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Assessing the invasion risk of weeds from the APG-IV grade-superasterids in Moradabad district

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ABSTRACT

The global proliferation of invasive plant species is causing havoc in ecological and agricultural ecosystems. Early warning and avoidance of high-risk introductions of such species is critical for minimising losses and increasing gains. The Weed Risk Assessment method has been a successful prediction project for forecasting naturalisations of weed species in four Moradabad sub-districts. A research looked at 17 weed species in the Superasterids Grade of the APG-IV classification system. The study highlights that 53% of the reported weed species were of low rank, 35% of medium rank, and 12% were of high risk rank status. In our investigation, we discovered that Alternanthera philoxeroides (Mart.) Griseb. had the highest weed risk score (25) while Mirabilis jalapa L. and Opuntia elatior Mill. had the lowest weed risk score (1.08). The study reports that 75% of the weed species were herbs. Ruderal weeds (41%) were the most common, followed by Agrestal weeds (41%) and (18%) were in both categories. In terms of the origin of weed species, mostly weeds were from Tropical America (62%), and the minimum from Tropical Africa (6%).

Keywords: Global Compendium of Weeds, Moradabad, Superasterids, Weed Risk Assessment, Weeds

INTRODUCTION

India imports seeds and planting material from different parts of the world, which may be a source of many potential weeds. Assessment of invasiveness is crucial for selecting agricultural and non-agricultural species. Australian Weed Risk Assessment (WRA) provides accurate risk determination for most plant species. Plant species undergoes three stages to become a troublesome weed: entering new habitat, dispersing, and affecting the environment or human activities. Regulatory techniques allow introduction of new plant species in Australia and New Zealand, requiring strict processes and risk assessment for their effective management. Australia has used the Australian WRA as a fundamental component of its federal regulatory framework for the introduction of new plants since 1997 (Weber *et al.,* 2009). Others have adopted or examined this WRA, frequently with minor changes to accommodate local situations. For example, the WRA system has gone through multiple levels of testing in Japan (Kato *et al.,* 2006 ; Nishida *et al.,* 2009) the Czech Republic (Křivánek & Pyšek, 2006), the U.S.A. (Gordon & Gantz, 2008), Florida, U.S.A. (Gordon *et al.,* 2008), Hawaii, U.S.A. (Daehler & Carino, 2000), Tanzania (Dawson *et al.,* 2009) and the Pacific Islands (Daehler *et al.,* 2004).

Weed risk assessment can help identify efficient weed management techniques on Indian public lands also, aiding policymakers in managing plant invasions, developing human capital, and raising public awareness. Future technologies could address agricultural industry concerns. There are several ways for predicting weed potential (Mack, 1996) but a risk assessment methodology that is objective, accurate, and widely acknowledged is urgently needed to determine how weedy new plant introductions will be. About one-third of all agricultural pest losses are caused by weeds (DWR, 2015). Weeds are typically the most severe danger to diminishing agricultural productivity, along with pets (parasites, bacteria, and so on.) insects, rats, nematodes, mites, birds, and other less important animal pests (Oerke, 2006). In India, weeds have been responsible for economic losses of more than 11 billion dollars in only ten crops (Gharde *et al.,* 2018). Weeds, for example, reduce agricultural output, well farming expenses, and cause significant ecological harm (Sinden *et al.,* 2004;

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Rao *et al.,* 2020). Ruderals are those weed plants that thrive in dumps, urban wastelands, docks, footpaths, railways, roadsides, and other areas extensively influenced by human occupation, industry, and trade (Frenkel, 1977). Agrestals are a kind of plant that grows in agricultural grounds. Weeds are often viewed in agro-ecosystems as invasive, unwelcome intruders that compete for resources, reduce yields, and need the use of labour-intensive measures such as human labour and sophisticated technology to prevent crop losses (Dwari & Mondal, 2012).

Weeds are undesirable plants that interfere with our operations and harm the environment. They have emerged as a disruptive companion to our crops, vying for resources such as soil, water, and nutrients (Ali *et al.,* (2003) & (Muzik, (1970). These undesirable ruderals and agrestals are responsible for approximately forty-five percent of the yearly decline of agricultural commodities due to a variety of pests. (Rao, 1999).Weeds, with very few exceptions, generally have a short vegetative phase, a high reproduction rate, and the capacity to diminish agricultural yields (Ghaffoor, 2004). The formation of soil seed banks (SSBs) is a weed technique that permits it to survive in farmed regions for decades. Several species generate a large number of seeds, which aids in the spread of the SSB and makes it more difficult to eliminate (Boguzas *et al.,* 2004). Soil fertility is determined by macro-nutrients (N, P, and K) and micronutrients (Zn, Fe, Cu, and Mn). Soil fertility has a significant impact on the efficiency of agriculture **(**Amritanshu *et al.,* 2023)**.** Weed is not equally distributed throughout the ground, and stains or thick woody formations indicate the spatial heterogeneity of the infestation (Izquierdo *et al.,* 2009; Iwara *et al.,* 2011).Soil's physical, chemical, and biological properties vary spatially, with comparable values over short distances and varying values over longer distances. Weed management and nitrogen strategies have a considerable impact on soil enzymatic activity in conservative agriculture systems (Kothari *et al.,* 2023). Topography, soil type and structure, groundwater features, microclimate, and management approaches contribute to the geographical heterogeneity of soil attributes and weeds (da Silva *et al.,* 2008).

MATERIALS AND METHODS

Study area

This area is located in western U.P. between 28°-21´ to 28°-16´ Latitude North and 78°- 4´ to 79 Longitude East. The Gangetic plain is represented by Moradabad, which is separated into three sections by the rivers Ramganga and Sot. Moradabad is located on the banks of the Ram-Ganga River, a Ganges tributary that comes from the Kumaon Himalaya.

Field survey and data collection

From April 2022 to January 2023, 30 field site (agricultural and non-agricultural) surveys were conducted to gain knowledge about the availability and geographic distribution of the various ruderals and agrestal weed flora expanding in the focus area and to generate a generalised weed risk score of weeds from Superasterids. The APG-IV classification system was graded by utilising the risk-based Assessment score method to forecast the weed hazards of various weeds in the district. Data were collected from 30 different localities of 8 blocks, situated in the area of Moradabad district. The latest addition to the current research is a mathematical framework that evaluates a weed plant's danger propensity as a score that can be juxtaposed to other weed species, as well as the Global threat Score of Weeds has recently been reported by Randall, (2017). Extensive appropriate information on geography, habitat, behaviour, ecosystem illustration, and morphological declarations of all Superasterids Grade weed plant species were documented in an on-site note book throughout the field survey. Field-collected weed specimens were dried, stored, tagged, and mounting on herbarium sheets using normal herbarium processes (Jain, 1977). A number of the field locations were explored with the help of neighbourhood intermediate and degree college students. Using the documentation that is presently accessible and morphological analysis, collected grassy weeds have been identified (Singh & Beena, 2018). Invasive alien weed plant specimens gathered from the areas of study were recognised on-site, whereas unidentifiable plants were recognised using the documentation that was available, including Flora of Uttar Pradesh volume I (Singh *et al.,* 2016). & vol. II, (Sinha *et al.,* 2020), ‘Handbook

on Weed Identification' (Naidu, 2012), weeds just reported from the Global Compandium of Weeds (Randall, 2017), and also, the collected weed plant species were cross verified with the help of preserved authentic herbarium specimen of BSI Herbarium Dehradun, Northern Circle (https://bsi.gov.in/regional-centres/en?rcu=131) and the citation of plant name was checked with the help of www.ipni.org.in , https://efloraofindia.com/ Janaki Ammal Virtual herbarium (https://iiim.res.in/herbarium / herbarium.htm) and also with the virtual herbarium of B.S.I. Kolkata (https://ivh.bsi.gov.in/). Recorded weed species were arranged in different APG-IV families and graded according to the modern system of classification, APG-IV system (APG. *et al.,* 2016). The collected weed plant species are properly identified with the help of the Virtual Herbarium of ICAR-DWR, Jabalpur, Madhya Pradesh. The herbarium plant specimen of collected weed plants were preserved and submitted to the Botany Department of D.A.V. (P.G.) College for further use.

Table 1: Weed species with their respected risk system categories

Weed Name	Entry					Dispersal					Impact				Origin status	GWRR Score	Risk Rank Status
	A	B	C	D	E	F	G	H	I	J	K	L	M	N			
Alternanthera bettzickiana (Regel) G.Nicholson	+	-	-	+	-	+	-	-	+	+	+	-	-	+	TA	6.84	MEDIUM
Alternanthera philoxeroides (Mart.) Griseb.	+	-	+	+	-	+	+	+	+	+	+	-	+	+	TA	25	HIGH
Alternanthera sessilis (L.) R.Br. ex DC.	-	-	-	+	-	+	-	-	+	-	+	-	+	+	TA	2.4	LOW
Amaranthus spinosus L.	+	-	+	+	-	+	+	-	+	+	+	-	-	+	TA	12	MEDIUM
Antigonon leptopus Hook. & Arn.	-	-	+	+	+	+	+	+	+	+	-	-	-	+	TA	3.0	LOW
Celosia argentea L.	+	-	+	+	-	+	-	+	+	+	+	-	-	+	TF	12	MEDIUM
Chenopodium album L.	+	-	+	+	-	+	+	+	+	+	+	-	-	+	EU	15	MEDIUM
Chenopodiastrum murale (L.) S.Fuentes, Uotila & Borsch	+	-	+	+	-	+	+	+	+	-	+	-	-	+	EU	12	MEDIUM
Digera muricata (L.) Mart.	+	-	+	+	-	+	-	-	+	-	+	-	-	+	NA	6	LOW
Dysphania ambrosioides (L.) Mosyakin & Clemants	+	-	+	+	-	+	+	-	+	+	-	-	-	+	SA	4	LOW
Gomphrena serrata L.	-	-	+	-	-	+	-	+	+	-	+	-	-	+	TA	2.16	LOW
Mirabilis jalapa L.	-	-	+	-	+	+	-	-	+	+	-	-	-	+	PE	1.08	LOW
Opuntia elatior Mill.	-	-	+	-	+	+	-	-	+	+	-	-	-	+	TA	1.08	LOW
Opuntia stricta (Haw.) Haw.	-	-	+	-	+	+	+	+	+	+	-	-	-	+	TA	1.80	LOW
Ouret lanata (L.) Kuntze	+	-	-	+	-	+	+	+	-	+	-	-	-	+	TA	3.04	LOW
Portulaca oleracea L.	+	-	+	+	+	+	+	+	+	+	+	-	-	+	SA	16.8	HIGH
Portulaca quadrifida L.	+	-	+	+	+	+	-	-	+	-	+	-	-	+	TA	6.72	MEDIUM

Origin:(EU)=Europe,(NA)=NorthAmerica,(PE)=Peru,(TA)=TropicalAmerica,(TF)=TropicalAfrica,(SA)=SouthAmerica

Fourteen categories, in three phases (Table 1), were chosen from the plants database (Randall, 2016). The scoring within each phase is additive, with the successive scores of the three phases multiplied. Weed Risk Score Analysis Equation=Entry (A+B+C+D+E) x Dispersal (F+G+H+I+J) x Impact (K+L+M+N).

RESULT AND DISCUSSION

Grade Superasterids of APG-IV includes the families i.e. *Aextoxicaceae, Berberidopsidaceae, Balanophoraceae, Misodendraceae, Opiliaceae, Schoepfiaceae, Loranthaceae, Olacaceae, Santalaceae, Viscaceae, Aizoaceae, Caryophyllaceae, Molluginaceae, Polygonaceae, Amaranthaceae, Didiereaceae, Nepenthaceae, Portulacaceae, Chenopodiaceae, Droseraceae, Nyctaginaceae, Simmondsiaceae, Basellaceae, Drosophyllaceae, Phytolaccaceae, Talinaceae, Cactaceae, Frankeniaceae , Plumbaginaceae, Tamaricaceae.* Out of the above families in our study, 17 weed species were recorded from the following 5 APG-IV families: *Amaranthaceae, Polygonaceae, Nyctaginaceae, Cactaceae* and *Portulaceae*. The dominant family was Amaranthaceae with 11 weed species, closely followed by Cactaceae with 2 species, Portulacaceae with 2 species, Polygonaceae and Nyctaginaceae with 1 species each (Fig. 6). According to the findings, Alternanthera was the most prevalent weed genus, with 3 species, followed by *Opuntia* and *Portulaca* with 2 species each (Fig. 7). In this study, we found that 17 weed species were reported from the

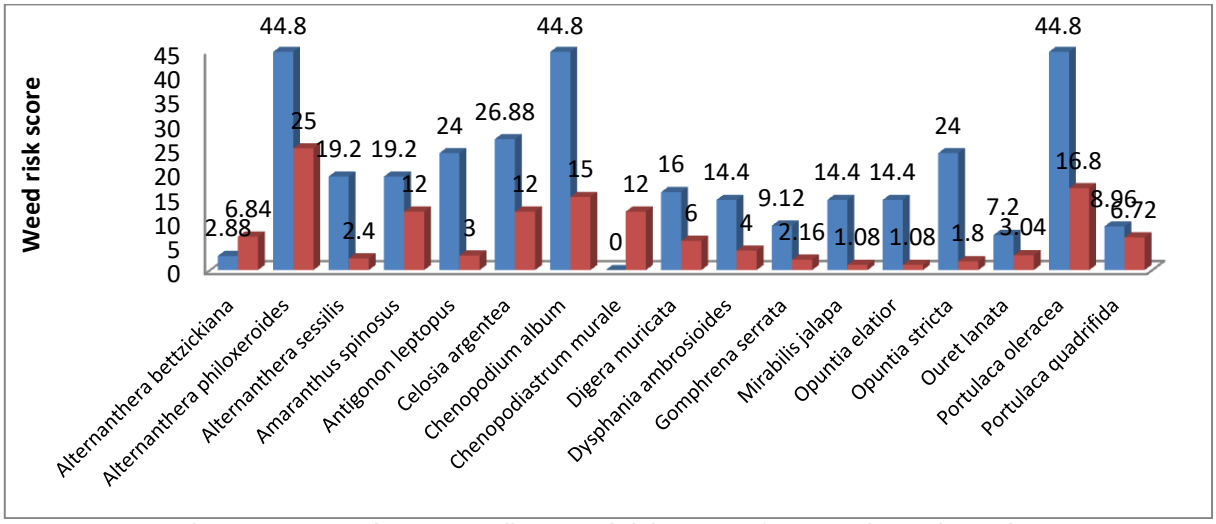

Fig. 1: Comparative Generalize weed risk score of reported weed species

study site. In the phase of entry of weed species, there were 11 weed species in class-A, i.e., *Alternanthera bettzickiana, Alternanthera philoxeroides, Amaranthus spinosus, Antigonon leptopus, Celosia argentea, Chenopodium album, Chenopodiastrum murale, Digera muricata, Dysphania ambrosioides, Ouret lanata, Portulaca oleracea* and *Portulaca quadrifida*; 0 weed species in class-B;14 weed species in class-C, i.e., *Alternanthera philoxeroides, Amaranthus spinosus, Celosia argentea, Chenopodium album, Chenopodiastrum murale, Digera muricata, Dysphania ambrosioides, Gomphrena serrate, Mirabilis jalapa, Opuntia elatior, Opuntia stricta, Portulaca oleracea and Portulaca quadrifida*; 13 weed species in class-D, i.e., *Alternanthera bettzickiana, Alternanthera philoxeroides, Alternanthera sessilis, Amaranthus spinosus, Antigonon leptopus, Celosia argentea, Chenopodium album, Chenopodiastrum murale, Digera muricata, Dysphania ambrosioides, Ouret lanata, Portulaca oleracea* and *Portulaca quadrifida*; & 06 weed species in class-E, i.e., *Antigonon leptopus, Mirabilis jalapa, Opuntia elatior, Opuntia stricta, Portulaca oleracea* and *Portulaca quadrifida* (Fig. 3).

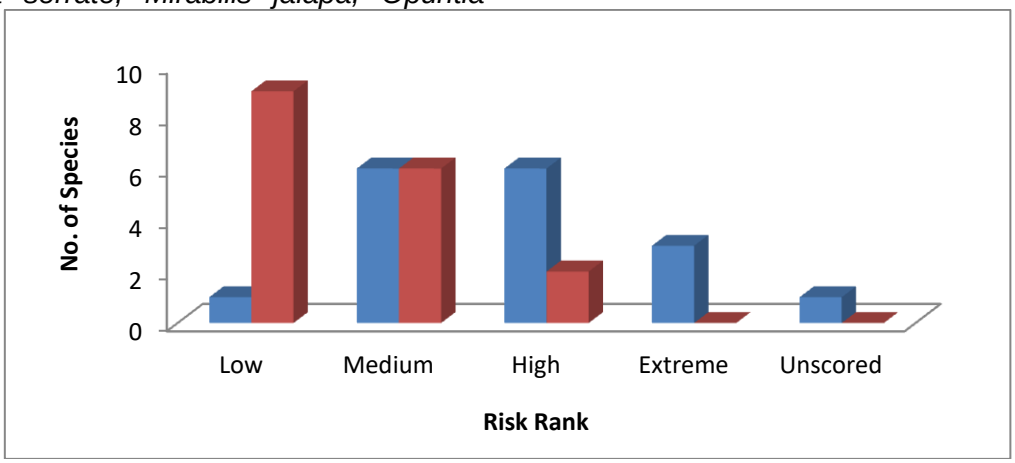

Fig. 2: Comparative outcome of weeds in different risk rank status

In the phase of dispersal of weed species, there were 17 weed species in class-F, i.e., *Alternanthera bettzickiana, Alternanthera philoxeroides, Alternanthera sessilis, Amaranthus spinosus, Antigonon leptopus, Celosia argentea, Chenopodium album, Chenopodiastrum murale, Digera muricata, Dysphania ambrosioides, Gomphrena serrata, Mirabilis jalapa, Opuntia elatior, Opuntia stricta,Ouret lanata, Portulaca oleracea* and *Portulaca quadrifida*; 9 weed species in class-G, i.e., *Alternanthera philoxeroides, Amaranthus spinosus, Antigonon leptopus, Chenopodium album, Chenopodiastrum murale, Dysphania*

ambrosioides, Opuntia stricta,Ouret lanata, Portulaca oleracea; 9 weed species in class-H, i.e., *Alternanthera philoxeroides, Antigonon leptopus, Celosia argentea, Chenopodium album, Chenopodiastrum murale, Gomphrena serrata, , Opuntia stricta,Ouret lanata, Portulaca oleracea*; 16 weed species in class-I, i.e., *Alternanthera bettzickiana, Alternanthera philoxeroides, Alternanthera sessilis, Amaranthus spinosus, Antigonon leptopus, Celosia argentea, Chenopodium album, Chenopodiastrum murale, Digera muricata, Dysphania ambrosioides, Gomphrena serrata, Mirabilis jalapa, Opuntia elatior, Opuntia stricta, Portulaca oleracea* and *Portulaca quadrifida*; 12 weed species in class-J, i.e., *Alternanthera bettzickiana, Alternanthera philoxeroides, Amaranthus spinosus, Antigonon leptopus, Celosia argentea, Chenopodium album, Dysphania ambrosioides, Mirabilis jalapa, Opuntia elatior, Opuntia stricta, Ouret lanata, Portulaca oleracea* (Fig. 3).

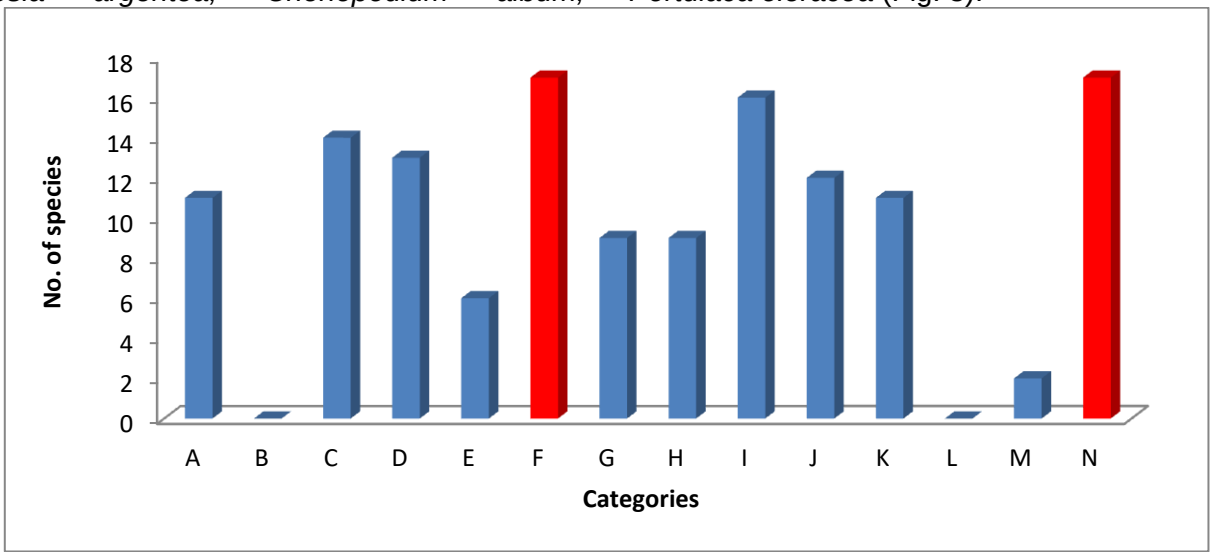

Fig. 3: Number of weed species in different categories of entry, dispersal and impact phase

In the phase of impact of weed species, there were 11 weed species in class-K, i.e., *Alternanthera bettzickiana, Alternanthera philoxeroides,Alternanthera sessilis, Amaranthus spinosus, Celosia argentea, Chenopodium album, Chenopodiastrum murale, Digera muricata, Gomphrena serrata, Ouret lanata, Portulaca oleracea* and *Portulaca quadrifida*; 0 weed species in class L; 2 weed species in class-M, i.e. *Alternanthera philoxeroides* and *Alternanthera sessilis*; 17 weed species in class-N, i.e. *Alternanthera bettzickiana, Alternanthera philoxeroides, Alternanthera sessilis, Amaranthus spinosus, Antigonon leptopus, Celosia argentea, Chenopodium album, Chenopodiastrum murale, Digera muricata, Dysphania ambrosioides, Gomphrena serrata, Mirabilis jalapa, Opuntia elatior, Opuntia stricta, Ouret lanata, Portulaca oleracea* and *Portulaca quadrifida* (Fig. 3).

All the reported weed species showed the following types of origin centres: 10 weed species (62%) were from Tropical America, followed by 2 weed species (13%) from Europe, 2 weed species (13%) from South America, 1 weed species (6%) from Tropical Africa, 1 weed species (6%) from Peru, 1 weed species (6%) from North America (Fig. 5). The current study reveals that 9 weed species were recorded in the low risk rank on the basic generic weed risk score analysis, i.e., *Alternanthera sessilis, Antigonon leptopus, Digera muricata, Dysphania ambrosioides, Gomphrena serrate, Mirabilis jalapa, Opuntia elatior, Opuntia stricta* and *Ouret lanata*; 6 weed species were recorded in the medium risk rank, i.e., *Alternanthera bettzickiana, Amaranthus spinosus, Celosia argentea, Chenopodiastrum murale and Portulaca quadrifida; and 2 weed species were recorded in the high risk rank, i.e., Alternanthera philoxeroides and Portulaca oleracea* (Table. 1).

The current study reveals that 12 weed species (70%) were recorded as herbs, followed by creeping herb 3 weed species (18%), while climbing herb and under shrub represents by 1 species each (6%), (Fig. 4). There were two types of weed categories, and we found that 41% of weed species were Ruderal weed

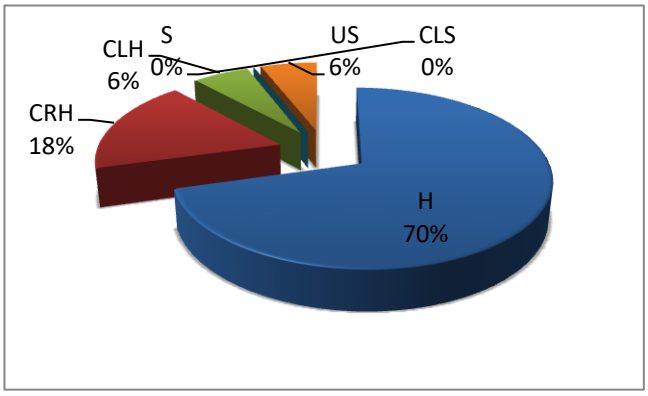

Fig. 4: Life forms of reported weed species

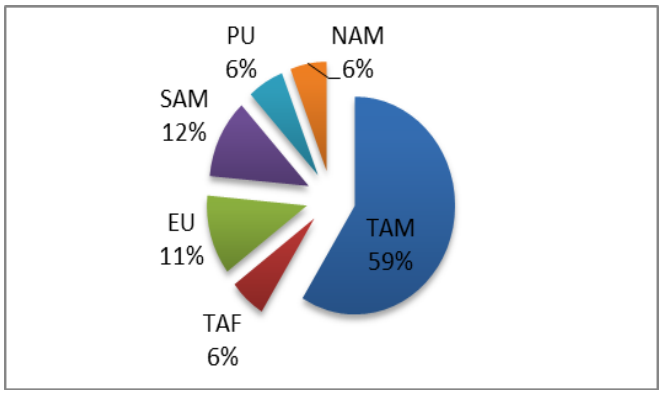

Fig. 5. % of weed species with origin centres

species, followed by 41% Agrestal weed species, and 18% as above for both types of weed species. Comparative representation of the current study with the Findings of the Global Compendium of Weeds reveals that there were 1 weed species in the low rank status of the Global Compendium, and we recorded 9 weed species out of 17 in low rank status. In our current study, we found that only 6 weed species were in medium risk rank status although 6 weed species were in the database of the Global Weed Compendium.

Table 2: A comparative representation of the current study with the Findings of Global Compendium of Weeds

Weed Name	APG-IV Families under Superasterids Grade	Life forms	Weed's category		Generalize weed risk score		Weed Risk Rank Status	
			RW	AW	Global weed compendium	Current study	Global weed compendium	Current study
Alternanthera bettzickiana (Regel) G.Nicholson	Amaranthaceae	H	RW	AW	2.88	6.84	LOW	MEDIUM
Alternanthera philoxeroides (Mart.) Griseb.	Amaranthaceae	H	RW	AW	44.8	25	EXTREME	HIGH
Alternanthera sessilis (L.) R.Br. ex DC.	Amaranthaceae	H	RW	AW	19.2	2.4	HIGH	LOW
Amaranthus spinosus L.	Amaranthaceae	H	RW	AW	19.2	12	HIGH	MEDIUM
Antigonon leptopus Hook. & Arn.	Polygonaceae	CLH	RW	-	24	3.0	HIGH	LOW
Celosia argentea L.	Amaranthaceae	H	-	AW	26.88	12	HIGH	MEDIUM
Chenopodium album L.	Amaranthaceae	H	-	AW	44.8	15	EXTREME	MEDIUM
Chenopodiastrum murale (L.) S.Fuentes, Uotila & Borsch	Amaranthaceae	H	-	AW	UNSCORED	12	N/A	MEDIUM
Digera muricata (L.) Mart.	Amaranthaceae	H	-	AW	16.00	6	HIGH	LOW
Dysphania ambrosioides (L.) Mosyakin & Clemants	Amaranthaceae	H	RW	-	14.4	4	MEDIUM	LOW
Gomphrena serrata L.	Amaranthaceae	CRH	RW	AW	9.12	2.16	MEDIUM	LOW
Mirabilis jalapa L.	Nyctaginaceae	H	RW	-	14.4	1.08	MEDIUM	LOW
Opuntia elatior Mill.	Cactaceae	H	RW	-	14.4	1.08	MEDIUM	LOW
Opuntia stricta (Haw.) Haw.	Cactaceae	H	RW	-	24	1.80	HIGH	LOW
Ouret lanata (L.) Kuntze	Amaranthaceae	US	RW	-	7.2	3.04	MEDIUM	LOW
Portulaca oleracea L.	Portulacaceae	CRH	-	AW	44.8	16.8	EXTREME	HIGH
Portulaca quadrifida L.	Portulacaceae	CRH	-	AW	8.96	6.72	MEDIUM	MEDIUM

Life Form: (H)=Herb, (S)=Shrub, (CRH)=Creeping herb, (CLH)=Climbing Herb (CLS)=Climbing Shrub; (AW)=Agrestals weeds, (RW)=Ruderals weeds

In our work, we found that there were 2 weed species in the high and zero weed species in extreme risk rank statuses, while there were 6 weed species in the high-risk rank and 3 weed species in the extreme risk rank status. There were 1 weed species in unscored status in the compendium, and in our analysis, we found no species in unscored status (Table. 2 & Fig. 1).

According to the database of the Global Weed Compendium, weed species, i.e., *Alternanthera philoxeroides, Chenopodium album* and *Portulaca oleracea* were recorded in extreme status, but in our analysis, *Alternanthera philoxeroides* as high risk rank status, *Chenopodium album* as medium and *Portulaca oleracea* as high risk rank status (Fig. 2).

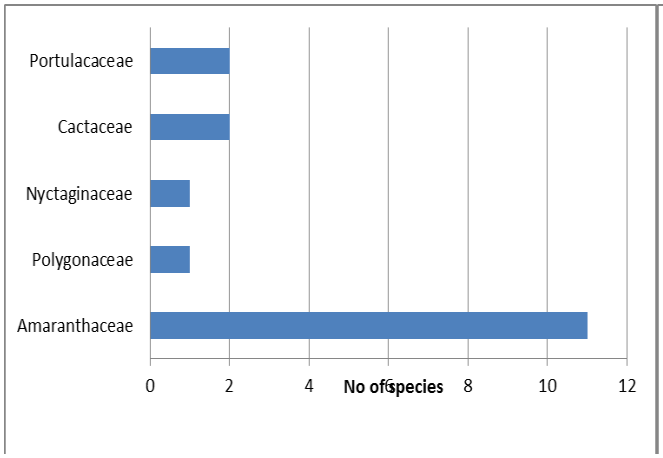

Fig. 6: Number of weed species within families

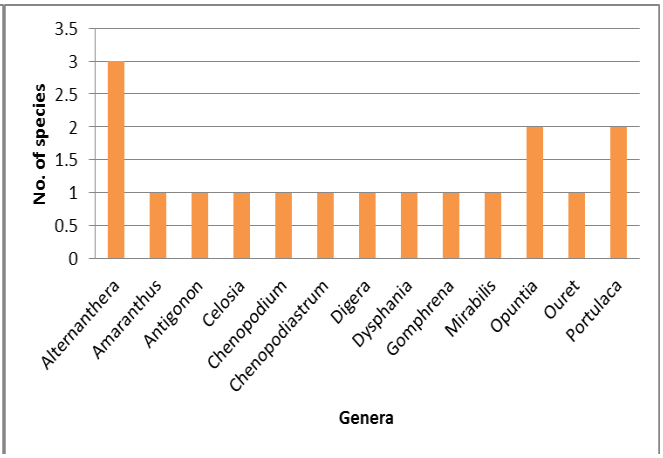

Fig. 7: Dominated weed genera representation

This is a problem that currently impacts most of the study of invasive species, and while a well referenced definitions article has been prepared, those concepts are not properly applied (Richardson *et al.,* 2000). 'Invasive is a phrase that is frequently misused and misinterpreted in the literature. Agricultural or environmental weed are typically more informative and relevant terminology. Because the majority of sources in the literature do not use the term appropriately, 'Invasive' now scores the same as these more specified impacts. Many plant species identified as environmental weeds might frequently be considered naturalisation reports. Environmental consequences are more difficult to measure than agricultural impacts, and more work need to be done to identify and quantify the entire extent and price of weed environmental impacts. However, for the most part, species listed as environmental and agricultural weeds have been regarded as such unless the source's criteria show a glaring mismatch. Furthermore, desire for ornamental species is frequently driven by fashion, advertising, and price, all of which are human blunders that have resulted in numerous successful plant invasions (Dehnen-Schmutz *et al.,* 2007). Climate is a crucial factor in assessing potential dangers. If a suitable climate exists and no cultural, agronomic, or managerial impediments exist, the system risk rank outcome may be appropriate. However, if no suitable conditions are available, the likelihood of rated species establishing in a location is likely low. Applying a discount based on climate match can change the risk score based on a species' preferred environment.

The study finds that the aforementioned approach may be used to determine the risk rank status of the concerned weed species in the concerned climatic and various habitats. The revealed data will supply the future aspect of the problematic weed species, and we will be able to check them. The research will also aid in the optimal use of weedicides and concentrations for certain weed species in various agricultural settings.

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REFERENCES

Ali, R., Khalil, S K., & Raza, S.M. (2003) Effect of herbicides and row-spacing on maize (Zea mays L.). *Pakistan Journal of Weed Science Research (Pakistan)* **9**(3).

Amritanshu, S.P., Tyagi, A., Srivastava, A., & Pathak, A. (2023) Status of some extractable macro-and micro-nutrients in the soils of Dehradun district of Uttarakhand. *Annals of Plant and Soil Research* **25**(2): 221-229.

Angiosperm Phylogeny Group, Chase, M.W., Christenhusz, M.J., Fay, M.F., Byng, J. W., Judd, W.S., & Stevens, P.F. (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical journal of the Linnean Society* **181**(1): 1-20.

Boguzas, V., Marcinkeviciene, A., & Kairyte, A. (2004) Quantitative and qualitative

evaluation of weed seed bank in organic farming. *Agronomy research* **2**(1): 13-22.

Da Silva, J.M., de Souza Lima, J.S., Pires, F.R., & de Assis, R.L. (2008) VARIABILIDADE ESPACIAL DOS ATRIBUTOS Fí SICOS EM UM LATOSSOLO SOB PLANTIO DIRETO E PREPARO CONVENCIONAL NO CULTIVO DA SOJA NO CERRADO. *Revista de Ciências Agrárias Amazonian Journal of Agricultural and Environmental Sciences* **50**(1): 167-180.

Daehler, C.C., & Carino, D.A. (2000) Predicting invasive plants: prospects for a general screening system based on current regional models. *Biological invasions* **2**: 93-102.

Daehler, C.C., Denslow, J.S., Ansari, S., & KUO, H.C. (2004) A risk-assessment system for screening out invasive pest plants from Hawaii and other Pacific islands. *Conservation biology* **18**(2): 360-368.

Dawson, W., Burslem, D.F., & Hulme, P.E. (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. *Biological Conservation* **142**(5): 1018-1024.

Dehnen-Schmutz, K., Touza, J., Perrings, C., & Williamson, M. (2007) A century of the ornamental plant trade and its impact on invasion success. *Diversity and Distributions* **13**(5): 527-534.

Director, D. W. R. (2015) ICAR-DWR Vision 2050.

Dwari, S., & Mondal, A. K. (2012) The impact, uses, and ecological role of agrestals in two selected agroecosystems of Eastern India. *International Journal of Biodiversity and Conservation* **4**(13): 472-480.

Frenkel, R. E. (1977) *Ruderal vegetation along some California roadsides* (Vol. 20). Univ of California Press.

Ghaffoor, A. (2004) Integrated weed management in different varieties of onion (Allium cepaL.). *Pakistan Journal of Weed Science Research (Pakistan)* **10**(1).

Gharde**,** Y., Singh, P.K., Dubey, R.P., & Gupta, P.K. (2018) Assessment of yield and economic losses in agriculture due to weeds in India. *Crop Protection* **107**: 12-18.

Gordon**,** D.R., & Gantz, C.A. (2008) Screening new plant introductions for potential invasiveness: a test of impacts for the United States. *Conservation Letters* **1**(5): 227-235.

Gordon, D.R., Onderdonk, D.A., Fox, A.M., Stocker, R.K., & Gantz, C. (2008) Predicting invasive plants in Florida using the Australian weed risk assessment. *Invasive Plant Science and Management* **1**(2): 178-195.

Iwara, A. I., Gani, B. S., Njar, G.N., & Deekor, T. N. (2011) Influence of soil physico-chemical properties on the distribution of woody tree/shrub species in South-Southern Nigeria. *Journal of Agricultural Sciences* **2**(2): 69-75.

Izquierdo, J., Blanco-Moreno, J.M., Chamorro, L., Recasens, J., & Sans, F. X. (2009) Spatial distribution and temporal stability of prostrate knotweed (Polygonum aviculare) and corn poppy (Papaver rhoeas) seed bank in a cereal field. Weed science **57**(5): 505-511.

Jain, S.K. (1977) Handbook of field and herbarium methods.

Kato, H., Hata, K., Yamamoto, H., & Yoshioka, T. (2006) Effectiveness of the weed risk assessment system for the Bonin Islands. *Assessment and Control of Biological Invasion Risks. Shoukadoh Book Sellers, Kyoto, Japan and IUCN, Gland, Switzerland* 65-72.

Kothari, Arkaprava R., & Das, A. (2023) Effect of nitrogen level and herbicide management on soil microbial function under conservation agriculture in Maize-Wheat system. *Annals of Plant and Soil Research* **25**(4): 541-548.

Křivánek, M., & Pyšek, P. (2006) Predicting invasions by woody species in a temperate zone: a test of three risk assessment schemes in the Czech Republic (Central Europe). *Diversity and Distributions* **12**(3): 319-327.

Mack, R. N. (1996) Predicting the identity and fate of plant invaders: emergent and emerging approaches. *Biological conservation* **78**(1-2): 107-121.

Muzik**,** T. J. (1970). Weed biology and control. *Weed biology and control.*

Naidu, V. S. G. R. (2012). Hand book on weed identification.

Nishida, T., Yamashita, N., Asai, M., Kurokawa, S., Enomoto, T., Pheloung, P. C., & Groves, R. H. (2009) Developing a pre-entry weed risk assessment system for use in Japan. *Biological invasions* **11**: 1319-1333.

Oerke, E. C. (2006) Crop losses to pests. *The Journal of Agricultural Science* **144**(1): 31-43.

Randall, R. P. (2016, September) Can a plant's cultural status and weed history provide a generalised weed risk score. In *Proceedings of the 20th Australasian Weeds Conference* (pp. 11-15).

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

Randall, R.P. (2016) 'Plants Database'. Department of Agriculture and Food, Western Australia. Unpublished database (4.62 million records).

Rao, A. N., Singh, R. G., Mahajan, G., & Wani, S. P. (2020) Weed research issues, challenges, and opportunities in India. *Crop Protection* **134**: 104451.

Rao, V. S. (1999) Principles of Weed Science. Santa Clara California USA. Oxford and IBH publishing Co. Pvt. Ltd. New Delhi **1**(3): 1-58.

Richardson, D. M., Pyšek, P., Rejmanek, M., Barbour, M. G., Panetta, F. D., & West, C. J. (2000) Naturalization and invasion of alien plants: concepts and definitions. *Diversity and distributions* **6**(2): 93-107.

Sinden, J., Jones, R., Hester, S., Odom, D., Kalisch, C., James, R., ... & Griffith, G. (2004) *The economic impact of weeds in Australia. Technical series*, *8*.

Singh, K. P., Sinha, G. P., & Khanna, K. K. (Eds.) (2016) *Flora of Uttar Pradesh: Ranunculaceae-Apiaceae/Edited by KP Singh, KK Khanna, GP Sinha; Contributors, KP Singh [and Eight Others]*. Botanical Survey of India.

Singh, S. P., & Kumari, B. (2018) Grasses of JP Nagar (Amroha) District of Uttar Pradesh. *Journal of Medicinal Plants Studies* **6**: 159-61

Sinha**,** G. P., & Shukla, A.N. (2020) *Flora of Uttar Pradesh* **vol. II.** Botanical Survey of India.

Weber, J., Panetta, F. D., Virtue, J., & Pheloung, P. (2009) An analysis of assessment outcomes from eight years' operation of the Australian border weed risk assessment system. *Journal of Environmental Management* **90**(2): 798-807.