4
EFFECT OF BAY LEAF, POTATO PEEL, AND BANANA PEEL EXTRACTS ALONG WITH IRON TREATMENTS ON PANICLE LENGTH AND PANICLE WEIGHT

(a) Panicle length (cm)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	19.4	29.733	28.3	26.6	22.7	25.347
Dehangi	20.433	36.367	32.667	29.967	23.6	28.607
Lachit	17.9	25.667	22.433	20.4	19.033	21.087
Luit	20.133	30.867	29.633	28.067	23.567	26.453
Mean	**19.467**	**30.658**	**28.258**	**26.258**	**22.225**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.59	1.72				
Treatment (T)	0.52	1.49				
V × T	1.17	2.98				

(b) Panicle weight (g plant⁻¹)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	7.8	8.467	8.433	8.367	8.267	8.267
Dehangi	8.233	9.333	9.267	8.967	9	8.96
Lachit	5.733	8	7.933	7.867	6.133	7.133
Luit	7.7	8.267	8.2	8	8.167	8.067
Mean	**7.367**	**8.517**	**8.458**	**8.3**	**7.892**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.16	0.47				
Treatment (T)	0.14	0.41				
V × T	0.32	0.81				

Bay leaves improve panicle development by increasing food intake, regulating hormones, and reducing stress. Bay leaf extracts may increase the availability and uptake of critical nutrients such as nitrogen (N), phosphorus (P), and potassium (K), all of which are essential for panicle development and elongation. Bioactive chemicals found in bay leaf extracts may affect plant hormone levels, particularly gibberellins (GAs) and auxins, which are required for panicle elongation and grain growth. Foliar application of Moringa leaf (high in phenolic compounds) coupled with other plant growth stimulants increases panicle length, 1000-seed weight, and quinoa crop production, which is consistent with previous findings (Rashid et al., 2021). According to Raza et al. (2014), K increased the spike length, number of spikelets per spike, number of grains, and grain production of wheat during dry conditions.

The results revealed significant variations of panicle weight (Table 4b) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the panicle weight percentage increased by 13.50% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (12.90%) > 100 ppm $FeSO_4$ plus aqueous Potato peel (11.24%) > Natural soil (6.65%). Overall, the panicle weight decreased in the variety Lachit (20.39%) > Luit (9.96%) > Inglongkiri (7.73%) as compared to the Dehangi.

Bay leaf extracts promote root function and nutrient absorption, especially nitrogen (N), phosphorus (P), and potassium (K), which are required for panicle development and grain filling. The presence of bioactive chemicals in bay leaf extracts may increase chlorophyll content and photosynthetic efficiency, resulting in increased glucose synthesis and translocation to panicles, hence boosting grain weight. According to Görmüş (2004), using K enhanced boll weight, number of bolls per plant, seed and lint yield in cotton.

3.5 Number of seeds per panicle and 'Test Weight':

The results revealed significant variations of number of seeds per panicle (Table 5a) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the number of seeds per panicle increased by 23.27% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (20.30%) > 100 ppm $FeSO_4$ plus aqueous Potato peel (17.18%) > Natural soil (6.80%). Overall, the number of seeds per panicle decreased in the variety Lachit (19.03%) > Luit (13.04%) > Inglongkiri (9.97%) as compared to the Dehangi.

Bay leaf includes bioactive chemicals, essential oils, and secondary metabolites that can have a considerable impact on rice seed production, grain filling, and total seed quantity. When applied as a soil amendment, foliar spray, or extract, bay leaf improves nutrient assimilation, hormone regulation, and stress tolerance, resulting in more seeds per panicle and higher overall output. Raza et al. (2014) demonstrated that K increased spike length, number of spikelets per spike, number of grains, and grain yield in wheat under drought conditions. Vyas et al. (2008) demonstrated that potassium spraying considerably increased soybean seed yield.

TABLE 5
EFFECT OF BAY LEAF, POTATO PEEL, AND BANANA PEEL EXTRACTS ALONG WITH IRON TREATMENTS ON NUMBER OF SEEDS AND TEST WEIGHT

(a) Number of seeds per panicle

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	69.5	85.1	82.5	78.033	68.9	76.807
Dehangi	81.1	90.867	89.7	87.933	76.967	85.313
Lachit	53.833	79.867	71.767	77.133	62.767	69.073
Luit	57.1	85	84.167	72.667	71.967	74.18
Mean	**65.383**	**85.208**	**82.033**	**78.942**	**70.15**	
	S.Ed(±)	CD(0.05)				
Variety (V)	1.54	4.53				
Treatment (T)	1.38	3.93				
V × T	3.09	7.85				

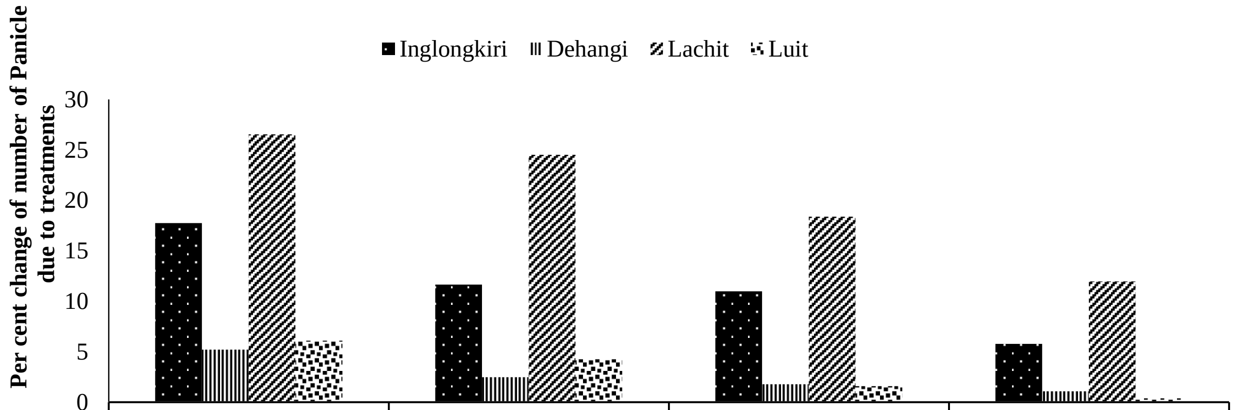
(b) Test weight (g)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	18.233	29.367	26.333	24.767	20.567	23.853
Dehangi	22.433	30.233	30.167	28	23.633	26.893
Lachit	12.667	23.733	22.3	20.033	14.7	18.687
Luit	21.667	26.9	24.5	24.467	23.733	24.253
Mean	**18.75**	**27.558**	**25.825**	**24.317**	**20.658**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.53	1.55				
Treatment (T)	0.47	1.34				
V × T	1.05	2.69				

The results revealed significant variations of test weight (Table 5b) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the test weight percentage increased by 31.96% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous banana peel (27.40%) > 100 ppm $FeSO_4$ plus aqueous potato peel (22.89%) > Natural soil (9.24%). Overall, the test weight decreased in the variety Lachit (30.51%) > Inglongkiri (11.30%) > Luit (9.81%) as compared to the Dehangi. Ahmed et al. (2020) observed that higher K treatment enhanced maize and soybean test weights by 8 and 4%, respectively.

3.6 Panicle number per plant:

The results revealed significant variations of panicle number per plant (Fig. 1) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the panicle number per plant percentage increased by 13.70% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (10.49%) > 100 ppm $FeSO_4$ plus aqueous Potato peel (7.85%) > Natural soil (4.47%). Overall, the panicle number per plant decreased in the variety Lachit (17.20%) > Inglongkiri (9.96%) > Luit (9.17%) as compared to the Dehangi.



Treatments →	100 ppm FeSO4 plus aqueous Bay leaf (10g in 100 ml)	100 ppm FeSO4 plus aqueous Banana peel (10g in 100 ml)	100 ppm FeSO4 plus aqueous Potato peel (10g in 100ml)	Natural soil
Inglongkiri	17.75	11.67	10.98	5.8
Dehangi	5.21	2.5	1.8	1.09
Lachit	26.54	24.5	18.37	11.97
Luit	6.09	4.27	1.6	0.41

FIGURE 1: Changes of panicle number per plant in comparison to control

Bay leaf extracts promote tiller initiation and development by increasing cytokinin levels. Additionally, higher chlorophyll content and improved carbon assimilation lead to more panicles per plant. Raza et al. (2014) found that potassium increased wheat spike length, spikelet number, number of grains, and grain yield. K treatment resulted in a 21.8% rise in spike length, a 23.27% increase in spikelets, a 39.24% increase in grains, and a 30.77% increase in yield as compared to the control.

3.7 High Density (HD) grains and sterility:

The results revealed significant variations of high density grains (Table 6a) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the high density grains increased by 14.8% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous banana peel (11.5%) > 100 ppm $FeSO_4$ plus aqueous potato peel (9.43%) > Natural soil (6.49%). Overall, the HD grains decreased in the variety Lachit (11.61%) > Luit (7.28%) > Inglongkiri (3.06%) as compared to the Dehangi (iron tolerant).

TABLE 6
EFFECT OF BAY LEAF, POTATO PEEL, AND BANANA PEEL EXTRACTS ALONG WITH IRON TREATMENTS ON HIGH DENSITY (HD) GRAINS AND STERILITY

(a) HD grains (%)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	63.467	79.6	77.3	76.267	65.367	72.4
Dehangi	67.367	82.567	80.8	72.833	73.733	75.46
Lachit	57.833	71.567	59.5	63.867	66.467	63.847
Luit	57.433	71.567	74.5	70.867	66.5	68.173
Mean	**61.525**	**76.325**	**73.025**	**70.958**	**68.017**	
	S.Ed(±)	CD(0.05)				
Variety (V)	1.31	3.86				
Treatment (T)	1.17	3.34				
V × T	2.62	6.68				

(b) Sterility (%)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	38.233	21.833	22.233	23.267	26.5	26.413
Dehangi	26.6	18.9	20.033	21.9	24.867	22.46
Lachit	43.6	22.167	23.4	25.233	28.933	28.667
Luit	33.833	21.7	21.9	24.367	28.4	26.04
Mean	**35.567**	**21.15**	**21.892**	**23.692**	**27.175**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.67	1.98				
Treatment (T)	0.6	1.71				
V × T	1.35	3.42				

Bay leaves are high in potassium, polyphenols, and vital minerals, which can help to improve grain filling and solidity. Potassium is essential for photosynthesis, glucose translocation, and metabolism, which ultimately raise crop productivity and grain quality (Pettigrew, 2008; Lu et al., 2016).

The results revealed significant variations of sterility (Table 6b) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the sterility percentage decreased by 14.41% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous Banana peel (13.67%) > 100 ppm $FeSO_4$ plus aqueous Potato peel (11.87%) > Natural soil (8.39%). Overall, the sterility percent increased in the variety Lachit (6.20%) > Inglongkiri (3.95%) > Luit (3.58%) as compared to the Dehangi.

Bay leaves are rich in potassium, antioxidants, and bioactive substances; they may aid in numerous ways by supporting glucose translocation for grain setting, minimizing aborted spikelets and empty grains by enhancing nutrient uptake. The larger level of K helps to transport food material to develop grains, thus minimizing the number of sterile grains. In rice, using K at 100 kg ha^{-1} resulted in lower grain sterility compared to no K application. Islam et al. (2016) found that at 100 kg K ha^{-1}, grain sterility was 22.60%, compared to 30.33% without it.

3.8 Economic yield and biological Yield:

The results revealed significant variations of economic yield (Table 7a) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the economic yield increased by 42.39% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous banana peel (35.86%) > 100 ppm $FeSO_4$ plus aqueous potato peel (27.50%) > Natural soil (9.68%). Overall, the economic yield decreased in the variety Lachit (28.68%) > Inglongkiri (14.78%) > Luit (8.07%) as compared to the Dehangi (iron tolerant). Khan et al. (2007) found that applying 60 kg ha^{-1} K increased yield and yield-contributing characters in both rice and wheat, with wheat yielding 13% more and rice yielding 50% more than the control. It was an idea for producing more food as per the demand of time and space (Kijne et al., 2003).

TABLE 7
EFFECT OF BAY LEAF, POTATO PEEL, AND BANANA PEEL EXTRACTS ALONG WITH IRON TREATMENTS ON ECONOMIC YIELD AND BIOLOGICAL YIELD

(a) Economic yield (g plant⁻¹)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	10.167	17.5	16.367	14.867	11.8	14.14
Dehangi	12.033	22.8	18.867	16.333	12.933	16.593
Lachit	8.533	15.767	13	11.733	10.133	11.833
Luit	11.9	17.933	18.233	15.867	12.333	15.253
Mean	**10.658**	**18.5**	**16.617**	**14.7**	**11.8**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.36	1.05				
Treatment (T)	0.32	0.91				
V × T	0.72	1.83				

(b) Biological yield (g plant⁻¹)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	31.433	46.533	46.1	44.867	38.833	41.553
Dehangi	36	50.567	49.767	48.3	40.4	45.007
Lachit	29.767	40.467	34.233	30.233	29.167	32.773
Luit	34.1	43.1	42.267	40.467	37.767	39.54
Mean	**32.825**	**45.167**	**43.092**	**40.967**	**36.542**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.88	2.59				
Treatment (T)	0.79	2.24				
V × T	1.76	4.48				

The results revealed significant variations in biological yield (Table 7b) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the biological yield percentage increased by 27.33% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous banana peel (23.83%) > 100 ppm $FeSO_4$ plus aqueous potato peel (19.87%) > Natural soil (10.17%). Overall, the biological yield decreased in the variety Lachit (27.18%) > Luit (12.14%) > Inglongkiri (7.67%) as compared to the Dehangi.

Bay leaf extracts may increase chlorophyll levels, resulting in better photosynthesis and biomass build-up. Increased carbon uptake promotes vegetative and reproductive growth. Bay leaf extracts contain bioactive chemicals that encourage cell division and elongation, resulting in greater shoot and root growth and, eventually, increased overall biomass production. Waraich et al. (2011) found that 200 mM KNO_3 application enhanced plant branches, plant height, and the number of bolls per plant in cotton.

3.9 Grain Harvest Index (GHI) and plant height:

The results revealed significant variations in GHI (Table 8a) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the GHI increased by 27.56% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous banana peel (23.97%) > 100 ppm $FeSO_4$ plus aqueous potato peel (19.09%) > Natural soil (9.11%). Overall, the GHI decreased in the variety Lachit (27.38%) > Luit (13.84%) > Inglongkiri (9.38%) as compared to the Dehangi. Reduced assimilate transfer lowers the harvest index, resulting in shrinkage and decreased seed weight, which is similar with the findings of Ashley et al. (1978).

TABLE 8
EFFECT OF BAY LEAF, POTATO PEEL, AND BANANA PEEL EXTRACTS ALONG WITH IRON TREATMENTS ON GRAIN HARVEST INDEX AND PLANT HEIGHT

(a) Grain Harvest Index (%)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	36.133	51.333	46.533	46.867	39.1	43.993
Dehangi	45.4	52	49.5	47.667	48.167	48.547
Lachit	26.967	44.4	42.733	33.5	28.667	35.253
Luit	32.1	46.367	46.167	45.733	38.767	41.827
Mean	**35.15**	**48.525**	**46.233**	**43.442**	**38.675**	
	S.Ed(±)	CD(0.05)				
Variety (V)	1.06	3.12				
Treatment (T)	0.95	2.7				
V × T	2.12	5.4				

(b) Plant height (cm)

Variety	100 ppm $FeSO_4$ (control)	100 ppm $FeSO_4$ + aqueous Bay leaf (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Banana peel (10 g/100 ml)	100 ppm $FeSO_4$ + aqueous Potato peel (10 g/100 ml)	Natural soil	Mean
Inglongkiri	88.733	96.9	93.133	94.8	92.633	93.24
Dehangi	93.667	99.233	98.367	98	95.467	96.947
Lachit	72.733	78.533	76.4	75.367	73.533	75.313
Luit	81.767	92.533	90.9	85.6	88.6	87.88
Mean	**84.225**	**91.8**	**89.7**	**88.442**	**87.558**	
	S.Ed(±)	CD(0.05)				
Variety (V)	0.51	1.5				
Treatment (T)	0.46	1.3				
V × T	1.02	2.6				

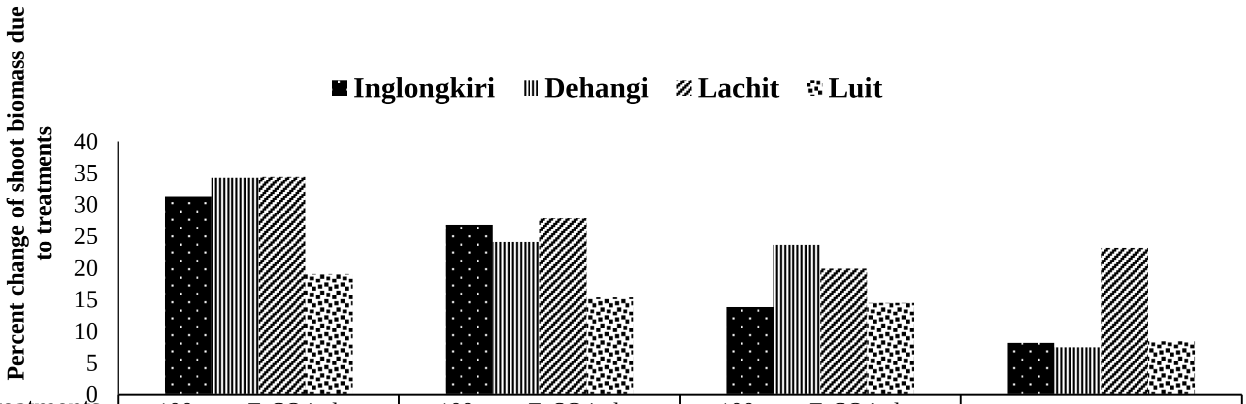
The results revealed significant variations in plant height (Table 8b) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the plant height increased by 8.25% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm $FeSO_4$ plus aqueous banana peel (6.10%) > 100 ppm $FeSO_4$ plus aqueous potato peel (4.77%) > Natural soil (3.81%). Overall, the plant height decreased in the variety Lachit (22.31%) > Luit (9.35%) > Inglongkiri (3.82%) as compared to the Dehangi.

Bay leaves are high in potassium and phenolic compounds such as flavonoids, phenolic acids, tannins (proanthocyanidins), lignands, and essential oils (Alejo-Armijo et al., 2017), all of which can have a positive impact on plant growth parameters such as height. *Salvia officinalis* leaf extract, particularly at the maximum dosage (40 mL/L), significantly enhanced plant height, number of leaves, number of branches, yield, and essential oil percentage, as well as improved leaf anatomical structure (Abbas et al., 2016). Taller plants were observed following foliar spray of Moringa leaf during the first year of normal sowing (Rashid et al., 2021). Zelelew et al. (2016) studied potato (*Solanum tuberosum* L.) growth with five K dosages (0, 75, 150, 225, and 300 kg K_2O ha^{-1}). They discovered that increasing K levels increased plant height, aerial stem number, and leaf number per plant from 0 kg to 150 kg ha^{-1}.

3.10 Shoot Biomass:

The results revealed significant variations of shoot biomass (Fig. 2) among the treatments. As compared to the 100 ppm $FeSO_4$ (control), the shoot biomass increased by 30.08% at 100 ppm $FeSO_4$ application plus aqueous bay leaf > 100 ppm

$FeSO_4$ plus aqueous banana peel (23.56%) > 100 ppm $FeSO_4$ plus aqueous potato peel (18.25%) > Natural soil (11.62%). Overall, the shoot biomass decreased in the variety Lachit (23.09%) > Inglongkiri (14.17%) > Luit (13.96%) as compared to the Dehangi.



Treatments →	100 ppm FeSO4 plus aqueous Bay leaf (10g in 100 ml)	100 ppm FeSO4 plus aqueous Banana peel (10g in 100 ml)	100 ppm FeSO4 plus aqueous Potato peel (10g in 100ml	Natural soil
Inglongkiri	31.29	26.82	13.84	8.16
Dehangi	34.28	24.13	23.66	7.46
Lachit	34.43	27.87	19.95	23.15
Luit	19.05	15.4	14.51	8.4

FIGURE 2: Changes of Shoot biomass in comparison with control at harvest

Bioactive chemicals in bay leaf extracts increase nutrient availability, particularly nitrogen and potassium, which are necessary for shoot development and biomass build-up. Bay leaf extracts stabilize chlorophyll and increase photosynthetic efficiency. This leads to increased energy production, shoot growth, and biomass accumulation. Data from numerous studies and the literature reveal that phenolic compounds exhibit growth-promoting properties as a result of their positive impact on various phases of plant growth and developmental processes, such as seed germination, shoot length, root length, plant biomass, photosynthetic pigments, and plant metabolism (Zaid et al., 2019; Saidi et al., 2021). Exogenous application of Moringa leaf (phenolic-rich) protects crops from harmful environmental effects while also improving plant morphological features (plant fresh and dry biomass) in normal and benign conditions (Yasmeen et al., 2012). K is required for plant nutrition since it is responsible for several physical processes that regulate plant growth, yield, and quality criteria such as flavor and nutritional health (Lester, 2005). According to Cakmak (2005), K is not a major component of plant structure or any organic molecule, but rather plays an important role in optimizing various physiological and biochemical processes involved in yield, quality, and plant growth.

IV. CONCLUSION

Bay leaf played a crucial role in enhancing iron tolerance in rice by significantly improving root proliferation and biomass, which facilitated better nutrient absorption. Additionally, bay leaf positively influenced key physiological parameters, contributing to overall plant health and yield. Among the varieties, Dehangi emerged as the most tolerant to iron toxicity, while Lachit was the most susceptible. The use of bio inputs viz., kitchen waste extracts, particularly bay leaf, offers an eco-friendly and cost-effective approach to mitigating iron stress in acid soils of Assam.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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