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Mitigating Allelopathic Stress in Rice through Seed Treatments, Temperature Management, and Weed Control Strategies.

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Abstract

Rice is a global staple that requires good germination, temperature regulation, and effective weed control to promote growth, productivity, and food security. This study looked at the impact of seed treatments, temperature regimes, and post-emergence herbicides on rice (Oryza sativa L.) germination, growth, and yield. Seeds were treated with hardening, $CaCl_2$, NaCl, and KNO_3 and tested for germination rate, mean germination time (MGT), germination index (GI), and energy of germination. Total phenolic content (TPC) and chlorophyll levels were measured, and growth parameters were recorded at temperatures ranging from 30 to 50°C. Hardening and $CaCl_2$ greatly increased germination and vigor, with 35°C being ideal for seedling growth. Field testing demonstrated that bispyribac sodium offered over 90% weed control, resulting in increased plant height, panicle length, and yield. The combination of seed hardening, temperature optimization, and herbicide use increased rice establishment and productivity.

***Keywords*:** Allelopathy, Rice (Oryza sativa), Seed hardening, Temperature regimes, Weed control efficiency, Germination and growth.

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INTRODUCTION

Allelopathy refers to either the inhibitory or stimulatory effect of one plant on another through the production of chemicals and their release into the environment [1]. Allelopathic influence of weeds as well as its competition for basic requirement of plant decreases the germination and yield of crops. Allelopathy is the secondary metabolisms that are released underfavorable condition into the soil environment by different mechanisms that include soaked seeds in leaf leachates or root exudate from other plants, and some grew seedlings on substrate mixed with residues from other plants. Phytotoxic influence of weeds fluctuates from species to species [2].

Allelochemicals are nature's own herbicides [3] which offer several benefits over the synthetic compounds: (i). There is big diversity in chemical structures of allelochemicals and some of them can serve as lead molecules for the development of herbicides [4]. (ii). Natural compounds are mostly water-soluble and non-halogenated molecules [5] and (iii). Allelochemicals have short half-life than synthetic herbicides and thus are considered safe for environmental toxicology. There is a need to discover new herbicides, as the herbicide-resistant weeds are increasing and conventional synthetic herbicides are becoming less effective against these weed biotypes [6].

Allelochemicals plays an important role in natural and managed ecosystems. Food crop rice Orzya sativa l. can produce and release allelochemicals participating in

its defense against weeds. However, it remains obscure which allelochemicals in rice predominantly involve in defense mechanism against weeds [7]. In this study many types of compounds were systematically isolated and identified from allelopathic rice P1312777 seedling. Among them, alkaloids, alkylresorcinols, cyclohexenone, urea derivatives, flavonoids, phenolics, glucosides, diterpinoids and triterpenoids had inhibitory activities on the growth of Leptochloa Chinensis weed associated with rice [8].

Crop competition is a very useful method of cultural weed control. Production practices that optimize crop growth enable the crop plants to compete effectively with weeds [9]. Crop rotation may also be helpful in maintaining adequate weed control. Many weeds cannot tolerate crop rotation [10].

Annual weeds are easier to kill when they are small seedlings and when conditions favour rapid growth, but, crop plants are also easily injured under these conditions [11]. Selective herbicides should control the weeds with little or no injury to the crop. Timing and rate of herbicide application are very important in chemical weed control. Applying herbicides at the wrong time often results in poor weed control and crop injury [12]. Chemical weed control can be obtained with herbicides applied either preplant incorporated, pre-emergence, or post emergence. Many herbicides can be applied by more than one of these methods [13].

Propanilis a highly selective post-emergence herbicide that is used extensively to control Leptochloa Chinensis and shows great adaptability and is essential component of all type of ecosystems [14]. Propanil, quinchlorac, molinate, fenoxaprop-p-ethyl, benthiocarb [15] and cyhalafop in combination withsethoxydim [16] have been used to control L. chinensis in rice crops. However, propanil has been preferred by the rice farmers for weed control because of its high selectivity. However, a propanil-resistant L. chinensis biotype was first reported in the rice fields

Butachlor is an aromatic amide that is 2-choro-N-(2,6-diethylphenyl) acetamide in which the amide nitrogen has been replaced by a butoxymethyl group. It has a role as herbicide, an environmental contaminant and a xenobiotic [17]. These herbicides are used for pre-emergence control of most annual grasses, certain broadleaf weeds in seeded and transplanted rice [18].

Pretilachlor50% EC (PRETILA GOLD) is a broad-spectrum and selective herbicide. Pretilachlor 50% EC is a pre-emergency herbicide for transplanted rice. It is applied before emergency of weeds, within 0-4 days of transplanting. It controls almost all the weeds (annual grasses, Sedges and broad-leaved weeds) in rice [19]. It has no phytotoxic effect on any variety of rice when used as recommended. Good compatibility for mixtures with other herbicides [20].

Rice production has obstacles such as inadequate germination, temperature stress, and weed competition, which reduce yield. Previous research has addressed these variables independently, but integrated techniques are absent. This study assesses the effectiveness of seed treatments, temperature regimes, and herbicides in improving rice germination, growth, and productivity.

MATERIAL AND METHODS

1 Germination test of rice

Seeds were sown in petri dishes (15 in each) between two layers of moist Whatman.45 filter papers at 27°C in an incubator and were replicated four times for each treatment. Germination was observed daily according to the AOSA method.

The time to get 50% germination (T50) was calculated according to the following formulae:

$$T50 = ti + \frac{\left[\frac{N}{2} - ni\right](tj - ti)}{nj - ni}$$

Where N is the final number of seeds germinating and ni, nj cumulative number of seeds germinated by adjacent counts at times ti and tj when ni< N/2 <nj. Mean germination time (MGT) was calculated according to the equation of Ellis and Roberts:

$$MGT = \frac{\sum Dn}{\sum n}$$

Where n is the number of seeds, which were germinated on day D and D is the number of days counted from the beginning of germination. Germination index (GI) was calculated as described in the Association of Official Seed Analysts as the following formulae:

$$GI = \frac{No.\,of\,germinatedseeds}{Dayoffirstcount} + - - - - + \frac{No.\,of\,germinatedseeds}{Dayoffinalcount}$$

Energy of germination was recorded on the 4th day after planting. It is the percentage of germinating seeds 4 days after planting relative to the total number of seeds tested

2. Sample Collection

Root and shoot of rice for the current research were collected from the local market of Okara, Pakistan. Root of rice was authenticated from Department of Botany, University of Okara, Pakistan.

2.1 Sample Preparation

Root and shoot of rice were cleaned with distilled water and cut into pieces and shade dried for 2 weeks under glasshouse conditions. These dried samples were grinded into a very fine powder. Plant was extracted with methanol, *n*-hexane and distilled water by soaking and shaking the plant materials vigorously at 200rpm for 72hours on an orbital shaker at 25°C. The filteration was performed through two layers of cheesecloth and whatman filter paper. By using rotatory evaporator the filtrate was evaporated at 40°C to crude extract yield. Each crude extract yield were weighted and stored at 4°C until use.

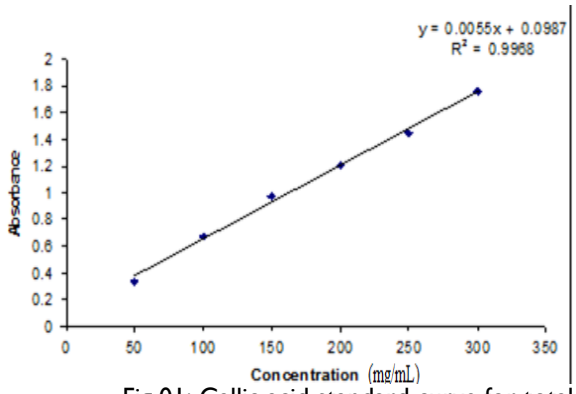

Fig 01: Gallic acid standard curve for total phenolic contents

3. Total phenolic content (TPC)

Folin–Ciocalteau reagent was used for the determination of total phenolics[21]. Extracts of rice plant extracts were made in PBS by homogenizing it in mortar pestle. After that mixture was centrifuged and residues were discarded, and the supernatant separated and filtered to remove particles. Sample 100 µL + 20 µL 10% Folin–Ciocalteu reagent was vortexed for 5 minutes then 800 µL 700 mm Na_2CO_3 was added to the mixture. After standing for 1 hour at room temperature, absorbance was measured at 765 nm, along with blank. The amount of phenolics in the sample was calculated. The total phenolic content is determined as the equivalent standard (GAE) in 100 g per milligram of rice plant extract, and it is formed from gallic acid as the standard solution**Fig.1**. Also used calibration curve in the gallic acid equivalents (GAE), the total content of phenolic (TPC) compounds was determined by the following formula.

T = C x V / M

Where:

T = total contents of phenolic compound in mg GAE/g of rice plant extracts.

C = the concentration of gallic acid calculated from calibration curve in mg/mL.

V = the volume of plant extract in mL.

M = the weight of plant extract in grams.

4. Determination of chlorophyll content

Estimation of chlorophyll content by acetone, methanol, DMSO and ethanol incubation method leaf rice tissue (100mg) were placed in a graduated tube containing 25mL of 80% acetone buffer (80mL of acetone made up to 100mL with 20mL of 2.5mM sodium phosphate buffer, pH 7.8) and the chlorophyll was extracted without grinding and centrifugation, by incubating the leaf tissues into the solvent in a dark place. The contents of tube were shaken occasionally to accelerate the pigment extraction. At the desired period of incubation, the extract liquid was filtered through glass to remove leaf pieces and transferred to another graduated tube. Then the extract liquid was made up to a total volume of 25mL with 80% of acetone buffer. After checking the turbidity of the extracts at 750nm, the chlorophyll content was analyzed by spectrophotometrically in a dual beam recording UV-visible spectrophotometer (Beckman UV-VIS 35, USA) using 3ml sealed quartz-glass cuvettes with a path length of 1cm. The chlorophyll content was calculated following the equation was proposed by Barnes. The chlorophyll content was measured at three hourly intervals till there was a decline in the total content of chlorophyll at two different incubation temperatures of 4^{0C}±2^0C and 36^0C±2^0C at three hourly intervals [22].

5. Determination of root and shoot length, root and shoot fresh and dry weight

In this study experimental treatments were set out in (complete randomized design with 3 replications. A set with total 50 complete randomly selected seed from all varieties were kept in the petri dishes with 13.5 cm in diameter fifty germinator model –PL3 at different temperature as described above. Data were observed for several parameters including shoot length, root length, shoot fresh weight, shoot fresh weight, root dry weight and shoot dry weight. The seed germinated percentage was recorded after 48 hours, while root and plumule length and their fresh and dry weights were observed after 7 days. The physiological indices of root and shoot growth were also determined. The root and the shoot length were measured through measuring scale, while their fresh weights were recorded using electronic balance. The shoot and root samples were kept separately in paper bags and dried in an electric oven maintaining 65°C temperature for 7 days. After drying, the root and shoot dry weights were recorded by an electric balance.

A field study was conducted at three different locations in Adaptive Research Zone, Sheikhupura during the year 2015. The experiment was laid out in a complete randomized block design (RCBD) and replicated three times. The plot size 6 x10.3 m2.was maintained at all the locations and a fine rice variety super basmati was transplanted in 22.5 cm spaced rows and plant to plant.Three different locations were as under:

Location A

Adaptive Research Farm, Sheikhupura.

Location B

Farmer field village, DeraGujranTehsilSafdarabad.

Location C

Farmer's field village GhallaMaharanFerozwattwan Tehsil Sheikhupura

TREATMENTS

The experiment comprised of five treatments including weedy check. The treatments were four different herbicides used as post emergence for weed management in transplanted rice. All the herbicides were sprayed in respective plots with a knapsack hand sprayer using a flood jet nozzle 20days after transplanting on emerged weeds **(Table.1).**

Table 01: Treatments and weed control efficiency.

Treatments	Trade name	Common name	Dose ha^{-1}
T1	Clover 20% WP	bispyribac sodium	200 g
T2	Sun Star Gold 60WG	ethoxysulfuran	50 g
T3	Kelion 50 WG	orthosulfamuron	150 g
T4	Ryzelon 240 SC	Penoxulam	62 ml
T5	Control (weedy check)		

All the phosphatic, potash and one third nitrogenous fertilizers were applied before transplanting while remaining nitrogenous fertilizer was applied in two splits first at 30 days and second at 55 days after transplanting. Data on weed density m-2 pre and post (after 15 and 30 days of applications) application of herbicides, plant height in cm, number of productive tillers m-2, panicle length (cm), number. of grains per panicle, thousand grain weight (g) and paddy yieldwere taken. Weed control efficiency was calculated as described by [23].

Weed control efficiency (WCE) = WDC - WDTX 100 DC

Where WDC = weed density in control plot, WDT = weed density in treated plot Total weed densities per square meter were recorded from each experimental plot. To calculate average plant height, panicle length (cm) and grains per panicle, 10 productive tillers were selected at random from each quadrate. From each experimental plot thousand grains were counted manually and then weight in gram was calculated with the help ofan electric balance. Paddy yield per square meter in gramwas recorded from each experimental plot and converted in to kg ha-1. The data were subjected to analysis of variance technique and the means were separated by the least significant difference test (LSD) at 5% level of probability.

RESULT AND DISCUSSION

Plants found their medicinal and nutritional value since modern times. Among them medicinal plants such as Rice *(Leptochloa Chinensis)* have vital role which cannot falsified. Medicinal plant species were extracted in solvents such as methanol, aqueous solution and *n*-hexane. These extracts were then subjected to tests to check their biological and medicinal properties. These plant extracts were subjected to antioxidant, total phenolic content, total flavonoid content and determination of anthocyanin. The results of all above mentioned activities are discussed in detail as following:

Table 02: Effect of seed treatments on the germination vigor of fine rice.

Treatments	Time to start germination(days)	T_{50} (days)	MGT (Days)	Final germination (%)	GI	GE (%)	Radicle length (mm)	Plumule length (mm)
Control	3.23^{b}	4.45^{a}	4.84^{b}	72.00^{bc}	20.18^{a}	21.66^{a}	45.92^{d}	51.68^{c}
Hardening	1.02^{a}	1.89^{a}	2.44^{b}	90.68^{bc}	56.23^{a}	86.34^{a}	51.53^{a}	51.75^{bc}
CaCl2	2.27^{a}	2.20^{a}	2.61^{b}	85.00^{b}	41.85^{a}	81.69^{ab}	50.14^{a}	44.27^{a}
NaCl	2.05^{a}	2.33^{a}	3.42^{a}	74.00^{b}	43.00^{c}	52.00^{ab}	56.60^{ab}	41.55^{a}
KNO3	3.01^{b}	2.53^{a}	4.32^{a}	61.65^{b}	36.30^{bc}	34.00^{d}	57.75^{ab}	65.44^{ab}
KCl	2.77^{c}	3.48^{c}	3.85^{a}	83.00^{a}	$62..00^{a}$	66.35^{c}	52.18^{c}	49.6^{b}
LSD at 0.05	0.572^{c}	0.459^{c}	0.533^{b}	6.124^{a}	7.217^{bc}	5.945^{d}	$2.251b^{b}$	1.973^{b}

1. **Germination of seeds**

Pre-sowing osmo-hardening and hardening treatments significantly ($P < 0.05$) affected the germination and vigour of both coarse and fine rice seeds. In fine rice, the highest final germination percentage was noted in hardened with a statistically similar germination for the seeds osmohardened with $CaCl_2$ and KCl.

Table 03: Effect of seed treatments on the germination vigor of coarse rice

Treatments	Time to start germination(days)	T_{50} (days)	MGT (Days)	Final germination (%)	GI	GE (%)	Radicle length (mm)	Plumule length (mm)
Control	3.63^{b}	4.17^{c}	4.85^{ab}	90.68^{a}	37.78^{c}	32.00^{a}	25.25^{b}	44.68^{bc}
Hardening	1.04^{b}	2.09^{c}	2.57^{ab}	94.00^{a}	84.45^{c}	88.34^{a}	64.36^{b}	92.88^{ab}
CaCl2	1.27^{c}	1.95^{b}	2.51^{a}	95.35^{b}	86.66^{a}	90.68^{ab}	58.14^{b}	94.57^{b}
NaCl	2.26^{a}	2.05^{b}	2.62^{a}	88.37^{b}	77.92^{a}	81.65^{ab}	56.60^{a}	41.55^{b}
KNO3	2.01^{a}	2.93^{bc}	3.12^{b}	91.00^{c}	66.55^{b}	83.00^{bc}	68.21^{a}	95.35^{c}
KCl	3.27^{a}	3.68^{a}	4.13^{b}	77.35^{c}	$52..35^{d}$	46.35^{c}	57.08^{c}	75.76^{c}
LSD at 0.05	0.730^{b}	0.534^{d}	0.613^{b}	4.324^{b}	4.653^{c}	6.675^{d}	2.223^{c}	5.677^{a}

Germination was reduced in seeds osmohardened with NaCl and KNO_3. All the treatments of fine rice resulted in reduced values for the time to start germination, MGT and T_{50}compared with untreated seeds, indicating more rapid germination after treatment. However, seeds hardened with tap water or $CaCl_2$ showed the lowest values, that is, the most rapid germination.

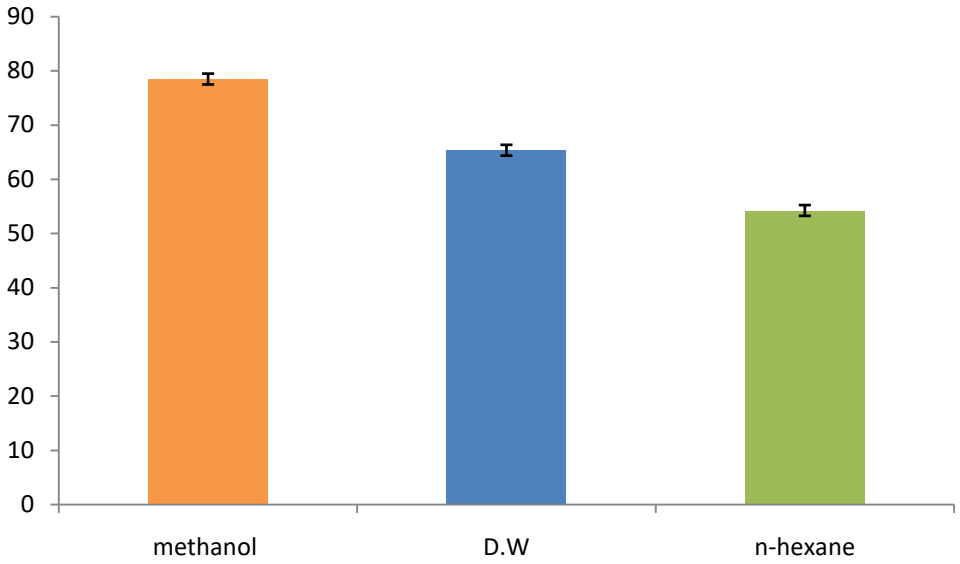

Figure 02: Graphical presentation of total phenolic content of different extracts of rice

The lowest germination index (GI) and energy of germination (GE) were observed in untreated seeds and all the treatments resulted in higher GI and GE. However, maximum GI and GE were noted in simply hardened seeds. $CaCl_2$ hardened seeds showed a similar GE and KCl hardened seeds a similar GI to that of simply hardened seeds. A similar trend was observed in coarse rice to that of fine rice as compared in the Table 02 and 03. All the treatments resulted in lower values of time to start germination; MGT and T_{50}. Again, the most rapid germination and therefore lower values were observed for seeds following hardening and Osmo hardening with $CaCl_2$. Rest of the treatments including control behaved similarly. In contrast to fine rice, the lowest final germination percentage was recorded in seeds Osmo hardened with KCl. The lowest GI and GE were observed in untreated seeds; all the treatments resulted in higher GI and GE. The maximum GI and GE were noted in hardened and $CaCl_2$Osmo hardened seeds.

2. Total phenolic contents (TPC):

The maximum total phenolic contents were observed in methanolic extract that was 78.45 ± 0.18mg/g and least phenolic content observed in *n*-hexane that was 54.21 ± 2.13mg/g. The total phenolic content of rice *Leptochloa Chinensis* extracts was given in **table 4 and figure 2,** respectively. The mutant line enhanced the amount of TPC in the rice straw by 1156.6 g GAE/g DW of the sample. Furthermore, K2 had higher TPC in rice grain (80.3 g GAE/g DW) but lower TPC in husk (405.9 g GAE/g DW) than the original cultivar, but the differences were not significant [24].

3. Determination of chlorophyll content

Chlorophyll extraction at two different temperatures (4^0 and 36^0) showed a maximum around 27hr. The extraction and recovery of total chlorophyll at 4°C was about 10% more than that of 36°C. The recovery of chlorophyll using extracts from solvents like methanol, ethanol with grinding of leaf tissues followed by centrifugation resulted in poor yield of pigments where compared to that of 80% acetone buffer. The maximum chlorophyll content was present in acetone 80% (incubation) and least chlorophyll content was present in methanolic extract represented inTable 05, respectively.

Table 04: Total phenolic content of different extracts of rice

Samples	TPC (mg/g)
Methanol	78.45 ± 0.18[a]
Distilled water	65.32 ± 1.19[a]
n-hexane	54.21 ± 2.13[b]

4. **Determination of shoot length**

The varietal effect suggested that shoot length in Bangelo variety was the highest (4.47cm), followed by DR-83 (4.24cm) and IR-6 (4.18cm). However, lowest shoot length was observed in variety Kangni-27 (2.84cm). The varieties respondingto temperature variably and differences were slight in shoot length (P>0.05) when Bangelo, DR-83-(4.24) and IR-6 (4.18) were compared (Table 01). Among the tested temperature regimes, shoot length variations between 40 and 45oC temperatures werenonsignificant (P>0.05) vs. rest of the temperature treatments. The shoot length was maximum (4.84 cm) under 35oC temperature, whereasseedlings kept under 30oC temperature showedshoot length of

4.00 cm. Moreover, seedlings under 40 and 45oC temperature recorded theshoot length of 3.57 and 3.34 cm, respectively. Seedlings raised in highest tested temperature (50oC) resulted in lowest shoot length of 2.79 cm.

Table 05: Determination of chlorophyll content in rice

Treatments	Chla+b
Acetone 80% (maceration)	1.87
Methanol	1.45
Ethanol	1.74
DMSO	2.23
Acetone 80% (incubation)	2.42

5. Root length

Rice varieties tested in this study were of diversified origin; hence, their response to varying temperature regimes differed significantly from each other, as shown in Table 02.The varietal effect indicated that root length in variety Bangelo was maximum (3.49cm), followed by DR-83 (3.04cm) and Shahkar (2.90cm). Whereas, the lowest root length was observed in variety Sarshar (2.04cm). Maximum root length (3.36cm) was observed under 35°C temperature, while seedlings raised under 30°C temperature ranked 2nd with root length of 2.79 cm. Moreover, seedlings raised under 40°C and 45°C temperature resulted in root length of 2.70 cm and 2.28 cm, respectively.

6. Shoot fresh weight

The analyzed data in Table 1 showed the maximum mean shoot fresh weight of384.39 mg, in Bangelo followed by 338.15 and 352.26 mg in DR-83 and IR-6, respectively. On the other hand, the lowest shoot fresh weight (250.79 mg) was observed in variety Kangni-27.The highest shoot fresh weight of rice seedlings (399.59 mg) was recorded when kept under 35°C temperature, followed by 30°C, 40°C and 45°C temperatures with shoot fresh weight of 348.30, 307.50 and 287.14 mg, respectively. Whereas, highest tested temperature regime (50°C) resulted in lowest shoot fresh weight of 243.66 mg.

7. Root fresh weight

The results (Table 02) showed that the highest root fresh weight (262 mg) was noted in variety Bangelo, followed by DR83 (228.50 mg), Shahkar (217.50 mg), DR 82 (213.50 mg) and DR-92 (202.00 mg). However, the lowest root fresh weight was observed in variety Sarshar (152.50 mg).Root fresh weight of rice was maximum(252.25 g) under 35°C temperature, followed by 30, 40 and 45°C temperatures with root fresh weight of 209.50, 203.00 and 171.00 mg, respectively. Further increase in temperature up to 50°C resulted in the lowest root fresh weight of 157.00 mg.

Table 06: Root fresh weights (mg), shoot fresh weight (mg), root dry weight (mg) of rice cultivars as affected by different temperature regimes.

Temperature	Root length	Shoot length	Root fresh weight (mg)	Shoot dry weight (mg)	Root dry weight (mg)	Shoot fresh weight (mg)
30°C	**4.43^{a}**	**3.36^{a}**	**209.52^{b}**	**21.26^{b}**	**13.16^{b}**	**215.43^{a}**
35°C	**4.38^{a}**	**2.38^{a}**	**252.27^{bc}**	**24.38^{a}**	**15.88^{b}**	**260.29^{a}**
40°C	**2.37^{a}**	**1.39^{a}**	**204.00^{bc}**	**18.77^{c}**	**12.86^{b}**	**208.02^{c}**
45°C	**4.35^{a}**	**1.45^{a}**	**172.00^{b}**	**17.53^{c}**	**10.66^{a}**	**180.90^{b}**
50°C	**4.28^{a}**	**0.75^{a}**	**158.00^{b}**	**14.88^{c}**	**9.87^{c}**	**162.54^{a}**

8. Shoot dry weight

The highest shoot dry weight (23.44 mg) was recorded by variety Bangelo, followed by DR-83 (21.48 mg), IR-6 (20.62 mg), DR82 (19.63 mg) and DR-92 (19.31 mg). The shoot dry weight was lower in varieties Shandar (16.19 mg), Sarshar (18.66 mg) and IR-8 (18.66 mg). Whereas, the lowest shoot dry weight (15.29 mg) was observed in variety Kangni-27.The highest shoot dry weight (24.37 mg) was noted when rice seedlings were kept under 35°C temperature, followed by 30, 40 and 45°C temperatures with shoot dry weight of 21.24, 18.75 and 17.51 mg, respectively.

9. Root dry weight

It is evident from Table 06 that the highest root weight of15.50 mg was noted in variety Bangelo, followed by DR-83 (14.39 mg), Shahkar (13.70 mg), DR-82 (13.45 mg) and DR-92 (12.72 mg). However, the lowest root dry weight was observed in variety Sarshar (9.60 mg). The root dry weight 15.89 mg was increased when seeds were kept under 35oC followed by 30 and 40°C with root dry weight of 13.19 and 12.87 mg; however, shoot dry weight of rice seedlings decreases with increasing the temperature further (50°C).

10. Weed density and weed control efficiency percent

Post treatment data pertaining to weed density as influenced by different herbicides used in transplanted rice showed significant differences at three locations during kharif (summer), 2015. All the treatments significantly suppressed the weed density as compared to weedy check at all the locations (Table 02).The highest number of weeds m-2 (91.00, 67.34 & 56.30)

were recorded in weedy check while the lowest weed population (7.66, 3.67 & 5.60) were recorded in the plot treated with bispyribacsodiumat all the three locations A , B and C respectively (Table 02). Data presented in Table-2 exhibits that weedy check had significantly highest weed density among all treatments. Greatest weed control efficiency (WCE) percentage of different herbicides over weedy check remained 91.58, 94.55 & 90.05 % as obtained from the bispyribac sodium treated plot at all three locations A, B and C respectively (Table-03). [25] Reported that growth of weeds suppressed by the application of herbicides. The findings of our study are also supported with the results of [26] who found that the application of bispyribac sodium at 15-25 DAT could be suitable for complex weed flora in transplanted rice. According to them bispyribac sodium and penoxsulam act as ALS inhibitors retarding the synthesis of branched chain amino acids and suppressed the weed growth.

11. Yield parameters

Data pertaining to growth & yield attributes viz. plant height (cm), panicle length (cm), grains per panicle, thousand grain weight(g) and number of filled gains tillers (productive tillers) (m-2) at all three locations are presented in Table 05**.**

12. Plant height (cm)

The effects of different herbicides on plant height remained at par and showed significant results as compared with weedy check at three locations. Maximum plant heights 114.9, 96.3 &104.8 cm were recorded from the plot treated with bispyribacsodium, while minimum rice plant height (88.9, 92.3 &91.3 cm) was depicted from the weedy check plot at A, B & C locations respectively. It might be due the nutrients uptakes by the weeds that became cause of differences in plant height. [27] reported that nutrients uptake by weeds were 30 kg N, 10 kg P and 17 kg K per hectare in transplanted rice [28]. Reported similar results in their studies. Similarly, Srinivasan and and Palaniappan reported that severe infestation of weeds suppressed the plant height and decreased shoot and grain production.

CONCLUSION

The study evaluated the effects of different seed treatments, temperature regimes, and herbicides on rice germination, growth, and yield. Hardening and $CaCl_2$ treatments significantly enhanced germination rate, vigor, and final germination percentage compared to untreated seeds. Optimal growth, including shoot and root length, fresh and dry weight, was observed at 35°C, while extreme temperatures reduced performance. Bispyribac sodium was most effective in controlling weed density, achieving over 90% weed control efficiency. Improved weed management led to higher plant height, grain yield, and overall crop productivity.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

INFORMED CONSENT

Not Applicable.

ETHICAL STATEMENT

No human or animal studies were performed.

AUTHOR CONTRIBUTION

All Authors contributed equally.

REFERENCES

1. Hierro JL, Callaway RM. The ecological importance of allelopathy. Annu Rev Ecol Evol Syst. 2021;52:25–45.
2. Kalisz S, Kivlin SN, Bialic-Murphy L. Allelopathy is pervasive in invasive plants. Biol Invasions. 2021;23(2):367–371.
3. Farooq M, Khaliq A, Cheema ZA, Cheema S. Application of allelopathy in crop production: success story from Pakistan. In: Cheema ZA, Farooq M, Wahid A, editors. Allelopathy: Current Trends and Future Applications. Berlin: Springer; 2013. p. 113–143.
4. Carocho M, Ferreira ICFR. A review on antioxidants, prooxidants and related controversy: natural and synthetic compounds, screening and analysis methodologies and future perspectives. Food Chem Toxicol. 2013;51:15–25.
5. Morris N, Miller P, Orson J, Froud-Williams R. The adoption of non-inversion tillage systems in the United Kingdom and the agronomic impacts on soil, crops and the environment—A review. Soil Tillage Res. 2010;108(1–2):1–15.
6. Bajwa AA. Sustainable weed management in conservation agriculture. Crop Prot. 2014;65:105–113.
7. Jabran K, Chauhan BS. Weed management in aerobic rice systems. Crop Prot. 2015;78:151–163.
8. Kong C. Allelochemicals involved in rice allelopathy. In: Fujii Y, Hiradate S, editors. Allelopathy: New Concepts and Methodology. Enfield (NH): Science Publishers; 2007. p. 267–281.
9. Rizwan M, Atta B, Rizwan M, Sabir AM, Tahir M, Sabar M, et al. Silicon plays an effective role in integrated pest management against rice leaf folder *Cnaphalocrocis medinalis* (Guenée) (Lepidoptera: Pyralidae). Pak J Zool. 2021;53(6):1–7.
10. Asghar M, Hassan TU, Arshad M, Aziz A, Latif MT, Sabir AM. Effect of plant spacing on incidence of rice planthoppers in transplanted rice crop. Int J Trop Insect Sci. 2021;41(1):575–585.
11. Fatima I, Ahmad M, Vithanage M, Iqbal S. Abstraction of nitrates and phosphates from water by sawdust- and rice husk-derived biochars: their

potential as N- and P-loaded fertilizer for plant productivity in nutrient-deficient soil. J Anal Appl Pyrolysis. 2021;155:105073.
12. Sarwar T, Khan S, Yu X, Amin S, Khan MA, Sarwar A, et al. Analysis of arsenic concentration and its speciation in rice of different markets of Pakistan and its associated health risk. Environ Technol Innov. 2021;21:101252.
13. Tauseef M, Rafique N, Ahmad I, Ishtiaq M, Samad A, Saba S, et al. Analysis of multiple pesticide residues in rice by LC–MS/MS. Chem Pap. 2021;75(6):2871–2879.
14. Ishfaq A, Khalid P. Determinants of agricultural productivity: a case study of Pakistan. Trends Anim Plant Sci. 2025;5:2428.
15. Hakim MA, Juraimi AS, Musa MH, Ismail MR, Rahman MM, Selamat A. Impacts of weed competition on plant characters and the critical period of weed control in rice under saline environment. Aust J Crop Sci. 2013;7(8):1141–1151.
16. Chuah TS, Norhafizah MZ, Ismail S. Phytotoxic effects of extracts and compounds isolated from Napier grass (*Pennisetum purpureum*) on Chinese sprangletop (*Leptochloa chinensis*) germination and seedling growth in aerobic rice systems. Weed Sci. 2014;62(3):457–467.
17. Akbar N, Jabran K, Ali MA. Weed management improves yield and quality of direct-seeded rice. Aust J Crop Sci. 2011;5(6):688–694.
18. Bari MN. Effects of herbicides on weed suppression and rice yield in transplanted wetland rice. Pak J Weed Sci Res. 2010;16(4):349–361.
19. Shultana R, Al-Mamun MA, Rezvi SA, Zahan MS. Performance of some pre-emergence herbicides against weeds in winter rice. Pak J Weed Sci Res. 2011;17(4):389–398.
20. Shahabuddin M, Hossain M, Salim M, Begum M. Efficacy of pretilachlor and oxadiazon on weed control and yield performance of transplant Aman rice. Prog Agric. 2016;27(2):119–127.
21. Othman AZ, Mukhtar NJ, Ismail NS, Chang SK. Phenolics, flavonoids content and antioxidant activities of four Malaysian herbal plants. Int Food Res J. 2014;21(2):759–766.
22. Liu W, Li L, Yu Y, Li Z, Chen L, Liu T. Physiological and transcriptomic responses of attached-cultivated *Arthrospira platensis* to heat stress. J Appl Phycol. 2025;37:1–18.
23. Jehangir IA, Raja W, Hussain A, Sofi NR, Mubarak T, Ahangar MA. Optimizing crop establishment and weed management for enhanced productivity and energy efficiency in rapeseed under North Himalayan temperate conditions. Int J Plant Prod. 2025;19(4):865–875.
24. Tuyen PT, Xuan TD, Khang DT, Ahmad A, Quan NV, Anh TT, Minh TN, Anh LH. Phenolic compositions and antioxidant properties in bark, flower, inner skin, kernel, and leaf extracts of *Castanea crenata* Sieb. et Zucc. Antioxidants. 2017;6(2):31.
25. Abeysekera ASK, Herath HMS, Wickrame UB, Johnson DE. Improving crop establishment and reducing losses from weeds in direct-seeded rice in Sri Lanka. In: Research to Impact: Case Studies for Natural Resource Management for Irrigated Rice in Asia. 2010. p. 151–160.
26. Yadav DB, Yadav A, Punia SS. Evaluation of bispyribac-sodium for weed control in transplanted rice. Indian J Weed Sci. 2009;41(1–2):23–27.
27. Parameswari YS, Srinivas A. Weed management in rice: a review. Int J Appl Pure Sci Agric. 2017;3(1):1–10.
28. Ramesh K, Rao AN, Chauhan BS. Role of crop competition in managing weeds in rice, wheat, and maize in India: a review. Crop Prot. 2017;95:14–21.