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RESEARCH ARTICLE

Biological spectrum, phenology, and diversity of invasive ruderal and agrestal weeds in Moradabad district of Uttar Pradesh, India

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Abstract

The study was conducted in Moradabad district (28°-21´ to 28°-16´ Latitude and 78°- 4´ to 79 Longitude) of western Uttar Pradesh, India, from April 2022 to June 2023, to understand the accessibility and distribution of alien invasive ruderals and agrestals weed flora. Detailed field observations on Raunkiaer's life form for each weed species were recorded and collected weed species were arranged in different APG-IV families and grades according to the modern system of classification. Study reveals 82 weed species, classified into 64 genera, 25 APG-IV families and 8 APG-IV grades. The dominated weed family is Asteraceae and weed genera is Alternanthera. Field sampling involved extensive observations of ecological and phenological traits, including Raunkiaer's life form, for various ruderal and agrestal weed species. Weeds were categorised into 4 sub-categorise, and we get such a type of data that (68%) 56 spp. were Therophytes, followed by Phanerophytes (14%) 11 spp., Hemi-cryptophytes (7%) 6 spp., Chamaephytes (6%) 5 spp., and Cryptophytes (5%) 4 spp. The dominant life form was 65 species (79%) herb followed by 11 species (13%) shrub, 3 species (4%) climbing herb, 2 species (3%) creeping herb and 1 species (1%) climbing shrub. The study reveals that 40% of weeds are classified as ruderals, 33% as both types, and 27% as agrestals. The phyto-geographical analysis of alien invasive weed species origination represent that the maximum 49 species (60%) recorded, were from Tropical America (TAM), followed by 11 species (14%) from South America (SAM), 9 species (11%) from Tropical Africa (TAF), 4 species (5%) from the Mediterranean region (MR) and Europe (EU) each, and 1 species (1%) from Malaysia (ML), Africa (AF), North America (NAM), Brazil (BR), and Peru (PU). Phenological analysis shows maximum flowering in August and fruiting in April. The study provides baseline data on alien weed species in Moradabad district, aiding in effective management and regulatory pathways. India needs nationwide research to evaluate economic losses, identify invasion patterns, and develop effective management techniques. This information may be used to forecast phenotypic alterations and develop governance plans for these species.

Keywords: APG-IV; Biological Spectrum; Invasive Weeds; Phenology; Moradabad

1. Introduction

During the anthropocentric period, expansion of species outside their original circulation range, breaching natural bio-geographical boundaries, is a significant environmental impact (Kueffer, 2017). The global agricultural production system is facing numerous challenges, including the presence of numerous invasive alien species, including numerous weed species (Paini et al., 2016). Imported alien species contribute to global ecological deterioration through land use and climate change, affecting biodiversity, ecosystems, and agricultural products through their combined native effects (Lopez et al., 2022; Ravi et al., 2022). In recent decades, the agriculture industry has been threatened by global ecological changes such as climate change and biological incursions (Bang et al., 2022; Pathak, 2023). The IUCN defines an alien invasive species as one that sustains itself in a natural or semi-natural ecosystem and threatens the host species' biological diversity (Shine and Gündling, 2000). Weeds cause around one-third of all agricultural pest losses (DWR, 2015). Along with microbes (parasites, microorganisms, and so forth.) insects, rodents, nematodes, mites, birds, and other less serious animal pests, Weeds frequently pose the greatest threat to declining agricultural output (Oerke, 2006). Weeds can contaminate crops and make harvesting difficult, reducing crop quality (Sonawane and Patil, 2024).

Weeds were blamed for more than 11 billion dollars in economic losses in just ten crops in India (Gharde et al., 2018). Invasive species like weeds reduce agricultural yields, raise farming costs, and cause major ecological damage (Sinden et al., 2004; Rao et al., 2020). Weeds have a considerable impact on agricultural output, and inadequate treatment can compound the problem. Reducing weed intensity is critical for maintaining and enhancing crop output. Weeds play a significant role in agricultural productivity. Weeds compete with crops for resources such as water, space, nutrients, and light. This fight between weeds and agricultural plants reduces yields and affects production quality (Sonawane and Patil, 2024). Ruderal are weed plants that thrive around rubbish heaps, urban wastes, docks, footpaths, railways road edges, and other areas extensively touched by human habitation, industry, and trade (Frenkel, 1977). Effective weed management is crucial for crop yield, quality, and long-term agricultural productivity (Kumar et al., 2024). The absence of native predators or the presences of novel weapons like allelopathic have been cited as reasons for plant species' success in alien environments (Hierro and Callaway, 2003). Agro-ecosystems are environments where invasive weed species have a real financial impact because they reduce crop yields (Cousens and Mortimer, 1995). Certain alien species imported for human benefit are known to inflict devastation on the ecosystem and economy (Souza et al., 2018). The Indian flora comprises around 40% foreign species, with 25% being invasive alien species (Singh, 2005). The proliferation of alien species causes serious ecological damage to native species richness and accelerates the loss of rare and sensitive taxa (Reddy, 2008; Yadav et al., 2016). The weeds frequently produce high propagules pressure, which promotes naturalisation and the expansion of these species into the

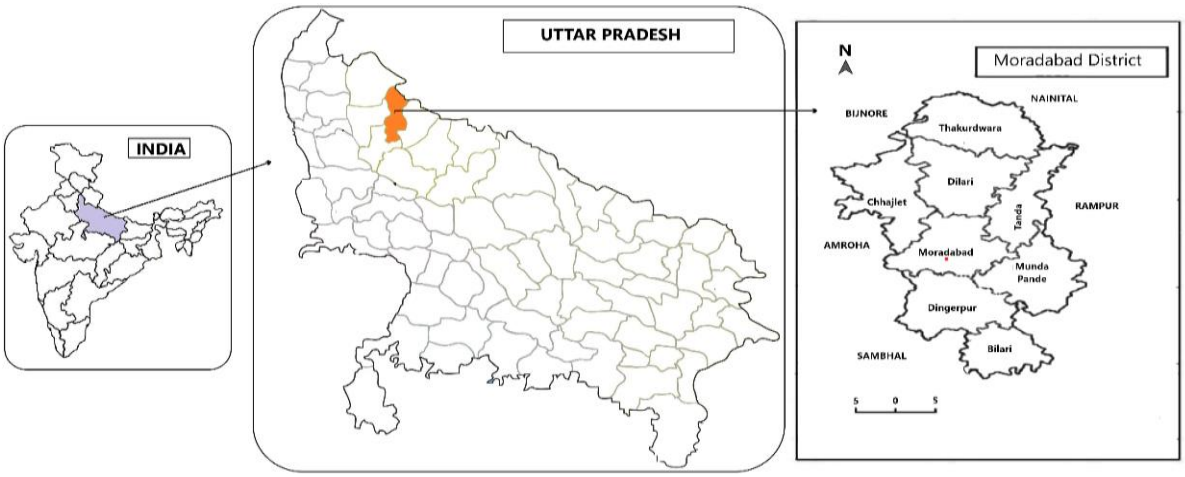

Figure 1. Map of study sites.

hinterland (Pyšek et al., 2009) therefore increasing the likelihood of biological invasions in the environment.

2. Material and method

The study was conducted in Moradabad district (28°-21´ to 28°-16´ Latitude and 78°- 4´ to 79 Longitude) of western Uttar Pradesh, India, from April 2022 to June 2023, to understand the accessibility and distribution of alien invasive ruderals and agrestals weed flora. Different agricultural and non-agricultural field sites were surveyed, with data collected during four different seasons. Field notes were taken on the plant, detailing its locality, habitat, habit, and diagnostic charters. Detailed field observations on Raunkiaer's life form for each weed species were recorded as per (Raunkiaer, 1934). The collected weed plant species were identified using the documentation that was available, including Flora of Uttar Pradesh Vol. I (Singh et al., 2016) and Vol. II (Sinha and Shukla, 2020), Handbook on Weed Identification (Naidu, 2012), weeds just reported from the Global Compandium of Weeds (Randall, 2017). The collected weed species were arranged in different APG-IV families and grades according to the modern system of classification (Chase et al., 2016).

3. Results and discussion

Analysis of Alien Invasive Weed Species study reveals that there are 82 weed species classified as belonging to 64 genera, 25 APG-IV families and 8 APG-Grades of the Angiosperm Phylogeny Group-IV System (Table 1).

3.1. Species–Family Analysis

The distribution of weed spp. 25 reported families revealed that Asteraceae was the dominant family with 14 spp., closely followed by Amaranthaceae with 9 spp., Malvaceae with 7 spp., Poaceae, Fabaceae, and Convolvulaceae with 6 spp. each, Solanaceae with 5 spp., Euphorbiaceae with 4 spp., Apocynaceae and Cactaceae with 3 spp. each, Cyperaceae, Plantaginaceae, Pontederiaceae, and Portulacaceae with 2 spp. each, and Polygonaceae, Papaveraceae, Cleomaceae, Acanthaceae, Verbenaceae, Onagraceae, Primulaceae, Lamiaceae, Nyctaginaceae, Oxalidaceae, and Zygophyllaceae, all with 1 sp. each.

3.2. Species – Genera analysis

In the distribution of weed species 64 reported weed Genera, *Alternanthera* was the dominant weed genera with 3 species, closely followed by *Ipomoea with* 3 species, *Senna with* 3 species, *Calotropis, Corchorus, Cuscuta, Cyperus, Datura, Echinochloa, Erigeron, Euphorbia, Opuntia, Pontederia, Portulaca, and Sonchus, all with 2 species each.Ageratum conyzoides, Amaranthus spinosus, Antigonon leptopus, Argemone Mexicana, Bidens pilosa, Blumea lacera, Catharanthus pusillus, Celosia argentea, Cenchrus purpureus, Chenopodium album, Chrozophora rottleri, Cleome viscosa, Croton bonplandianus, Dicliptera paniculata, Digera muricata, Dinebra retroflexa, Dysphania ambrosioides, Eclipta prostrata, Emilia sonchifolia, Evolvulus nummularis, Gamochaeta purpurea, Gnaphalium polycaulon, Gomphrena serrata, Imperata cylindrica, Lantana camara, Ludwigia octovalvis, Lysimachia arvensis, Malvastrum coromandelianum, Mecardonia procumbens, Melilotus albus, Mimosa pudica, Mirabilis jalapa, Nicotiana plumbaginifolia, Ocimum americanum, Ouret lanata, Oxalis corniculata, Parthenium hysterophorus, Physalis angulata, Saccharum spontaneum, Scoparia dulcis, Sesbania bispinosa, Sida acuta, Solanaum americanum,Tribulus terrestris, Tridax procumbens, Urena lobata, Waltheria indica, and Xanthium strumarium* are all one species each (Table 1).

3.3. Family–APG-IV Grades analysis

The distribution of weed families across 8 reported weed APG-IV grades showed that the dominant Grade was Lamiids with 7 families, i.e., *Apocynaceae, Convolvulaceae, Solanaceae, Acanthaceae, Verbenaceae, Plantaginaceae,* and *Lamiaceae,* followed by Superasterids with 5 families, i.e., *Amaranthaceae, Polygonaceae, Nyctaginaceae, Cactaceae, and Portulacaceae.* Fabids 4 families, i.e., *Euphorbiaceae, Fabaceae, Oxalidaceae, and Zygophyllaceae,* Commelinids 3 families, i.e., *Poaceae, Cyperaceae,* and *Pontederiaceae;* Malvids 3 families, i.e., *Cleomaceae, Malvaceae, and Onagraceae*; Campanulids 1 family, i.e., *Asteraceae*; Eudicots 1 family, i.e., *Papaveraceae;* and Asterids 1 family, i., *Primulaceae (*Table 1).

3.4. Weed species–APG-IV Grade analysis

In the distribution of weed species across the eight reported weed APG-IV grades, the dominant Grade was Lamiids with 19 species, i.e., *C. gigantean, C. procera, C. pusillus, C. chinensis, C. reflexa, D. innoxia, D. metel, D. paniculata, E. nummularius, I. eriocarpa, I. obscura, I. pes-tigridis, L. camara, M. procumbens, N. plumbaginifolia, O. americanum, P. angulata, S. dulcis,* and *S. americanum were* followed by Superasterids 16 species, i.e., *A. bettzickiana, A. philoxeroides, and A. sessilis. A. spinosus, A. leptopus, C. argentea, C. album, D.muricata, D. ambrosioides, G. serrata, M. jalapa, O. elatior, O. stricta, O. lanata, P.oleracea, and P. quadrifida;* Campanulids: 14 species, i.e., *A. conyzoides, B. pilosa, B. lacera, E. prostrata, E. sonchifolia, E. bonariensis, E. canadensis, G. purpurea, G.polycaulon , P. hysterophorus, S. asper, S. oleraceus, T. procumbens, and X. strumarium;* Fabids: 12 species, i.e., *C. rottleri, C. bonplandianus, E. heterophylla var. cyathophora, E. hirta, M. albus, M. pudica, O. corniculata, S. obtusifolia, S. occidentalis, S. tora, S. bispinosa and T. terrestris;* Commelinids: 10 species, i.e., *C. purpureus, C. difformis, C. iria, D. retroflexa, E. colona, E. crus-galli, I. cylindrica, P. crassipes, P. vaginalis, and S. spontaneum;* Malvids have nine species, i.e., *C. viscosa, C. aestuans, C. tridens, L. octovalvis, M. coromandelianum, S. acuta, T. rhomboidea, U. lobata, and W. indica;* Eudicots have one species, i.e., *A. mexicana, and* Asterids have one species, i.e., *L. arvensis.*

Table 1. Botanical name, Phenology and Raunkiaer's life form of different reported Alien invasive weeds.

SN	Plant name	APG-IV	APG-IV grade	Life form	Growth form	FL-FR	Raunkiaer's life form	Weed's category		Origin
		Families						AW	RW	
1	*Ageratum conyzoides* L.	Asteraceae	Campanulids	HB	AN	TY-TY	TH	AW	RW	TAM
2	*Alternanthera bettzickiana* (Regel) G.Nicholson	Amaranthaceae	Superasterids	HB	PN	Feb-Dec	CH	*	RW	TAM
3	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	Superasterids	HB	PN	Apr-Oct	CH	*	RW	TAM
4	*Alternanthera sessilis* (L.) DC.	Amaranthaceae	Superasterids	HB	PN	TY-TY	CH	AW	*	TAM
5	*Amaranthus spinosus* L.	Amaranthaceae	Superasterids	HB	AN	TY-TY	TH	AW	RW	TAM
6	*Antigonon leptopus* Hook. & Arn.	Polygonaceae	Superasterids	CLSB	PN	TY-TY	CH	*	RW	TAM
7	*Argemone mexicana* L.	Papaveraceae	Eudicots	HB	AN	Feb-Oct	TH	AW	RW	SAM
8	*Bidens pilosa* L.	Asteraceae	Campanulids	HB	AN	Aug-Dec	TH	AW	*	TAM
9	*Blumea lacera* (Burm.f.) DC.	Asteraceae	Campanulids	HB	AN	Nov-Jan	TH	*	RW	TAM
10	*Calotropis gigantea* (L.) W.T.Aiton	Apocynaceae	Lamiids	SB	PN	TY-TY	PH	*	RW	TAF
11	*Calotropis procera* (Aiton) W.T.Aiton	Apocynaceae	Lamiids	SB	PN	TY-TY	PH	*	RW	TAF
12	*Catharanthus pusillus* (Murray) G.Don	Apocynaceae	Lamiids	HB	AN	Aug-Oct	TH	*	RW	TAM
13	*Celosia argentea* L.	Amaranthaceae	Superasterids	HB	AN	Aug-Dec	TH	AW	*	TAF
14	*Cenchrus purpureus* (Schumach.) Morrone	Poaceae	Commelinids	HB	AN/BN	Nov-Apr	HC	AW	*	AF
15	*Chenopodium album* L.	Amaranthaceae	Superasterids	HB	AN	Sep-Mar	TH	AW	*	EU
16	*Chrozophora rottleri* (Geiseler) Spreng.	Euphorbiaceae	Fabids	HB	AN/PN	Mar-May	TH	*	RW	TAF
17	*Cleome viscosa* L.	Cleomaceae	Malvids	HB	AN	Jul-Nov	TH	AW	RW	TAM
18	*Corchorus aestuans* L.	Malvaceae	Malvids	HB	AN	Aug-Feb	TH	AW	*	TAM
19	*Corchorus tridens* L.	Malvaceae	Malvids	HB	AN	Sep-Jan	TH	AW	*	TAF
20	*Croton bonplandianus* Baill.	Euphorbiaceae	Fabids	HB	PN	Mar-Aug	CH	*	RW	SAM
21	*Cuscuta chinensis* Lam.	Convolvulaceae	Lamiids	CLB	PN	Sep-Dec	PH	AW	RW	MR
22	*Cuscuta reflexa* Roxb.	Convolvulaceae	Lamiids	CLB	AN	Oct-Feb	PH	*	RW	MR
23	*Cyperus difformis* L.	Cyperaceae	Commelinids	HB	AN	Jul-Oct	TH	AW	*	TAM
24	*Cyperus iria L.*	Cyperaceae	Commelinids	HB	AN	Aug-Jan	TH	AW	*	TAM
25	*Datura innoxia* Mill.	Solanaceae	Lamiids	HB	PN	Aug-Apr	TH	*	RW	TAM
26	*Datura metel* L.	Solanaceae	Lamiids	HB	PN	TY-TY	TH	*	RW	TAM
27	*Dicliptera paniculata* (Forssk.) I.Darbysh.	Acanthaceae	Lamiids	HB	AN	Sep-Apr	TH	*	RW	TAM
28	*Digera muricata* (L.) Mart.	Amaranthaceae	Superasterids	HB	AN	Jul-Apr	TH	AW	*	NAM
29	*Dinebra retroflexa* (Vahl) Panz.	Poaceae	Commelinids	HB	PN	Sep-Feb	TH	AW	RW	TAM
30	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Amaranthaceae	Superasterids	HB	AN	Feb-Apr	TH	AW	RW	SAM
31	*Echinochloa colona* (L.) Link	Poaceae	Commelinids	HB	AN	Aug-Nov	TH	AW	RW	SAM
32	*Echinochloa crus-galli* (L.) P.Beauv.	Poaceae	Commelinids	HB	AN	Oct-Dec	TH	AW	*	SAM
33	*Eclipta prostrata* (L.) L.	Asteraceae	Campanulids	HB	AN	TY-TY	TH	AW	RW	TAM
34	*Emilia sonchifolia* (L.) DC.	Asteraceae	Campanulids	HB	AN	Feb-Mar	TH	*	RW	TAM
35	*Erigeron bonariensis* L.	Asteraceae	Campanulids	HB	AN/BN	Jun-Jan	TH	AW	RW	SAM
36	*Erigeron canadensis* L.	Asteraceae	Campanulids	HB	AN	Dec-Jan	TH	AW	RW	SAM
37	*Euphorbia heterophylla var. cyathophora* (Murray) Griseb.	Euphorbiaceae	Fabids	HB	AN	Aug-Oct	TH	*	RW	TAM
38	*Euphorbia hirta* L.	Euphorbiaceae	Fabids	HB	AN	Aug-Nov	TH	AW	RW	TAM
39	*Evolvulus nummularius* (L.) L.	Convolvulaceae	Lamiids	CRB	PN	Jul-Apr	TH	*	RW	TAM
40	*Gamochaeta purpurea* (L.) Cabrera	Asteraceae	Campanulids	HB	AN	Jan-May	TH	*	RW	TAM
41	*Gnaphalium polycaulon* Pers.	Asteraceae	Campanulids	HB	AN	Mar-Apr	TH	AW	RW	TAM

Table 1. Botanical name, Phenology and Raunkiaer's life form of different reported Alien invasive weeds.

SN	**Plant name**	**APG-IV**	**APG-IV grade**	**Life form**	**Growth form**	**FL-FR**	**Raunkiaer's life form**	**Weed's category**		**Origin**
42	*Gomphrena serrata* L.	Amaranthaceae	Superasterids	HB	AN	Jun-Apr	TH	AW	RW	TAM
43	*Imperata cylindrica* (L.) Raeusch.	Poaceae	Commelinids	HB	PN	Oct-Jan	HC	*	RW	TAM
44	*Ipomoea eriocarpa* R.Br.	Convolvulaceae	Lamiids	HB	AN	Aug-Nov	TH	*	RW	TAF
45	*Ipomoea obscura* (L.) Ker Gawl.	Convolvulaceae	Lamiids	HB	PN	Sep-Jan	TH	*	RW	TAF
46	*Ipomoea pes-tigridis* L.	Convolvulaceae	Lamiids	CLB	AN	Aug-Nov	PH	AW	RW	TAF
47	*Lantana camara* L.	Verbenaceae	Lamiids	SB	PN	TY-TY	CH	*	RW	TAM
48	*Ludwigia octovalvis* (Jacq.) P.H.Raven	Onagraceae	Malvids	HB	AN	Oct-Jun	TH	AW	*	TAF
49	*Lysimachia arvensis* (L.) U.Manns & Anderb.	Primulaceae	Asterids	HB	AN	Dec-Apr	TH	AW	*	EU
50	*Malvastrum coromandelianum* (L.) Garcke	Malvaceae	Malvids	HB	AN	Sep-Jan	TH	AW	RW	TAM
51	*Mecardonia procumbens* (Mill.) Small	Plantaginaceae	Lamiids	HB	AN	Sep-May	TH	AW	RW	TAM
52	*Melilotus albus* Medik.	Fabaceae	Fabids	HB	AN	Jan-Apr	TH	AW	*	EU
53	*Mimosa pudica* L.	Fabaceae	Fabids	HB	PN	Sep-Nov	CH	AW	*	BR
54	*Mirabilis jalapa* L.	Nyctaginaceae	Superasterids	HB	AN	TY-TY	TH	*	RW	PU
55	*Nicotiana plumbaginifolia* Viv.	Solanaceae	Lamiids	HB	AN	Apr-Jul	TH	AW	*	TAM
56	*Ocimum americanum* L.	Lamiaceae	Lamiids	HB	AN	Aug-Mar	TH	AW	*	TAM
57	*Opuntia elatior* Mill.	Cactaceae	Superasterids	HB	PN	Jun-Jan	CP	*	RW	TAM
58	*Opuntia stricta* (Haw.) Haw.	Cactaceae	Superasterids	HB	PN	Apr-Jun	CP	*	RW	TAM
59	*Ouret lanata* (L.) Kuntze	Cactaceae	Superasterids	SB	PN	Jul-Apr	TH	*	RW	TAM
60	*Oxalis corniculata* L.	Oxalidaceae	Fabids	HB	PN	Mar-Dec	TH	AW	RW	EU
61	*Parthenium hysterophorus* L.	Asteraceae	Campanulids	HB	AN	Oct-Mar	TH	AW	RW	TAM
62	*Physalis angulata* L.	Solanaceae	Lamiids	HB	AN	Sep-Mar	TH	AW	*	TAM
63	*Pontederia crassipes* Mart.	Pontederiaceae	Commelinids	HB	PN	Mar-Jun	CP	*	RW	TAM
64	*Pontederia vaginalis* Burm.f.	Pontederiaceae	Commelinids	HB	PN	Jul-Dec	CP	*	RW	TAM
65	*Portulaca oleracea* L.	Portulacaceae	Superasterids	HB	AN	TY-TY	TH	AW	*	SAM
66	*Portulaca quadrifida* L.	Portulacaceae	Superasterids	HB	AN	TY-TY	TH	AW	*	TAM
67	*Saccharum spontaneum* L.	Poaceae	Commelinids	SB	PN	Oct-Feb	HC	*	RW	ML
68	*Scoparia dulcis* L.	Plantaginaceae	Lamiids	HB	AN/PN	TY-TY	HC	*	RW	TAM
69	*Senna obtusifolia* (L.) H.S.Irwin & Barneby	Fabaceae	Fabids	SB	PN	Aug-Apr	CH	*	RW	TAM
70	*Senna occidentalis* (L.) Link	Fabaceae	Fabids	SB	PN	Aug-Nov	CH	AW	RW	SAM
71	*Senna tora* (L.) Roxb.	Fabaceae	Fabids	SB	AN	Aug-Dec	CH	AW	RW	SAM
72	*Sesbania bispinosa* (Jacq.) W.Wight	Fabaceae	Fabids	SB	AN/BN	Sep-Jan	CH	*	RW	TAM
73	*Sida acuta* Burm.f.	Malvaceae	Malvids	HB	AN	Aug-Nov	TH	AW	RW	TAM
74	*Solanum americanum* Mill.	Solanaceae	Lamiids	HB	AN	Sep-Apr	TH	AW	*	TAM
75	*Sonchus asper* (L.) Hill	Asteraceae	Campanulids	HB	AN	Dec-Apr	TH	AW	RW	MR
76	*Sonchus oleraceus* L.	Asteraceae	Campanulids	HB	AN	Feb-Mar	TH	AW	RW	MR
77	*Tribulus terrestris* L.	Zygophyllaceae	Fabids	CRB	PN	TY-TY	HC	AW	RW	TAM
78	*Tridax procumbens* L.	Asteraceae	Campanulids	HB	PN	TY-TY	HC	AW	RW	TAM
79	*Triumfetta rhomboidea* Jacq.	Malvaceae	Malvids	SB	AN	Aug-Dec	TH	*	RW	TAM
80	*Urena lobata* L.	Malvaceae	Malvids	HB	AN/PN	Jul-Oct	TH	AW	RW	TAM
81	*Waltheria indica* L.	Malvaceae	Malvids	HB	PN	Jul-Sep	TH	AW	*	TAM
82	*Xanthium strumarium* L.	Asteraceae	Campanulids	SB	AN	Mar-Dec	TH	*	RW	SAM

Life Form: (**HB**)=Herb, (**SB**)=Shrub, (**CRB**)=Creeping herb, (**CLB**)=Climbing herb, (**CLSB**)=Climbing shrub; **Habit:** (**AN**)=Annual, (**BN**)=Biennial, (**PN**)=Perennial, (**AN/PN**)=Annual or Perennial, (**AN/BN**)=Annual or Biennia (**TY)=** Throughout the Year; **Raunkiaer's life form:** (**TH**)=Therophytes, (**PH**)=Phanerophytes, **(HC)**=Hemi-cryptophytes, **(CH**)=Chamaephytes, **(CP**)=Cryptophytes; **Origin:** (**SAM**)=South America, (**BR**)=Brazil, (**TAM**)=Tropical America, (**EU**)=Europe, (**TAF**)=Tropical Africa, (**MR**)=Mediterranean region, (**NAM**)=North America, (**AF**)=Africa, (**CAM**)=Central America, (**PU**)=Peru, (**ML**)=Malaysia; (**AW**)=Agrestals weeds, (**RW**)=Ruderals weeds; (*)= Absent/NA.

Table 2. Comparative examination of the current study with previous studies conducted.

SN	Research site	Species enlisted	No. of Genera	No. of Families	Source.
1.	Moradabad District Uttar Pradesh	82 (only weed species)	64	25 (APG-IV)	Present study
2.	India	173	117	44	(Reddy ,2008)
3.	Uttar Pradesh	153	107	45	(Khanna ,2009)
4.	Uttar Pradesh	152	109	44	(Singh et al., 2010)
5.	North-East Uttar Pradesh	149	100	41	(Srivastava et al., 2014)
6.	Delhi NCT	102	69	33	(Mishra et al., 2015)
7.	North-West U.P, Rohilkhand	79	64	29	(Kumari et al., 2016)

3.5. Phyto-geographical analysis

The phyto-geographical analysis of alien invasive weed species origination represent that the maximum 49 species (60%) recorded, were from Tropical America (TAM), followed by 11 species (14%) from South America (SAM), 9 species (11%) from Tropical Africa (TAF), 4 species (5%) from the Mediterranean region (MR) and Europe (EU) each, and 1 species (1%) from Malaysia (ML), Africa (AF), North America (NAM), Brazil (BR), and Peru (PU).

3.6. Biological spectrum and phenology

Field sampling involved extensive observations of ecological and phenological traits, including Raunkiaer's life form, for various ruderal and agrestal weed species. Weeds were categorised into 4 sub-categorise, and we get such a type of data that (68%) 56 spp. were Therophytes, followed by Phanerophytes (14%) 11 spp., Hemi-cryptophytes (7%) 6 spp., Chamaephytes (6%) 5 spp., and Cryptophytes (5%) 4 spp.

We get that 17 species were showing the maximum flowering in the month of August and minimum flowering all with 2 species each in the month of January and November, on the other hand 14 species representing the maximum fruiting stage in the month of April and minimum fruiting all with 1 species each in month of July, August and September and we observed that there are 15 species which were showing the phenological illustration whole the year. i.e. *A. conyzoides, A. bettzickiana, A. philoxeroides, A. sessilis, A. leptopus, C. gigantea, C. procera, D. metel, E. prostrata, L. camara, M. jalapa, P. oleracea, P. quadrifida, S. dulcis, T. terrestris, T. procumbens.*

3.7. Patterns of life form

Botanical study of weed species reveals that in the context of life form with in the reported weeds, the dominant life form was 65 species and (79%) herb followed by 11 species and (13%) shrub, 3 species and (4%) climbing herb, 2 species and (3%) creeping herb and 1 species and (1%) climbing shrub.

3.8. Patterns of weed's category

Study reveals that there are two types of weed i.e. ruderals and agrestals, and we found in our analysis that mostly weeds were 33 species and (40%) ruderals followed by 27 species and (33%) both types and 22 species and (27%) agrestals types of weeds categories.

4. Discussion

82 weed species, classified into 64 genera, 25 APG-IV families and 8 APG-IV grades. The dominated weed family is Asteraceae and weed genera is Alternanthera. Field sampling involved extensive observations of ecological and phenological traits, including Raunkiaer's life form, for various ruderal and agrestal weed species. Weeds were categorised into 4 sub-categorise, and we get such a type of data that (68%) 56 spp. were Therophytes, followed by Phanerophytes (14%) 11 spp., Hemi-cryptophytes (7%) 6 spp., Chamaephytes (6%) 5 spp., and Cryptophytes (5%) 4 spp. The dominant life form was 65 species (79%) herb followed by 11 species (13%) shrub, 3 species (4%) climbing herb, 2 species (3%) creeping herb and 1 species (1%) climbing shrub. The study reveals that 40% of weeds are classified as ruderals, 33% as both types, and 27% as agrestals. The phyto-geographical analysis of alien invasive weed species origination represent that the maximum 49 species (60%) recorded, were from Tropical America (TAM), followed by 11 species (14%) from South America (SAM), 9 species (11%) from Tropical Africa (TAF), 4 species (5%) from the Mediterranean region (MR) and Europe (EU) each, and 1 species (1%) from Malaysia (ML), Africa (AF), North America (NAM), Brazil (BR), and Peru (PU). Sandilyan et al (2018) reported 60 alien species naturalized in India's freshwater ecosystems, meeting National Biodiversity Authority standards for invasive species, prioritizing ecosystem, biodiversity, and livelihood impacts. Initial identification and swift intervention is a technique used to detect and eradicate invasive weeds before they spread (Reaser et al., 2020). Reddy (2008) reported, 173 invasive alien species from 117 genera and 44 families were identified. Nearly 80% of the species were brought from the Neo-tropics. Tropical America (74%) and Tropical Africa (11%) account for the largest amount of India's invasive alien flora. Herbaceous plants account for 151 species, followed by shrubs (14), climbers (5), and trees (3). Khanna (2009) reported 153 invasive alien Angiospermic plant species in Uttar Pradesh with seven origin centres. Singh et al., (2010) reported 152 invasive alien species from 44 Angiospermic families from Uttar Pradesh, with different origin centres. Srivastava et al (2014) reported 149 Angiospermic invasive alien weed species of 41 different plant families in North-East area of Uttar Pradesh. Mishra et al (2015) enlisted 102 invasive species from 33 different Angiospermic plant families in Delhi NCT and Kumari et al (2016) reported 79 invasive alien species of 29 different families from North-West U.P. Rohilkhand region of Uttar Pradesh (Table 2).

5. Conclusion

The provided alien weed species invasiveness and impact-able baseline data for the numerous reported ruderal and agrestal weed species in Moradabad district will help in the proper management and regulatory pathway of the weed plant species in diverse agro and non-agro contexts. There is a scarcity of baseline data, knowledge, and effective weed management strategies. India needs a countrywide research of invasive alien weed species to better evaluate economic losses, identify invasion patterns, and devise effective management techniques. Predicting the most dangerous alien plants is critical for preventing and regulating their spread.

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Author's contribution

Conceptualization of research work and designing of experiments (Sachin Sharma, S. P. Joshi); Execution of field experiments and data collection (Sachin Sharma, Manisha Pandey); Analysis of data and interpretation (Sachin Sharma, S. P. Joshi, Manisha Pandey); Preparation of manuscript (Sachin Sharma, S. P. Joshi, Manisha Pandey).

Conflict of Interest

The authors do not have any conflicts of interest

References

Bang A, Cuthbert RN, Haubrock PJ, Fernandez RD, Moodley D, Diagne C and Courchamp F. 2022. Massive economic costs of biological invasions despite widespread knowledge gaps: a dual setback for India. Biological Invasions 24(7): 2017-2039.

Chase MW, Christenhusz MJ, Fay MF, Byng JW, Judd WS and Stevens PF. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of Linnean Society 181(1): 1-20.

Cousens R and Mortimer M. 1995. *Dynamics of weed populations*. Cambridge University Press.

Directorate of Weed Research. 2015. *Vision 2050 (1st ed.)*. Indian Council of Agricultural Research, New Delhi. Pp 1-46.

Frenkel RE. 1977. *Ruderal vegetation along some California roadsides* (Vol. 20). University of California Press, United State: Pp 1-163.

Gharde Y, Singh PK, Dubey RP and Gupta PK. 2018. Assessment of yield and economic losses in agriculture due to weeds in India. Crop Protection 107(1): 12-18.

Hierro JL and Callaway RM. 2003. Allelopathy and exotic plant invasion. Plant and Soil 256(1): 29-39.

Khanna KK. 2009. *Invasive alien angiosperms of Uttar Pradesh*. In Biological Forum (Vol. 1, 2). Satya Prakashan. Pp 34-39.

Kueffer C. 2017. Plant invasions in the Anthropocene. Science 358(6364): 724-725.

Kumar AK, Jhansi R, Begum SH and Maurya GK. 2024. Mould board weeder for dryland field crops. Indian Journal of Weed Science 56(2): 200-203.

Kumari B, Singh SP, Singh AP, Kumar R and Verma S. 2016. A preliminary survey of invasive alien angiosperms of Rohilkhand region (UP), India. Plant Achieve 16(1): 45-50.

Lopez BE, Allen JM, Dukes JS, Lenoir J, Vilà M, Blumenthal DM and Bradley BA. 2022. Global environmental changes more frequently offset than intensify detrimental effects of biological invasions. Proceedings of the National Academy of Sciences 119(22): e2117389119.

Mishra AK, Mir SA, Sharma MP and Singh H. 2015. Alien plant species in Delhi flora. International Journal of Geology, Earth and Environmental Sciences 5(2): 128-140.

Naidu VSGR. 2012. *Hand book on weed identification*. Directorate of weed science research, Jabalpur, India. Pp 1-354.

Oerke EC. 2006. Crop losses to pests. Journal of Agricultural Science 144(1): 31-43.

Paini DR, Sheppard AW, Cook DC, De Barro PJ, Worner SP and Thomas MB. 2016. Global threat to agriculture from invasive species. Proceedings of the National Academy of Sciences 113(27): 7575-7579.

Pathak H. 2023. Impact, adaptation, and mitigation of climate change in Indian agriculture. Environmental Monitoring and Assessment 195(1): 52.

Pyšek P, Křivánek M and Jarošík V. 2009. Planting intensity, residence time, and species traits determine invasion success of alien woody species. Ecology 90(10): 2734-2744.

Randall RP. 2017. *A global compendium of weeds* (No. Ed. 3). RP Randall.

Rao AN, Singh RG, Mahajan G and Wani SP. 2020. Weed research issues, challenges, and opportunities in India. Journal of Crop Protection 134(1): 104451.

Raunkiaer C. 1934. *The life forms of plants and statistical plant geography*. Oxford University Press, London.

Ravi S, Law DJ, Caplan JS, Barron-Gafford GA, Dontsova KM, Espeleta JF, Villegas JC, Okin GS, Breshears DD and Huxman TE. 2022. Biological invasions and climate change amplify each other's effects on dryland degradation. Global Change Biology 28(1): 285-295.

Reaser JK, Burgiel SW, Kirkey J, Brantley KA, Veatch SD and Burgos-Rodríguez J. 2020. The early detection of and rapid response (EDRR) to invasive species: a conceptual framework and federal capacities assessment. Biological Invasions 22(1): 1-19.

Reddy CS. 2008. Catalogue of invasive alien flora of India. Journal of Life Sciences 5(2): 84-89.

Sandilyan S, Meenakumari B, Babu CR and Rupam Mandal. 2018. *Invasivealien species of India*. National Biodiversity Authority, Chennai. https://www.google.co.in/books/edition/Invasive_Plants/PkDCv9guLwwC?hl=en.

Shine C, Williams N and Gündling L. 2000. *A guide to designing legal and institutional frameworks on alien invasive species* (No. 40). IUCN.

Sinden J, Jones R, Hester S, Odom D, Kalisch C, James R and Cacho O. 2004. The economic impact of weeds in Australia. CRC for Australian Weed Management Technical Series 8: 1-66.

Singh KP. 2005. Invasive alien species and biodiversity in India. Current Science 88(4): 539-540.

Singh KP, Khanna KK and Sinha GP. 2016. *Flora of uttar pradesh: Ranunculaceae-Apiaceae*, (Vol. I). Botanical Survey of India, Ministry of Environment, Forest and Climate Change. Pp 1-674.

Singh KP, Shukla AN and Singh JS. 2010. State-level inventory of invasive alien plants, their source regions and use potential. Current Science 99(1): 107-114.

Sinha GP and Shukla AN. 2020. *Flora of uttar pradesh: Araliaceae-Ceratophyllaceae*, (Vol. II). Botanical Survey of India, Ministry of Environment, Forest and Climate Change. Pp 1-519.

Sonawane S and Patil NN. 2024. Deep learning-based weed detection in sesame crops using modified YOLOv5 model. Indian Journal of Weed Science 56(2): 194–199.

Souza AO, Chaves MDPSR, Barbosa RI and Clement CR. 2018. Local ecological knowledge concerning the invasion of Amerindian lands in the northern Brazilian Amazon by Acacia mangium (Willd.). Journal of Ethnobiology and Ethnomedicine 14(1): 1-14.

Srivastava S, Dvivedi A and Shukla RP. 2014. Invasive alien species of terrestrial vegetation of north-eastern Uttar Pradesh. International Journal of Forestry Research 2014(1): 959875.

Yadav V, Singh NB, Singh H, Singh A and Hussain I. 2016. Allelopathic invasion of alien plant species in India and their management strategies: a review. Tropical Plant Research 3(1): 87-101.