



Greener Synthesis and Plant Growth Regulator (PGR) Evaluation of Some Novel Bis-chalcones and Pyrazoles

Prashant P. Chaudhari^{1*} and Shankarsing S. Rajput²

¹Department of Engineering Science, Dr. D Y Patil School of Engineering, Dr. D Y Patil Knowledge City, Charoli (Bk), Lohegaon, Pune (412105), Maharashtra, India.

²Department of Chemistry, SVS's Dadasaheb Rawal College, Dondaicha (425408), Maharashtra, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: Formation, characterization and biological evaluation (PGR: Plant Growth Regulator) of some innovative bis-chalcone and pyrazole moieties from succinimide and glutarimide derivatives.

Study Design: The innovative class of bis-chalcones and pyrazoles were comprehended by reaction of Succinic/Glutaric anhydride derivatives and p-fluro benzaldehyde. All reactants in presence of acetic acid endowed a sequence of bis-chalcones and further, they endure cyclisation with hydrazine hydrate to yield pyrazoles. Microwave irradiation (solvent free) helps to make it better and easier. All the synthesized compounds have been tested as PGR against maize and moong seeds.

Place and Duration of Study: Experimental: Department of Engineering Science, Dr D Y Patil School of Engineering, Dr D Y Patil Knowledge City, Charoli (Bk), Lohegaon, Pune (412105), Characterization: Central Instrumentation Facility, Savitribai Phule Pune University, Ganeshkhind Road, Pune - 411 007 [India] between January 2013 to July 2017.

Methodology: Melting points were recorded in open glass capillaries and were uncorrected. The

*Corresponding author: E-mail: prashantchaudhari83@gmail.com;

chemical structures of the obtained compounds were confirmed by spectral analyses. IR spectra (in KBr pallets) were recorded on Bruker alpha FTIR spectrophotometer. ¹H NMR spectra were recorded on and 500 MHz by Bruker spectrophotometer. Maize (Rajeshwar) and moong (PKVM-8802) were used for PGR testing.

Results: It is precisely that; a novel class of bis-chalcones (I-VI) and pyrazoles (VII-XII) derivatives were synthesized by efficient, succinct methodology. It was unaffectedly and honestly scrutinized and characterized spectral data, physical constants. Also, all the synthesized novel compounds were tested as PGR against maize and moong seeds.

Conclusion: Conspicuous difference is found in the yield of greener methodology than conventional. The Compound III and VII achieved excellent yield via greener path. Also Compound III, VII, IX and XII are found very good plant growth regulator.

Keywords: *Green chemistry; cyclic imides; bis-chalcone; Bis Pyrazole; condensation; Plant Growth Regulator (PGR).*

1. INTRODUCTION

Now, as on today, it is very needy and important to promote Green Chemistry globally. It has been seen and surprising that how disparate answers are given by chemists, pharmacist, biologists, executives and engineers for the simple question "What is Green Chemistry?" As it may be expected considering that individual priorities change based upon a specific needs and many do not accurately know the truthful motivations, drivers, and decisive factors that succor to define Green Chemistry. Thereupon it becomes difficult to make general definition of Green Chemistry. A common impression obtained to define Green Chemistry as it is simple, good and highly efficient for process chemistry [1-3].

Heterocyclic compounds engross nitrogen [4], oxygen and sulphur heteroatom shows the number of functions in different fields because of their definite features. The nitrogen containing heterocyclic compounds integrated remarkably involved in the past studies of heterocyclic chemistry with the growth of synthetic route. Bis-chalcones and cyclic imides perform a significant starring role in the heterocyclic synthesis containing nitrogen groups. Cyclic imides like succinimides [5,6], glutarimides [7] and their malononitriles [8-11] and bis-chalcone [11-15] centered pyrazoles [16-18], pyrimidines [19-22] have shown the defensive analgesic [23], nephrotoxic [24], CNS anxiolytic and anti-depressive [25], anxiety and depression [26], brain metabolism [27], antiviral [28], myeloperoxidase induction [29], anticonvulsant [30], anti-proliferative [31], anti-mutagenic [32], muscle relaxant [33] activities. Especially they have also shown seedling growth [34] activities.

A class of compounds that contains innate plant hormones (phytohormones) and their fabricated

analogs [35] are plant growth regulators. They serve organic molecules that enhance the growth of cultivated plants and are operating in different concentrations [36]. A definite phytohormone can affect a number of pivotal developments occurring in plants through promoting their growth and progression considering a particular process can be controlled by different plant hormones. Generally, the mechanism of action of these molecules is determined by exogenous application [37]. The eight classes of natural plant hormones are abscisic acid, auxins, jasmonic acid, cytokinins, ethylene, brassinosteroids, gibberellins [38] and strigolactones [39]. Phenotypic cache of chemical bibliotheca, including a high-throughput scale, has metamorphose an indispensable weapon to establish novel active compounds in agro chemistry in concern with medicinal chemistry [40,41]. The roadmap is associated with a significant increase in costs because PGR screening is highly time-consuming if the number of substances are examined. In line with this discussion, *Arabidopsis thaliana* can be treated as a most convenient model system because it involves smallest genome among plants which is easy to handle. In order to monitor growth regulation, the more than half of studies explore either plant cell cultures or whole seedlings, where molecules significance target processes. These processes include cell wall biosynthesis [42], cytoskeleton functions [43,44], signaling [45], gravitropism [46], pathogenesis [47], purine biosynthesis [48] and intracellular transport [49,50].

2. MATERIALS AND METHODS

Melting points were recorded in open glass capillaries and were uncorrected. The chemical structures of the obtained compounds were confirmed by spectral analyses. IR spectra in KBr

pallets) were recorded on ATR Brucker alpha FT-IR spectrophotometer. ^1H NMR spectra were recorded on and 500 MHz by Brucker spectrophotometer. The chemical shifts were reported as parts per million (ppm) with $(\text{CH}_3)_4\text{Si}$ (TMS) as an internal standard. Signal multiplicities are represented by: s (singlet), d (doublet), t (triplet), m (multiplet). The purity of compound was checked by thin layer chromatography which was performed by using pre-coated silica gel aluminium plates with mixture of diethyl ether and ethyl acetate 7:3 proportion. Conventional Method: All the compounds (I-XII) were synthesized from the corresponding Succinic/Glutaric Anhydride derivatives; commercially purchased p-fluro benzaldehyde, hydrazine hydrate, glacial acetic acid and ethanol. Green Method: All the compounds (I-XII) were synthesized from the corresponding Succinic/Glutaric Anhydride derivatives; commercially purchased p-fluro benzaldehyde, hydrazine hydrate, and neutral Al_2O_3 .

Material used: In the material method, the 85 mm Dia. X 15 mm Ht., Petri Dish, Sterile, Disposable: procured from Laxbro Manufacturing Company, W-53, MIDC, Bhosari, Pune-411026. Seeds: maize (Rajeshwar), moong (PKVM-8802) were made available from MAHABEEJ: Maharashtra State Seed Corporation Limited, "Mahabeej Bhavan", Gultekdi, Market Yard, Pune -411008 [India]. Whatman Filter Paper No. 1 (Quantitative Circles 125 mm \varnothing). Standard – I: VIM – 95 (Humic Acid 95%, Fulvic Acid, K_2O). Standard – II: BIOZYME Crop+ (Seaweed-Ascophyllum Nodosum Extract, Proteins, Carbohydrates, Inorganic Salts, Other inherent nutrients contained in product of vegetable and animal origin: 22% w/w; Associated manufacturing derivatives, presser-vatives, stabilizers, aqueous diluent: 78% w/w). Standard – III: DMSO.

Concentration of compounds: Stock solution 100 ppm [0.1 gram per litre] of each compound was prepared in DMSO and water. Standard – I solution 100 ppm [0.1 gram per litre] of VIM – 95 was prepared in DMSO and water. Standard – II solution 100 ppm [0.1 gram per litre] of BIOZYME Crop+ was prepared in DMSO and water. Standard – III solution 100 ppm [0.1 gram per litre] was prepared in DMSO and water.

PGR Protocol: Healthy seeds of maize (Rajeshwar), moong (PKVM-8802) are of equal size were selected. Petri Dish (Sterile, Disposable of size 85 mm Dia. X 15 mm Ht.)

were labeled by using appropriate tag. Whatman Filter Paper No. 1 (Quantitative Circles 125 mm \varnothing) was kept inside Petri Dish. Healthy seeds (each maize and moong) of equal size were kept in the Petri Dishes which contain Whatman Filter Paper No. 1.

2.1 General Procedure of Synthesis

2.1.1 Preparation of bis bis-chalcones from N-phenyl Succinimide, N-phenyl Glutaramide derivatives (I-VI)

2.1.1.1 Conventional method (Reflux route: With solvent)

A mixture of N-phenyl Succinimide/N-phenyl Glutaramide derivatives (0.01 mole) and p-fluro benzaldehyde (0.02 mole) in glacial acetic acid (15 ml) was taken into a beaker. The reaction mixture was heated on sand bath for 15 minutes and left overnight at room temperature. The bis-chalcones (as shown in Scheme-Ia and Ib) were separated as colored crystals. The crude product is filtered dried and recrystallizes from ethanol.

2.1.1.2 Green Method (Microwave route: Without solvent)

A mixture of N-phenyl Succinimide/N-phenyl Glutaramide derivatives (0.01 mole) and p-fluro benzaldehyde (0.02 mole) in 1 gm of neutral Al_2O_3 were condensed with the help of microwave irradiations. This mixture is maintained in microwave at 800 W power for 4-6 minutes in solvent free condition. The bis-chalcones (as shown in Scheme-IIa and IIb) were separated as colored crystals. The novel developed compounds were recrystallized from ethanol.

2.1.2 Preparation of pyrazoles from bis bis-chalcones (VII-XII)

2.1.2.1 Conventional method (Reflux route: With solvent)

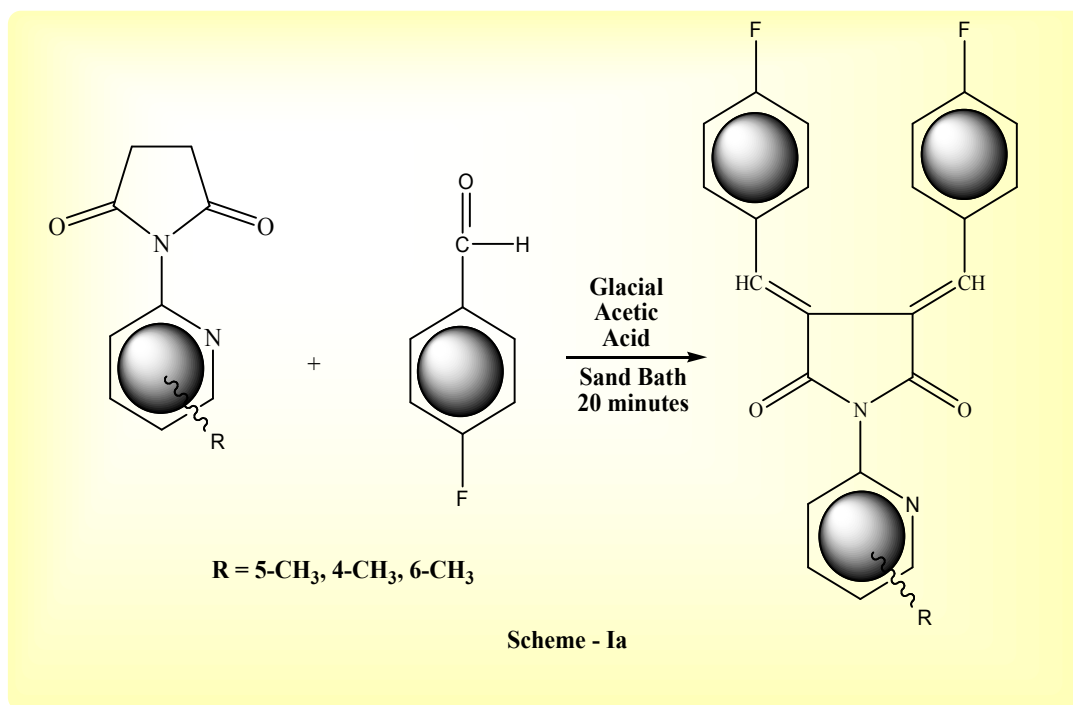
A mixture of bis-chalcone – I-VI (0.01 mole) and hydrazine hydrate (0.02mole) in ethanol (50ml) was refluxed on water bath for 16-18 hrs. It was cooled and poured into ice water. The product (as shown in Scheme – IIIa and IIIb) thus separated was filtered, washed with water dried and recrystallized from ethanol.

2.1.2.2 Green method (Microwave route: Without solvent)

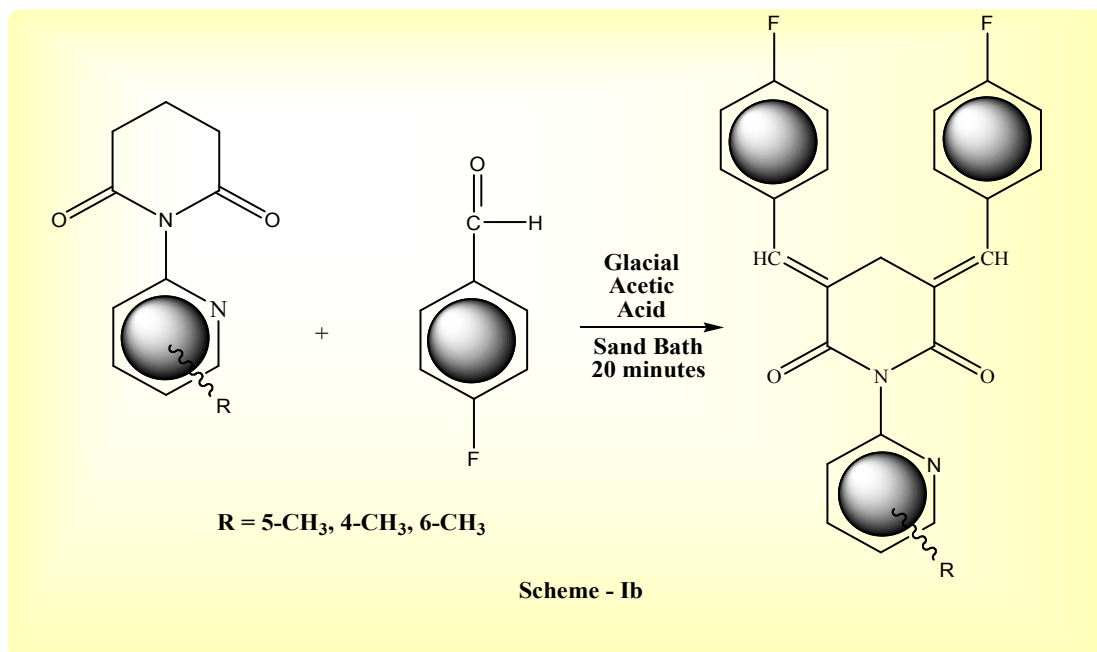
A mixture of bis-chalcone – I-VI (0.01 mole) and hydrazine hydrate (0.02mole) in 1

gm of neutral Al_2O_3 was condensed with the help of microwave irradiations. This mixture is maintained in the microwave at 800 W power for 6-8 minutes in solvent free condition.

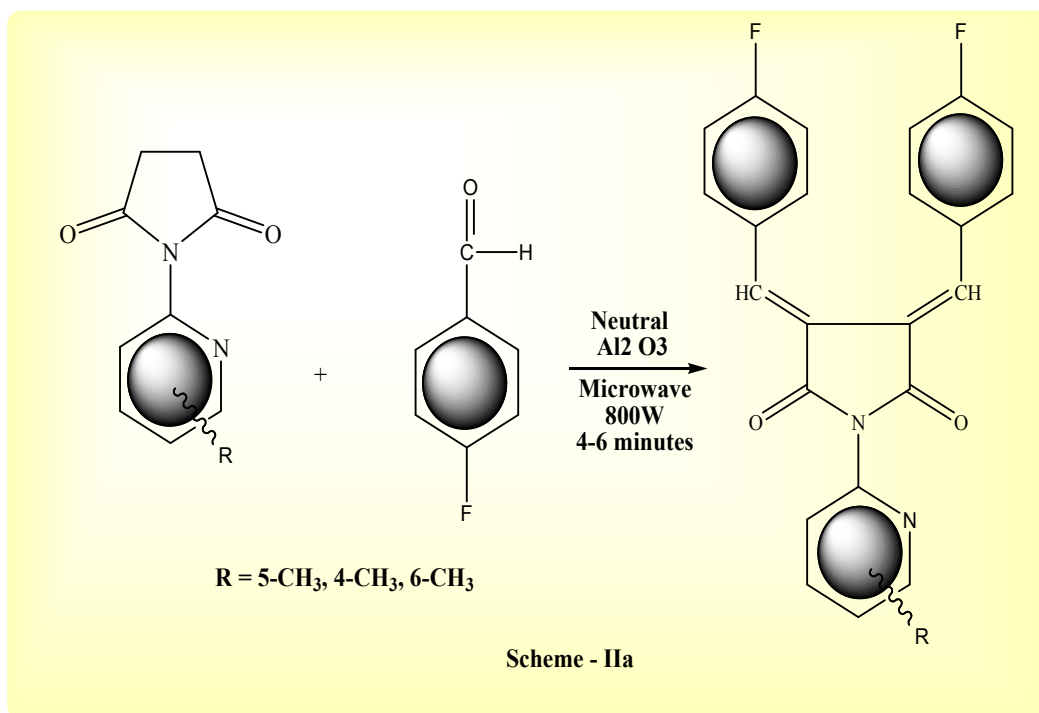
The novel developed compounds (as shown in Scheme-IVa and IVb) were recrystallized from ethanol.



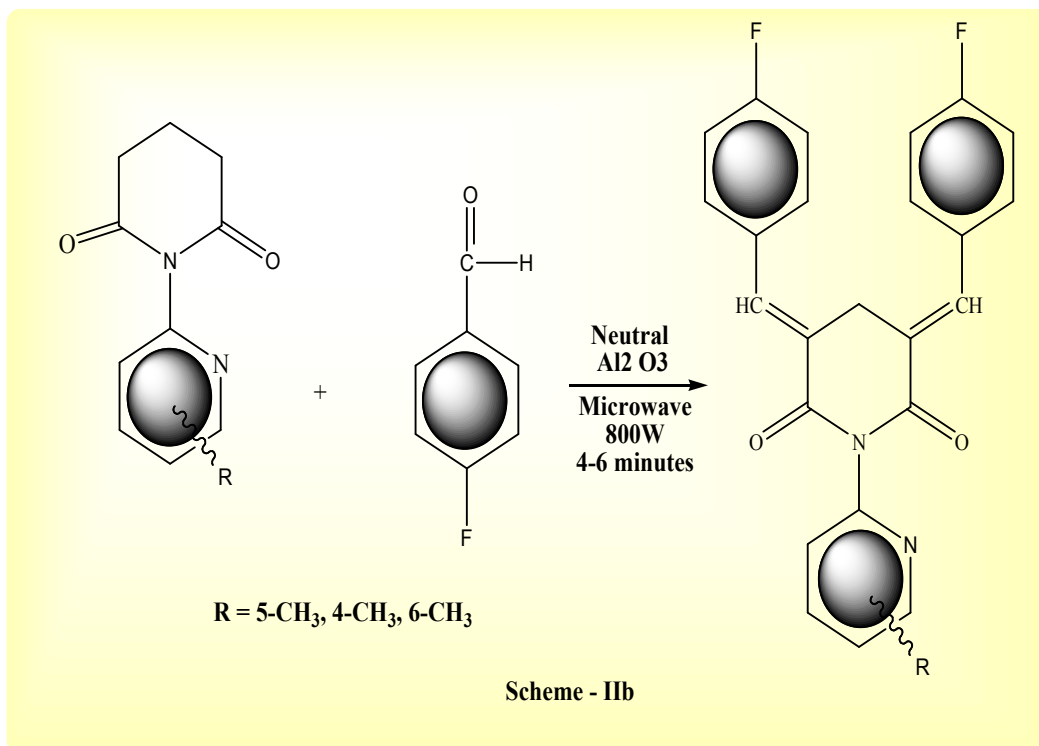
Scheme-Ia



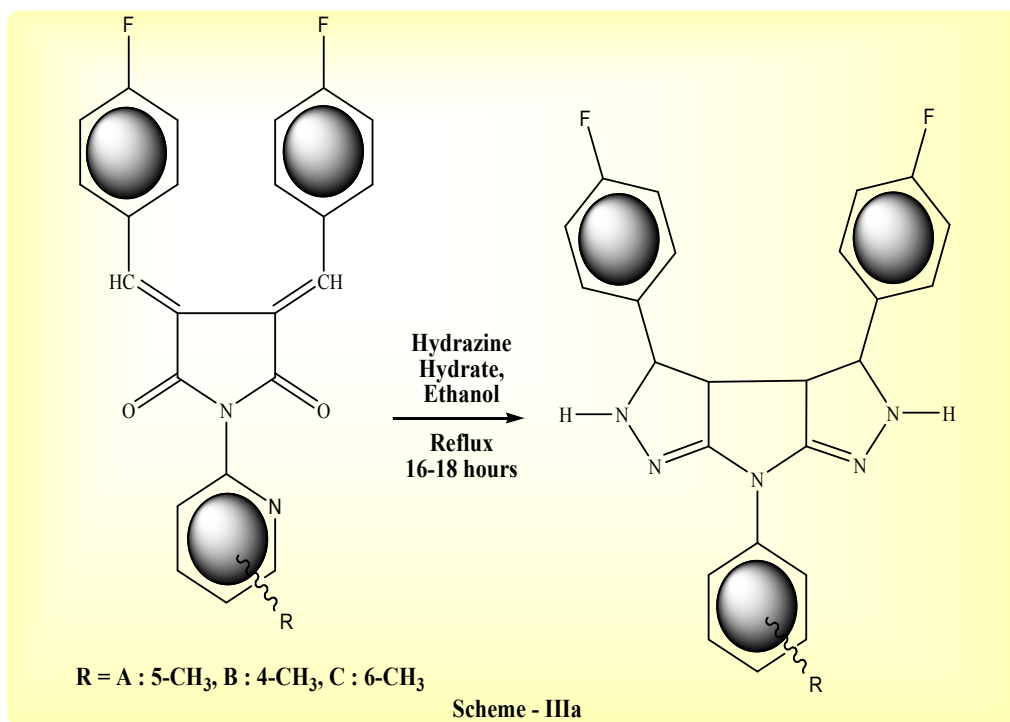
Scheme-Ib



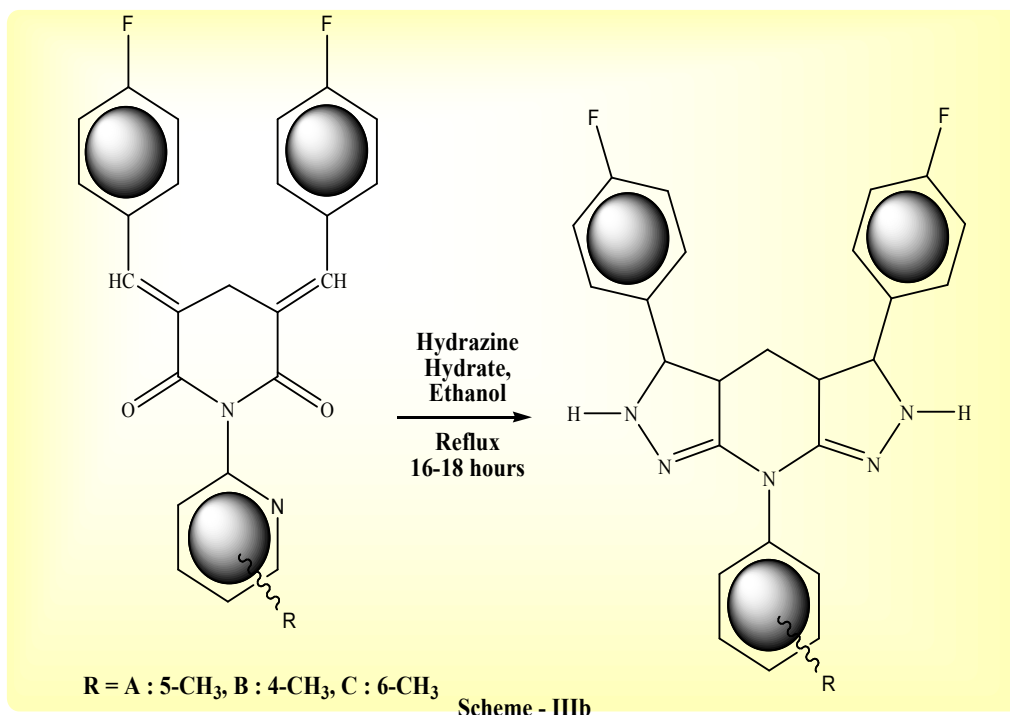
Scheme-IIa



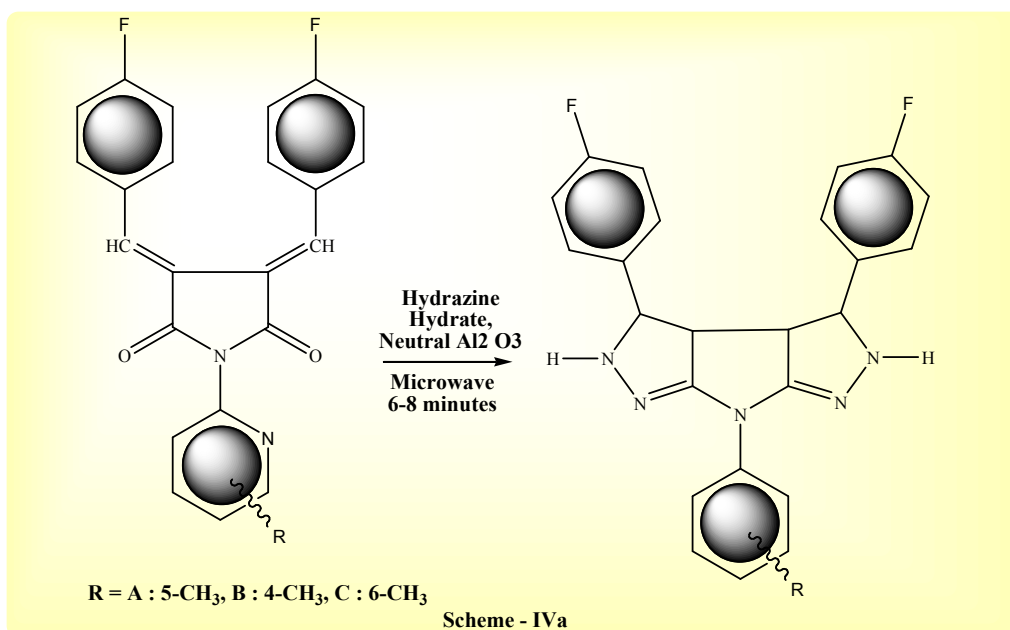
Scheme-IIb



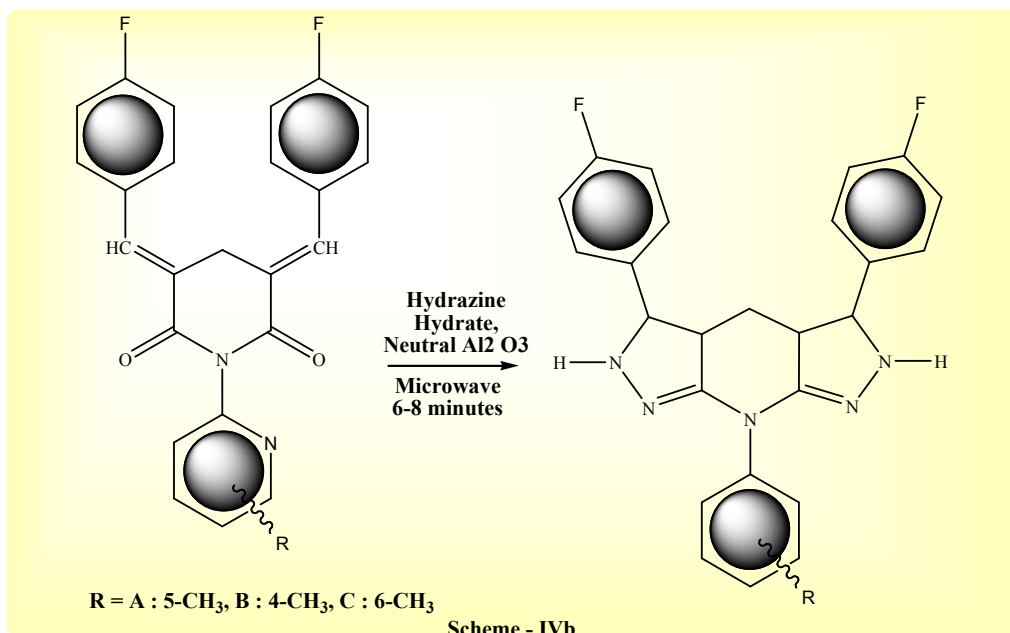
Scheme-IIIa



Scheme-IIIb



Scheme-IVa



Scheme-IVb

3. RESULTS AND DISCUSSION

The novel class of bis-chalcones(I-VI) were prepared by the reaction of n-phenyl succinimide/n-phenyl glutaramide moieties and p-fluro benzaldehyde. Further, bis-chalcones(I-VI) on reaction with substituted

hydrazine hydrate produced a series of pyrazoles(VII-XII). All compounds were synthesized by using conventional as well as greener approach. Major difference of yield is observed in conventional and greener synthesis. In case of bis-chalcone and pyrazole, highest yield is obtained for

Compound – III and Compound – X respectively by greener approach as shown in Chart No. 1.

3.1 Characterization of Compound I-XII

The formations of bis-chalcones (I-VI) and pyrazoles (VII-XII) were confirmed by FTIR, ¹H NMR and elemental analysis.

3.1.1 Physicochemical data of compound I-XII

The physicochemical data of bis-chalcones (I-VI) and pyrazoles (VII-XII) is as under.

3.1.2 Spectral analysis data of compound I-XII

3,4-bis((E)-4-fluorobenzylidene)-1-(5-methylpyridin-2-yl)pyrrolidine-2,5-dione (I)

FTIR (KBr): -C-F: 1176.24; >C=C<: 1685.72; >C=O: 1720.06; aromatic ring (3-Peaks): 3197.21, 3127.93, 790.52; -CH₃: 2799.21; C-N (Aliphatic): 1196.71; C-N (Aromatic): 1327.67; -C-C- Stretch in a ring (2-Peaks): 1570.08, 1530.18; -CH₃ bend: 1425.27, 1397.32 cm⁻¹. ¹H NMR (500.13 MHz, DMSO *d*₆, δ ppm): 7.72 (m, 2H, ethylene), 7.52-8.01 (m, 11H, aromatic), 2.18 (s, 3H, CH₃-pyridine).

Table 1. Physicochemical data of Compound I-XII

Comp No.	Nature/Color	% of Yield		M.P.	M.F.	M.W.	Composition
		With solvent	Without solvent				
I	Zinc yellow solid	64.22%	85.53%	280-82°C	C ₂₄ H ₁₆ O ₂ N ₂ F ₂	402.39	C (70.72%) H (4.16%) N (6.96%)
II	Melon Yellow Solid	66.41%	83.25%	284-86°C	C ₂₄ H ₁₆ O ₂ N ₂ F ₂	402.39	C (70.89%) H (4.37%) N (6.48%)
III	Reseda Green Solid	70.75%	91.10%	184-86°C	C ₂₄ H ₁₆ O ₂ N ₂ F ₂	402.39	C (71.03%) H (4.47%) N (6.38%)
IV	Ivory Solid	67.84%	90.31%	246-48°C	C ₂₅ H ₁₈ O ₂ N ₂ F ₂	416.41	C (71.89%) H (4.95%) N (6.02%)
V	Khaki grey solid	63.19%	80.58%	304-06°C	C ₂₅ H ₁₈ O ₂ N ₂ F ₂	416.41	C (72.77%) H (4.79%) N (6.16%)
VI	Ochre brown solid	68.57%	87.31%	218-20°C	C ₂₅ H ₁₈ O ₂ N ₂ F ₂	416.41	C (72.83%) H (4.79%) N (6.21%)
VII	Saffron yellow solid	52.75%	87.68%	314-16°C	C ₂₄ H ₂₀ N ₆ F ₂	430.45	C (66.10%) H (4.27%) N (19.17%)
VIII	Yellow orange solid	55.48%	77.52%	308-10°C	C ₂₄ H ₂₀ N ₆ F ₂	430.45	C (66.09%) H (4.18%) N (19.05%)
IX	Sulfur yellow solid	51.85%	63.62%	288-90°C	C ₂₄ H ₂₀ N ₆ F ₂	430.45	C (66.16%) H (4.30%) N (19.95%)
X	Ivory solid	54.14%	87.83%	296-98°C	C ₂₅ H ₂₂ N ₆ F ₂	444.47	C (67.02%) H (4.27%) N (19.05%)
XI	Saffron yellow solid	56.84%	85.84%	314-16°C	C ₂₅ H ₂₂ N ₆ F ₂	444.47	C (67.13%) H (4.38%) N (18.07%)
XII	Saffron yellow solid	53.58%	69.38%	286-88°C	C ₂₅ H ₂₂ N ₆ F ₂	444.47	C (67.18%) H (4.19%) N (18.11%)

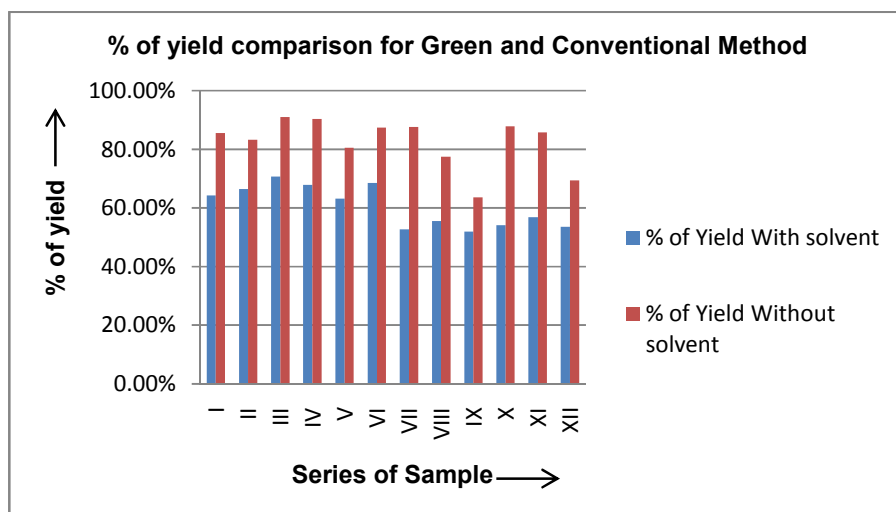


Chart 1. % of yield comparison for green and conventional method

3,4-bis((E)-4-fluorobenzylidene)-1-(4-methylpyridin-2-yl)pyrrolidine-2,5-dione (II)

FTIR (KBr): -C-F: 1172.06; >C=C<: 1678.16; >C=O: 1728.92; aromatic ring (3-Peaks): 3084.82, 3010.07, 800.78; -CH₃: 2789.83; C-N (Aliphatic): 1211.80; C-N (Aromatic): 1307.67; -C-C- Stretch in a ring (2-Peaks): 1678.77, 1535.27; -CH₃ bend: 1487.35, 1307.93 cm⁻¹. ¹H NMR (500.13 MHz, DMSO d₆, δ ppm): 7.83 (m, 2H, ethylene), 7.41-7.98 (m, 11H, aromatic), 2.20 (s, 3H, CH₃-pyridine).

3,4-bis((E)-4-fluorobenzylidene)-1-(6-methylpyridin-2-yl)pyrrolidine-2,5-dione (III)

FTIR (KBr): -C-F: 1167.85; >C=C<: 1672.24; >C=O: 1732.44; aromatic ring (3-Peaks): 3089.54, 3015.17, 810.74; -CH₃: 2779.47; C-N (Aliphatic): 1217.25; C-N (Aromatic): 1317.94; -C-C- Stretch in a ring (2-Peaks): 1557.28, 1531.47; -CH₃ bend: 1440.46, 1370.95 cm⁻¹. ¹H NMR (500.13 MHz, DMSO d₆, δ ppm): 7.86 (m, 2H, ethylene), 6.86-7.76 (m, 11H, aromatic), 2.49 (s, 3H, CH₃-pyridine).

3,5-bis((E)-4-fluorobenzylidene)-1-(5-methylpyridin-2-yl)piperidine-2,6-dione (IV)

FTIR (KBr): -C-F: 1165.29; >C=C<: 1670.87; >C=O: 1701.38; aromatic ring (3-Peaks): 3190.27, 3107.08, 792.29; -CH₃: 2979.55; -CH₂: 2935.23; C-N (Aliphatic): 1193.07; C-N (Aromatic): 1301.95; -C-C- Stretch in a ring (2-Peaks): 1575.84, 1402.46; -CH₃ bend: 1446.79, 1389.21; -CH₂ bend: 1460.35 cm⁻¹. ¹H NMR (500.13 MHz, DMSO d₆, δ ppm): 7.73 (m, 2H,

ethylene), 2.72 (d, 2H, methylene), 7.22-7.54 (m, 11H, aromatic), 2.30 (s, 3H, CH₃-pyridine).

3,5-bis((E)-4-fluorobenzylidene)-1-(4-methylpyridin-2-yl)piperidine-2,6-dione (V)

FTIR (KBr): -C-F: 1161.71; >C=C<: 1572.80; >C=O: 1740.08; aromatic ring (3-Peaks): 3010.01, 3106.18, 818.91; -CH₃: 2969.40; -CH₂: 2946.54; C-N (Aliphatic): 1223.00; C-N (Aromatic): 1297.51; -C-C- Stretch in a ring (2-Peaks): 1572.80, 1405.65; -CH₃ bend: 1508.00, 1369.24; -CH₂ bend: 1420.53 cm⁻¹. ¹H NMR (500.13 MHz, DMSO d₆, δ ppm): 7.32 (m, 2H, ethylene), 2.63 (d, 2H, methylene), 7.26-7.94 (m, 11H, aromatic), 2.30 (s, 3H, CH₃-pyridine).

3,5-bis((E)-4-fluorobenzylidene)-1-(6-methylpyridin-2-yl)piperidine-2,6-dione (VI)

FTIR (KBr): -C-F: 1157.53; >C=C<: 1664.26; >C=O: 1744.91; aromatic ring (3-Peaks): 3040.87, 2997.25, 815.18; -CH₃: 2959.26; -CH₂: 2950.24; C-N (Aliphatic): 1230.51; C-N (Aromatic): 1311.09; -C-C- Stretch in a ring (2-Peaks): 1535.85, 1403.22; -CH₃ bend: 1427.67, 1379.35; -CH₂ bend: 1432.46 cm⁻¹. ¹H NMR (500.13 MHz, DMSO d₆, δ ppm): 7.34 (m, 2H, ethylene), 2.62 (d, 2H, methylene), 7.38-7.75 (m, 11H, aromatic), 2.51 (s, 3H, CH₃-pyridine).

3,4-bis(4-fluorophenyl)-7-(5-methylpyridin-2-yl)-3,3a,3b,4,5,7-hexahydro-2H-pyrrolo[2,3-c:5,4-c']dipyrazole (VII)

FTIR (KBr): -C-F: 1175.25; -N-H: 3415.43; >C=N: 1670.23; aromatic ring (2-Peaks): 3032.71, 838.48; -CH₃: 2947.17; C-N (Aliphatic): 1220.80;

C-N (Aromatic): 1290.73; -C-C- Stretch in a ring (2-Peaks): 1610.41, 1564.22; -CH₃ bend: 1445.72, 1370.65 cm⁻¹. ¹H NMR (500.13 MHz, DMSO *d*₆, δ ppm): 2.17 (t, 2H, Methine), 3.08 (d, 2H, Methine), 9.95 (s, 2H,-N-H), 6.57-7.95 (m, 11H, aromatic), 2.28 (s, 3H, CH₃-pyridine).

3,4-bis(4-fluorophenyl)-7-(4-methylpyridin-2-yl)-3,3a,3b,4,5,7-hexahydro-2H-pyrrolo[2,3-c:5,4-c']dipyrzole (VIII)

FTIR (KBr): -C-F: 1169.33; -N-H: 3262.53; >C=N: 1679.69; aromatic ring (2-Peaks): 3026.78, 815.57; -CH₃: 2927.37; C-N (Aliphatic): 1224.43; C-N (Aromatic): 1297.14; -C-C- Stretch in a ring (2-Peaks): 1616.95, 1599.49; -CH₃ bend: 1461.58, 1331.88 cm⁻¹. ¹H NMR (500.13 MHz, DMSO *d*₆, δ ppm): 2.26 (t, 2H, Methine), 3.80 (d, 2H, Methine), 9.88 (s, 2H,-N-H), 6.77-7.86 (m, 11H, aromatic), 2.32 (s, 3H, CH₃-pyridine).

3,4-bis(4-fluorophenyl)-7-(6-methylpyridin-2-yl)-3,3a,3b,4,5,7-hexahydro-2H-pyrrolo[2,3-c:5,4-c']dipyrzole (IX)

FTIR (KBr): -C-F: 1153.58; -N-H: 3452.61; >C=N: 1628.10; aromatic ring (2-Peaks): 3014.92, 826.06; -CH₃: 2967.66; C-N (Aliphatic): 1222.93; C-N (Aromatic): 1293.15; -C-C- Stretch in a ring (2-Peaks): 1599.49, 1504.48; -CH₃ bend: 1448.58, 1368.54 cm⁻¹. ¹H NMR (500.13 MHz, DMSO *d*₆, δ ppm): 2.21 (t, 2H, Methine), 3.09 (d, 2H, Methine), 9.95 (s, 2H,-N-H), 6.30-7.39 (m, 11H, aromatic), 2.37 (s, 3H, CH₃-pyridine).

3,5-bis(4-fluorophenyl)-8-(5-methylpyridin-2-yl)-2,3,3a,4,4a,5,6,8-octahydrodipyrzolo[3,4-b:4',3'-e]pyridine (X)

FTIR (KBr): -C-F:1154.87; -N-H: 3449.78; >C=N: 1645.90; aromatic ring (2-Peaks): 3016.62, 836.18; -CH₃: 2970.00; -CH₂: 2927.26; C-N (Aliphatic): 1154.87; C-N (Aromatic): 1223.92; -C-C- Stretch in a ring (2-Peaks): 1547.06, 1519.54; -CH₃ bend: 1426.82, 1368.39; -CH₂ bend: 1509.44 cm⁻¹. ¹H NMR (500.13 MHz, DMSO *d*₆, δ ppm): 2.29 (m, 2H, methine), 3.08 (m, 2H, methine), 1.89 (m, 2H, methylene), 9.92 (s, 2H,-N-H), 6.55-7.94 (m, 11H, aromatic), 2.16 (s, 3H, CH₃-pyridine).

3,5-bis(4-fluorophenyl)-8-(4-methylpyridin-2-yl)-2,3,3a,4,4a,5,6,8-octahydrodipyrzolo[3,4-b:4',3'-e]pyridine (XI)

FTIR (KBr): -C-F:1190.04; -N-H: 3096.18; >C=N: 1654.41; aromatic ring (2-Peaks): 3032.03, 830.27; -CH₃: 2925.21; -CH₂: 2925.20; C-N

(Aliphatic): 1288.00; C-N (Aromatic): 1265.70; -C-C- Stretch in a ring(2-Peaks): 1579.89, 1548.96; -CH₃ bend: 1406.53, 1371.65; -CH₂ bend: 1487.49 cm⁻¹. ¹H NMR (500.13 MHz, DMSO *d*₆, δ ppm): 2.26 (m, 2H, methine), 3.42 (m, 2H, methine), 1.72 (m, 2H, methylene), 9.95 (s, 2H,-N-H), 6.54-7.29 (m, 11H, aromatic), 2.29 (s, 3H, CH₃-pyridine).

3,5-bis(4-fluorophenyl)-8-(6-methylpyridin-2-yl)-2,3,3a,4,4a,5,6,8-octahydrodipyrzolo[3,4-b:4',3'-e]pyridine (XII)

FTIR (KBr): -C-F:1156.22; -N-H: 3314.64; >C=N: 1646.90; aromatic ring (2-Peaks): 3199.74, 837.59; -CH₃: 3015.19; -CH₃: 2967.54; C-N (Aliphatic): 1156.22; C-N (Aromatic): 1222.37; -C-C- Stretch in a ring(2-Peaks): 1599.69, 1560.64; -CH₃ bend: 1455.99, 1368.34; -CH₂ bend: 1506.67 cm⁻¹. ¹H NMR (500.13 MHz, DMSO *d*₆, δ ppm): 2.24 (m, 2H, methine), 3.77 (m, 2H, methine), 1.88 (m, 2H, methylene), 9.91 (s, 2H,-N-H), 6.30-7.39 (m, 11H, aromatic), 2.37 (s, 3H, CH₃-pyridine).

3.1.3 PGR testing of compound I-XII

All the novel class of bis-chalcones (I-VI), pyrazoles (VII-XII) and Standard I, II, III were tested for their plant growth activity versus maize (Rajeshwar) and moong (PKVM-8802) by using DMSO as solvent. They were tested for root length, shoot length and weight of root before and after heating (at 50°C).

After 3 days: Compound No VIII and Compound No III, IV, XII are found effective for the root of maize and moong respectively. Also, Compound No VI-VIII and Compound No IX are shown synergetic activities for the shoot of maize and moong respectively.

After 6 days: Compound No IV, VI, VIII, X and Compound No VI are located efficiently for the root of maize and moong respectively. Also, Compound No X and Compound No VI, IX, XII are exposed paramount activities for the shoot of maize and moong respectively.

After 9 days: Compound No IV and Compound No III, VI, IX is established preminent for the root of maize and moong respectively. Also, Compound No X and Compound No VI, IX, XII are revealed most excellent activities for the shoot of maize and moong respectively. The weight of root (before heating) is observed

excellent because of Compound No VIII and Compound No VI-VIII, X, XI for maize and moong respectively. Weight of root (after heating) is exhibited admirable because of Compound No V, VIII and Compound No VI – VIII, X, XI than Standard – I, II, III for maize and moong respectively.

Table 2. Root/shoot length (in mm) after 3 days

Sample	Root length (in mm)		Shoot length (in mm)	
	Maize	Moong	Maize	Moong
I	3	0	7	2
II	5	0	5	3
III	6	6	4	11
IV	9	2	8	13
V	5	0	5	3
VI	7	7	19	15
VII	8	0	18	3
VIII	11	3	15	7
IX	3	7	8	22
X	6	3	13	9
XI	4	0	9	8
XII	5	5	7	13
Standard-I	10	3	14	11
Standard-II	11	2	15	16
Standard-III	9	4	12	10

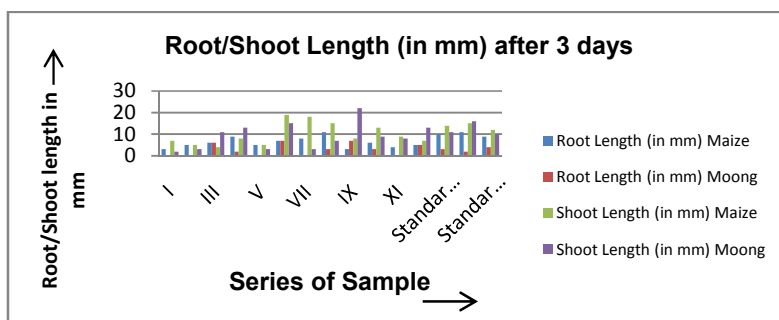


Chart 2. Root/shoot length (in mm) after 3 days

Table 3. Root/shoot length (in mm) after 6 days

Sample	Root length (in mm)		Shoot length (in mm)	
	Maize	Moong	Maize	Moong
I	12	2	13	9
II	11	2	17	8
III	10	10	18	28
IV	24	5	23	25
V	14	3	14	9
VI	15	13	32	29
VII	12	3	29	14
VIII	23	5	24	16
IX	7	11	19	39
X	15	5	33	18
XI	12	3	17	16
XII	11	9	15	29
Standard-I	12	6	34	20
Standard-II	15	8	39	29
Standard-III	11	12	30	22

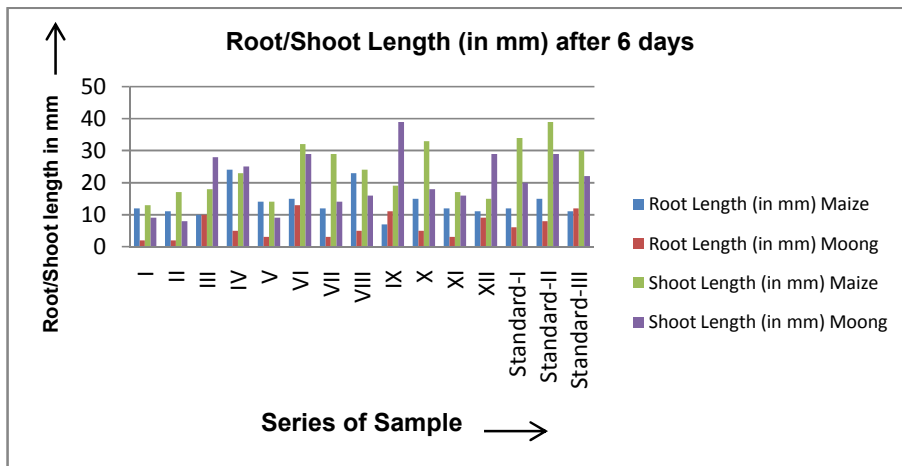


Chart 3. Root/shoot length (in mm) after 6 days

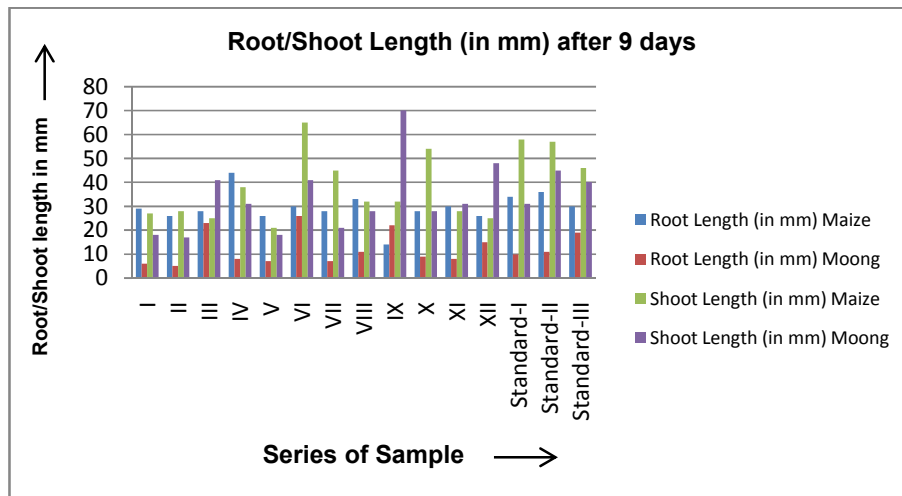


Chart 4. Root/shoot length (in mm) after 9 days
Table 4. Root/shoot length (in mm) after 9 days

Sample	Root length (in mm)		Shoot length (in mm)	
	Maize	Moong	Maize	Moong
I	29	6	27	18
II	26	5	28	17
III	28	23	25	41
IV	44	8	38	31
V	26	7	21	18
VI	30	26	65	41
VII	28	7	45	21
VIII	33	11	32	28
IX	14	22	32	70
X	28	9	54	28
XI	30	8	28	31
XII	26	15	25	48
Standard-I	34	10	58	31
Standard-II	36	11	57	45
Standard-III	30	19	46	40

Table 5. Weight of root (in gm) before and after heating (after 9 days)

Sample	Before heating		After heating	
	Maize	Moong	Maize	Moong
I	0.032	0.051	0.025	0.035
II	0.033	0.069	0.025	0.048
III	0.028	0.067	0.021	0.047
IV	0.031	0.041	0.024	0.028
V	0.035	0.043	0.026	0.030
VI	0.037	0.077	0.028	0.052
VII	0.025	0.039	0.019	0.027
VIII	0.029	0.063	0.022	0.043
IX	0.021	0.081	0.016	0.053
X	0.023	0.076	0.017	0.052
XI	0.025	0.058	0.019	0.040
XII	0.024	0.062	0.018	0.043
Standard-I	0.03	0.089	0.023	0.057
Standard-II	0.028	0.087	0.021	0.056
Standard-III	0.025	0.068	0.019	0.048

#Observations are made after 6 hrs during 24 hrs for 9 days

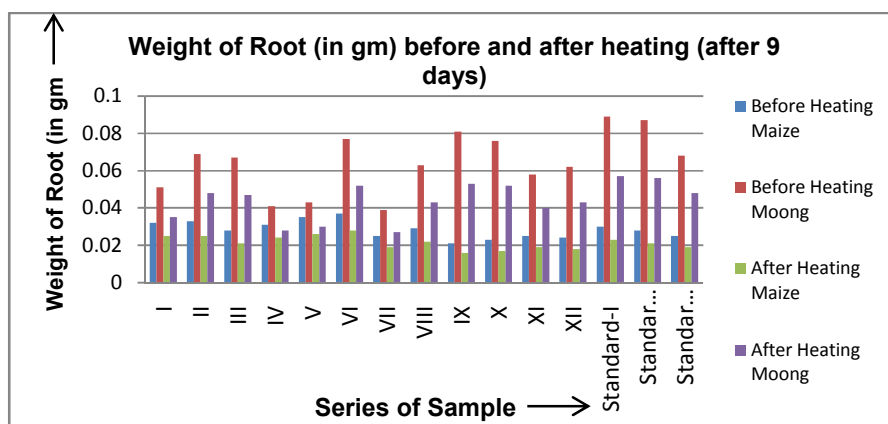


Chart 5. Weight of root (in gm) before and after heating (after 9 days)

Table 6. Weight of shoot (in gm) before and after heating (after 9 days)

Sample	Before heating		After heating	
	Maize	Moong	Maize	Moong
I	0.479	0.196	0.340	0.078
II	0.51	0.229	0.357	0.087
III	0.411	0.231	0.308	0.088
IV	0.513	0.188	0.359	0.076
V	0.552	0.223	0.381	0.087
VI	0.49	0.343	0.348	0.104
VII	0.442	0.311	0.323	0.106
VIII	0.597	0.446	0.412	0.111
IX	0.415	0.244	0.311	0.092
X	0.542	0.289	0.379	0.098
XI	0.549	0.297	0.379	0.103
XII	0.42	0.218	0.315	0.086
Standard-I	0.49	0.281	0.358	0.097
Standard-II	0.552	0.269	0.381	0.095
Standard-III	0.44	0.215	0.326	0.084

#Observations are made after 6 hrs during 24 hrs for 9 days

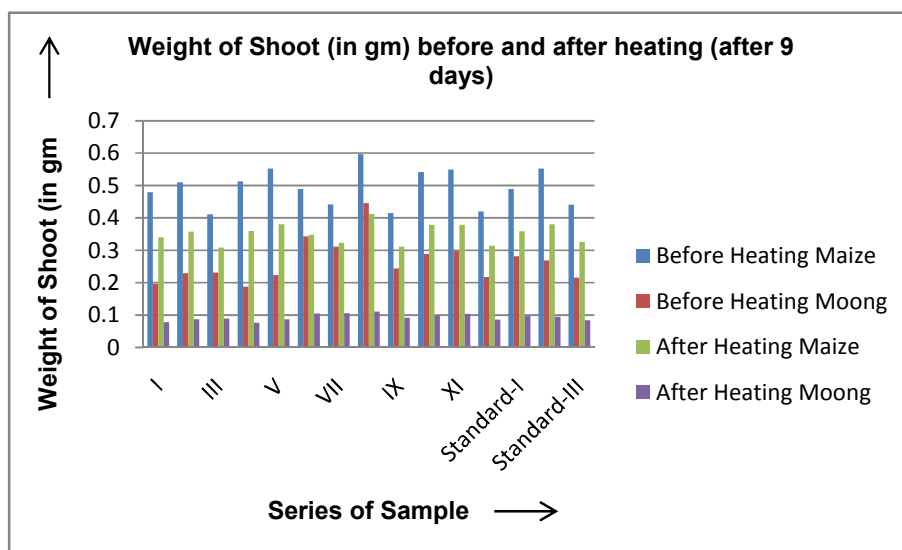


Chart 6. Weight of shoot (in gm) before and after heating (after 9 days)

4. CONCLUSION

It is precisely resolute and concluded that; a novel class of bis-chalcones and pyrazoles derivatives were synthesized from the substituted N-phenyl succinimides and N-phenyl glutarimides by efficient, succinct methodology. A novel and innovative approach were used for the synthesis of these compounds. The applied synthetic strategy was compared for the conventional and greener pathway which was very simple, sophisticated and straightforward. It was unaffectedly and honestly scrutinized and characterized spectral data, physical constants. Also, all the synthesized novel compounds were screened for their plant growth activity against maize (Rajeshwar) and moong (PKVM-8802) seeds using DMSO solvent. Conspicuous difference is found in the yield of greener methodology than conventional. The Compound III and VII achieved excellent yield via greener path. Also, Compound III is found very good growth regulator of root for moong. Compound No. VII and IX have displayed spectacular growing activities of root associated to Std-I, II and III in case of maize and moong respectively. Compound III determined wonderful growing activity for shoot of maize. The compounds XII has demonstrated outstanding and superb activities for shoot development of moong.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved

parties) for publication of this case report and accompanying images.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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