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Taxonomic diversity of broad-leaf weeds at Bangladesh Agricultural University campus and their ethno-botanical uses

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ABSTRACT

An intensive survey and literature review was furnished to study taxonomic diversity and ethno-botanical uses of broad-leaf weeds available in BAU campus. Availability of 107 broad-leaf weed species has been identified and those belong to 78 genera and 38 families. Among the families, Fabaceae is best-represented with 13 weed species followed by Euphorbiaceae and Amaranthaceae (seven species in each), Solanaceae (six species), Convolvulaceae and Polygonaceae (five species); 17 families are represented by two to four species while 15 families by single species in each. The genera *viz. Desmodium*, *Ludwigia* and *Solanum*, are represented by four species in each followed by *Amaranthus*, *Ipomoea*, *Lindernia*, *Persicaria* and *Senna* three species in each; however, most of the genera are represented by one or two species in each. Three distinct phenology (flowering periods) *viz.* October-March (52), April-September (40) and all the year-round (15), were observed among identified weed species and the knowledge on phonological development would be helpful to know soil seedbank potential for their effective management. These weed species possess many ethno-botanical uses e.g., medicinal value, consumed as vegetable, feed, fodder, etc. This study provides information on ethno-botanic uses, taxonomic diversities and phenology of the broad-leaf weeds for their effective management.

Introduction

Weeds are unwanted and undesirable plants which interfere with the utilization of land and water resources and thus adversely affect human welfare (Rao, 2000). About 1570 plant species are recognized as weeds (absolute weed) throughout the world (Wiersema and Leon, 1999) and about 350 species of weeds are recorded from the crop fields of Bangladesh. About 20% of the present weed flora have been recognized as naturalized exotic weeds e.g., *Argemone maxicana*, *Alternanthera philoxeroides*, *Clerodendrum viscosum*, *Croton bonplandianum*, *Lathyrus aphaca*, *Lantana camara*, *Mimosa pudica*, *Nicotiana plumbaginifolia*, *Urenia lobata*, *Vicia angustifolia*, etc. (Hossain and Pasha, 2004). Uncontrolled weed growth, especially in the early stages of crop establishment, causes yield loss up to 25-80% depending upon types of crops (Kashem *et al.*, 2009); and the global economic losses more than $40 billion per annum occurs due to weeds through reduction of agricultural and silvicultural productivity, reduced access to land and water, impaired aesthetics and disruption of human activities and well-being (Kashem *et al.*, 2009). Despite these negative effects, weeds act as ground cover, source of organic matter and genetic materials for crop improvement, nutrient cycling, and possess many ethno-botanical uses e.g., medicine, vegetable, feed and fodder for domestic animal, etc. Not only in the Indian subcontinent and its neighbourhoods, weed species are also used for medicinal purposes in other regions of the world, for example Highland Maya of Chiapas (Mexico) and North American regions; weeds used in traditional medicinal floras may be the source of important new drugs (Stepp and Moerman, 2001).

An effective management (/control) program is essential to reduce the crop yield losses due to weeds. Weed management is a better option than control due to reduce crop production cost, protect natural balance, conserve environment, avoid elimination of species, avoid injury of main crops, encourage beneficial effects, and increase production. The knowledge on weed morphology and identification, habitat, viability and dormancy of weed seed, competitive ability with crop, etc., is essential to achieve an effective management program (Kashem *et al.*, 2009). In Bangladesh, the detailed taxonomic studies including phenology of weeds have been neglected by both the practising plant taxonomists and/or the agricultural scientists. We have scanty information on

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the weeds of different crops in agronomic publications (Islam, 2014; Akter *et al*., 2018; Shabi *et al*., 2018). The Bangladesh Agricultural University (BAU) campus with three major topographic types *viz*. plain area, slightly undulated area and basin-shaped low lying area, facilitates a wide range of habitats such as wetlands, marshy lands, open fields, fallow lands, etc. (Sarwar and Prodhan, 2011). The mean annual rainfall is 244.15 mm and the temperature varies from 11.9º to 32.5º C. This diverse climatic condition and wide habitat range provide a suitable condition for the growth of weeds in this campus which harbours a wide range of plant diversities. To make a complete weed flora of BAU campus, an intensive taxonomic study on the weeds available in this campus has recently been started (Cyperaceae, Jannat-E-Tajkia *et al*., 2018; Poaceae, Sagar *et al*., 2018; Asteraceae, Mia *et al*., 2019). As a part of this research, the species diversity of (dicotyledonous) broad-leaf weeds including their habitat, flowering period and ethno-botanical uses, have been reported here which might be useful for the green weed management practices and for getting higher economic benefits.

Materials and Methods

A rigorous field survey was carried out at BAU campus during 2018 to 2019. During the survey, fresh flowering samples of broad-leaf weeds, excluding the family Asteraceae, were collected through the year round by frequent field visits (once a week). Weeds from the family Asteraceae has already been reported in our previous paper (Mia *et al*., 2019). Other related information e.g., habitat, location, collection date, flowering time, crop/plant association, etc. were recorded during the field collection. Fresh samples were dried well for making voucher specimens. The collected weed specimens, fresh or dried, were identified by matching with herbarium specimens or published literature (Ahmed *et al*., 2008a, b, 2009) or consulting with experienced taxonomist at the Bangladesh National Herbarium, Dhaka. The botanical names were updated consulting with the Plant List (http://www.theplantlist.org/). All the specimens are preserved in Prof. Dr. Arshad Ali Herbarium at the Botanical Garden, Department of Crop Botany, Bangladesh Agricultural University.

The information related to ethno-botanical uses were collected from the published literature (Ahmed *et al*., 2008a, b, 2009; Dansi *et al*., 2008; Gutiérrez *et al*., 2014; Hastings, 1990; Khan *et al*., 2013; Kumar and Sane, 2003; Kumar *et al*., 2019; Lokho and Narasimhan, 2013; Manandlar, 1995; Marandi and Britto, 2015; Minarchenko *et al*., 2017; Nayar *et al*., 1988; Keat *et al*., 2010; Oyedeji *et al*., 2011; Panda and Misra, 2011; Pandey and Singh, 2017; Pant and Samant, 2010; Pascual *et al*., 2001; Pragada and Rao, 2012; Sahu, 1984; Sarker *et al*., 2017; Srivastava, 2017; Uddin, 2006; Upreti *et al*., 2009).

Results and Discussion

An enumeration of the species recorded was presented with botanical name, common name(s), English name, family, flowering time and habitat. In this present paper, the occurrence of 107 weed species belong to 78 genera and 38 families has been reported (Tables 1 and 2). One weed species could only be identified down to genus level (*Phyllanthus* sp.). Among the families, Fabaceae is the best-represented family with 13 species followed by Euphorbiaceae and Amaranthaceae (Seven species in each), Solanaceae (six species). Convolvulaceae and Polygonaceae are represented by five species each; 17 families are represented by two to four species in each while 15 families by a single species in each (Table 2). Among the genera, the largest genera are *Desmodium*, *Ludwigia* and *Solanum* represented by 4 species each followed by *Amaranthus*, *Ipomoea*, *Lindernia*, *Persicaria* and *Senna* by 3 species each; however, most of the genera are represented by single or two species each (Table 1). The distribution pattern of weeds (number of genera and/or species) was varied from place to place. For example, the number of weed species belongs to the family Fabaceae varies from 6 to 14 (Mamun, 1989; Moody, 1989; Karim and Kabir, 1995; Khan and Parveen, 2018). Looking through the weed flora of the BAU campus, Poaceae was the largest family (81 species) followed by Cyperaceae (48 species) and Asteraceae (26 species); moreover, *Fimbristylis* (13 species) and *Cyperus* (12 species) of the family Cyperaceae were most species-rich genera followed by *Digitaria* (9 species) of the Poaceae (Jannat-E-Tajkia *et al*., 2018; Sagar *et al*., 2018; Mia *et al*., 2019). Apart from the Poaceae, many of the top 12 weed families are also the same families that are important for medicinal *viz*. Asteraceae, Fabaceae, Convolvulaceae, Euphorbiaceae, Solanaceae, Malvacae, and Chenopodiaceae (Stepp and Moerman, 2001; Table 2).

Some of these recorded weed species are common and major weeds in the rice, wheat, jute and other crop fields (Islam, 2014; Akter *et al*., 2018; Shabi *et al*., 2018). Species from the genera *Lantana*, *Amaranthus*, *Cassia*, *Cephalandra*, *Anisomeles*, *Cleome*, *Croton*, *Desmodium*, *Dryopteris*, *Justicia*, *Mimosa*, *Melochia*, *Oxalis*, *Scoparia*, etc., were very common and distributed all over the habitat (campus). The habitat diversity varied from crop fields and its levees to roadsides, fallow lands, play grounds, waste lands, edges of drains, dry lands, shallow water bodies, etc. Based on the phenology (flowering times), identified weed species belong to three distinct groups i.e., flowering occurs during the month of October–March (52 species), April–September (40 species) and all the year-round (15 species) (Table 1). The knowledge of habitats and flowering period can be utilized as an effective tool for the management of

weeds. Appropriate management practices before/at flowering will help us to maintain the weed population below the economic threshold level and break-up the weed seedbank in the soil for future regeneration. It is, therefore, essential to understand the phenology and habitat of the weeds to select the appropriate management practices. Hence, the population of weeds can be maintained below the economic threshold level if these weeds can be managed before flowering. Weeds, at the field margins and the surrounding natural vegetation, sometimes provide a habitat where beneficial arthropods may find refuge, alternative hosts, water, overwintering sites, favourable microclimate and escape from pesticides applied to the crop.

Weeds, regarded undesired in crop field and neglected as the constant source of annoyance and trouble to the farmers, are simply eradicated by mechanical and/or chemical means; though they are important from the standpoint of medicinal, allelopathic and food values (Bhattacharjya and Borah, 2008). Ethnic/tribal peoples have been consuming these weeds for generations not only as medicine but as food also. The study reveals that the weeds from the crop fields and wastelands possess multiple medicinal uses. The ethno-botanical uses of the reported weeds are much diversified (Table 3) and also recorded in different ethno-botanical references (Uddin, 2006). Out of 107 weed species, a total of 69 species have the medicinal properties/uses while 26 species used both as vegetable and medicinal purposes, three species as vegetable, one as fodder crop, one as fodder and medicine, one species is used as fish poison. Hitherto, six species did not have any known ethno-botanical uses (Table 3). Recent time, there are a lot of difficulties to collect medicinal plants from forest due to Government's forest policies. Therefore, the crop fields and other disturbed ecosystems are preferred habitats for medicinal plant collection and/or procurement by many traditional peoples (Immanuel and Elizabeth, 2009). Weeds in disturbed areas are likely to have more chemicals in them for defense which are biologically active and potentially useful for medical science. Out of the various parts used as native medicines, leaf and shoot or the whole plant is commonly used; roots, buds, flowers, fruits, seeds and exudates like latex and juices are less commonly used (Panda and Misra, 2011). These medicinal plants are commonly used by the local people to cure following the diseases *viz*. fever, asthma, urinary problems, cough, cold, small pox, dysentery, diarrhoea, diabetes, eczema, fracture of bone, headache, heart disease, itches, jaundice, menstrual disease, paralysis, piles, skin diseases, snake-bite, toothache, vomiting, worm, wound and others (Table 3).

Based on medicinal uses, species from the genera namely *Anisomeles*, *Chenopodium*, *Coccinia*, *Colocasia*, *Croton*, *Cuscuta*, *Desmodium*, *Eichhornia*, *Euphorbia*, *Heliotropium*, *Indigofera*, *Ipomoea*, *Justicia*, *Lantana*, *Lippia*, *Mimosa*, *Oldenlandia*, *Phyla*, *Portulaca*, *Senna*, *Sida* and *Solanum* have diversified ethno-medicinal uses. A single weed species is sometimes used for the treatment of many diseases. For example, *Colocasia esculenta* is used to treat jaundice, cut & wounds, antibacterial & hypotensive, menstruation, stomach problems, cysts, poultice to boils, conjunctivitis, constipation, colic, digestive; *Mimosa pudica* to treat dysentery, haemorrhoids, mouth ulcer, sore nipples, scurvy, disease of kidney, liver, spleen bladder, pyorrhoea, insulin secretion, blood purifier, fever, sun stroke; *Oldenlandia corymbosa* to clear heat and toxins, activate blood circulation, promote dieresis and relieve stranguria (urinary obstruction), tumours of the digestive tract lymphosarcoma and carcinoma of the liver & larynx, appendicitis, hepatitis, pneumonia, cholecystesis, cellulites, snake bite, skin sores, ulcers, sore throat, bronchitis, gynaecologic infections & pelvic inflammatory diseases (Table 3). Therefore, losses of a single species may sometimes be more detrimental in terms of ethno-medicinal values. On the other hand, more than one weed species with different formulation were sometimes used for the treatment of a single disease. For example, dysentery is treated with 23 species followed by fever with 21 species, skin diseases with 20 species, asthma with 17 species, ulcer with 16 species, jaundice with 12 species, stomach-ache with 10 species, rheumatism with 9 species, urinary problems with 8 species, and malaria with 6 species. Diarrhoea and Diabetes, two of the most deadly diseases of the present era (www.healthline.com/health/top-10-deadliest-diseases#copd), are also treated with eleven and seven weed species, respectively (Table 3).

Several recent studies have proved the weedy plants contain many medically useful active ingredients *viz.* alkaloids, glycosides, polyphenolics, steroids, tannins, resins, flavonoids, fatty acids, that are able to cure many nutritional disorders and diseases in the human health care system (Immanuel and Elizabeth, 2009). Therefore, there is a strong need to take necessary steps for the conservation and sustainable use of these weeds (as medicinal plants) in future through green weed management practices without hampering the crop yield and agricultural productivity.

Table 1. Broad-leaf weed diversity recorded from the Bangladesh Agricultural University campus

Sl. No.	Botanical Name	Local Name	English Name	Family	Flowering Period	Habitats
1	*Achyranthes aspera* Br.	Biral achra, Upat lengra	Prickly chafflower, Snake tail	Amaranthaceae	Aug-Nov	Sunny open places, roadsides, waste places, bank of ponds
2	*Alternanthera philoxeroides* (Mart.) Griseb.	Malancha	Alligator weed	Amaranthaceae	Jun-Sep	Stagnant or slow moving shallow water, wet soil
3	*Alternanthera sessilis* (L.) R.Br. *ex* DC.	Chanchi	Sessile Joyweed	Amaranthaceae	Year-round	Wet paddy fields, ditches to dry roadside banks, gardens or other disturbed grounds
4	*Amaranthus graecizans* L.	Not known	Prostrate pigweed	Amaranthaceae	Jul-Nov	Roadsides, waste places
5	*Amaranthus spinosus* L.	Katanotey	Spiny pigweed	Amaranthaceae	Year-round	Waste lands, roadsides, fields, gardens
6	*Amaranthus viridis* L.	Shaknotey	Pigweed	Amaranthaceae	Year-round	Waste & disturbed grounds, roadsides
7	*Ammannia multiflora* Roxb.	Not known	Joy weed	Lythraceae	Jul-Sep	Wet places, river banks, paddy fields
8	*Anisomeles indica* (L.) Kuntze	Gobura/Bantukma	Not known	Lamiaceae	Oct-Jul	Roadsides, bank of ponds, fallow lands
9	*Argyreia nervosa* (Burm.f.) Boj.	Pankalmi, Bara Dudhi, Hris Gandha	Elephant Creeper	Convolvulaceae	Jul-Oct	Bank of ponds
10	*Cardamine flexuosa* With.	Not known	Woodland Bittercress	Brassicaceae	Feb-Jul	Roadsides, fields, grasslands, disturbed sides
11	*Centella asiatica* (L.) Urb.	Thankuni	Asiatic pennywort	Apiaceae	Feb-May	Roadsides, bank of ponds, fallow lands
12	*Chenopodium album* L.	Bathua	Lambsquarter	Chenopodiaceae	Dec-Mar	Rabi crops fields, levees, irrigation channel
13	*Cleome diffusa* Banks *ex* DC.	Not known	Spreading spider flower	Capparaceae	Year-round	Shady, damp waste places, roadsides
14	*Clerodendrum viscosum* Kent.	Bhaidera	Hill glory bower	Verbenaceae	Dec-Mar	Roadsides, waste places
15	*Coccinia grandis* (L.) Voigt.	Telakucha	Scarlet-fruited gourd	Cucurbitaceae	Jan-Sep	Roadsides, fallow & waste lands
16	*Colocasia esculenta* (L.) Schott.	Kachu	Elephant-ear	Araceae	Aug-Nov	Moist to stagnant areas, bank of ponds
17	*Commelina benghalensis* L.	Kanaibashi	Day flowers	Commelinaceae	Mar-Oct	Moist to stagnant areas, irrigation channel, levee of crop fields, waste lands
18	*Commelina diffusa* Burm. f.	Monayna	Climbing dayflower	Commelinaceae	Jul-Nov	Rabi crops fields, roadsides, fallow lands
19	*Croton bonplandianum* Baill.	Bonmircha/Bon-Tulasi	Bonplant's croton	Euphorbiaceae	Year-round	Roadsides, levee of crop fields, dry & sandy exposed areas
20	*Cuscuta reflexa* Roxb.	Sharnalata	Dodder	Orobanchaceae	Apr-Sep	Roadsides, vegetation, hedges
21	*Cyanotis axillaris* (L.) Don *ex* Sweet	Kanainala	Creeping Cradle Plant	Commelinaceae	Aug-Nov	Fallow lands, levee of crop fields
22	*Cyathula prostrata* (L.) Blume	Pidini	Pasture weed	Amaranthaceae	Sep-Nov	Shaded localities, roadsides, dry grassland, bank of ponds
23	*Desmodium gangeticum* (L.) DC.	Narinda ghash, Salpani, Chalani	Sal leaved desmodium	Fabaceae	Apr-Nov	Roadsides
24	*Desmodium heterophyllum* (Willd.) DC.	Banmatar shuti	Variable leaf tick trefoil	Fabaceae	Mar-Jul	Bank of ponds, levee of crop fields, roadsides, shady waste places
25	*Desmodium laxiflorum* DC.	Not known	Loose-flowered desmodium	Fabaceae	Aug-Dec	Roadsides, waste places
26	*Desmodium trifolium* (L.) DC.	Tripatri	Creeping tick trefoil	Fabaceae	Year-round	Roadsides, bank of ponds, fallow lands, grasslands

Table 1. Cont.

Sl. No.	Botanical Name	Local Name	English Name	Family	Flowering Period	Habitats
27	*Drymaria cordata* subsp. *diandra* (Blume) J.A.Duke	Not known	West-India chickweed	Caryophyllaceae	Year-round	Waste places, edges of drains, grasslands
28	*Dryopteris filix-mas* (L.) Schott	Dhekishak, Paloi	Fern	Dryopteridaceae	Year-round	Bank ofponds, roadsides, waste places
29	*Duchesnea indica* (Jacks.) Focke.	Not known	Mock strawberry	Rosaceae	Mar-Jul	Roadsides, grassy waste places
30	*Eichhornia crassipes* (Mart.) Solms.	Kochuripana	Water hyacinth	Pontederiaceae	Apr-Jul	Stagnant areas
31	*Euphorbia hirta* L.	Bara dudhia	Pillpod/Garden spurge	Euphorbiaceae	Mar-Jun	Waste places, fallow lands, paddy fields, roadsides, bank of ponds
32	*Euphorbia thymifolia* L.	Harvangri, Dudhiya, Swetkan	Gulf sandmat	Euphorbiaceae	Year-round	Waste lands, along roadsides, wall sides
33	*Glycosmis pentaphylla* (Retz.) DC.	Motkila	Rum berry	Rutaceae	Oct-Apr	Bank of ponds, fallow lands
34	*Heliotropium indicum* L.	Hatisur	Indian Heliotrope	Boraginaceae	Sep-Apr	Open waste places, roadsides, bank of ponds, levee of crop fields
35	*Hydrocotyle sibthorpioides* Lamk.	Not known	Lawn pennywort	Apiaceae	Year-round	Wet damp or shaded soil, bank of ponds
36	*Hydrolea zeylanica* (L.) Vahl	Kashcora	Blue water leaf	Boraginaceae	Dec-Mar	Wet damp soil, paddy fields
37	*Indigofera suffruticosa* Mill.	Belati Nil	Indigo	Fabaceae	Aug-Jan	Waste lands, cultivated fields, roadsides
38	*Ipomoea alba* L.	Dudhikalmi	The Moon Flower	Convolvulaceae	Year-round	Waste lands, bank of ponds
39	*Ipomoea crassicaulis* (Benth.) Robinson	Pahari kalmi/ Dholkolmi	Bush morning glory	Convolvulaceae	Jan-Dec	Stagnant water, roadsides, bank of pond, fallow lands
40	*Ipomoea triloba* L.	Not known	3-lobed morning glory	Convolvulaceae	Dec-Mar	Roadsides, waste & fallow lands
41	*Justicia gendarussa* Burm.f.	Justicia/Jagatmadan	Gandarussa	Acanthaceae	Sep-Mar	Waste places
42	*Lantana camara* L.	Lantana, Putus	Lantana/Wild sage	Verbenaceae	Year-round	Roadsides, waste places
43	*Leonurus sibiricus* L.	Raktadrone	Red verticilla	Lamiaceae	Oct-Apr	Fallow lands, roadsides, bank of ponds
44	*Leucus aspera* (Willd) Link.	Shetdrone	White verticilla	Lamiaceae	Oct-Mar	Roadsides, fallow lands
45	*Lindernia antipoda* (L.) Aston	Choto helencha, Sada panighash	Sparrow false pimpernel	Scrophulariaceae	Sep-Dec	Fallow land, levee of crop fields
46	*Lindernia crustacea* (L.) Muell.	Chapraghash	Brittle false pimpernel	Scrophulariaceae	Feb-Apr	Roadsides and levee of crop fields
47	*Lindernia parviflora* Roxb.	Panighash	Small flowered Lindernia	Scrophulariaceae	Aug-Dec	Muddy or sandy soil, disturbed area, roadside
48	*Lippia alba* (Mill.) N.E.Br. *ex* Britton & P.Wilson	Matka	Thorny amaranth	Verbenaceae	Aug-Feb	Bank of ponds and roadsides
49	*Lobelia chinensis* Lour.	Not known	Chinese lobelia	Campanulaceae	Year-round	Damp places, grassy fields, edges of drains
50	*Ludwigia decurrens* (Walter) DC.	Panilong/Pani agra	Winged water primrose	Onagraceae	Oct-Mar	Moist to stagnant water, paddy fields, edges of drains
51	*Ludwigia octovalvis* (Jacq.) Raven	Panilong	Willow Primrose	Onagraceae	Oct-Mar	Moist to stagnant water, paddy fields, edges of drains
52	*Ludwigia perennis* L.	Panilong	Perennial water primrose	Onagraceae	Oct-Mar	Moist to stagnant water, paddy fields, edges of drains

Table 1. Cont.

Sl. No.	Botanical Name	Local Name	English Name	Family	Flowering Period	Habitats
53	*Ludwigia adscendens* (L.) H. Hara	Keshordam/ Panidoga	Creeping water primrose	Onagraceae	Jun-Nov	Water bodies, roadsides
54	*Marsilea quadrifolia* L.	Shushni shak	4- leaved water clover	Marsileaceae	Nov-Mar	Margins of ponds, boro rice fields
55	*Mazus pumilus* (Burm. f.) Steenis	Tutra	Japanese mazus	Phrymaceae	Sep-Jan	Fallow lands, ails of crop fields, roadsides
56	*Melilotus officinalis* subsp. *alba* (Medik.) H. Ohashi & Tateishi	Sada Methi/Shunzai	White melilot	Fabaceae	Jan-Apr	Crop fields
57	*Melochia corchorifolia* L.	Not known	Chocolate weed	Malvaceae	Jul-Oct	Sunny or slightly shaded humid localities
58	*Merremia umbellata* (L.) Hallier f.	Sada kalmi	Hogvine	Convolvulaceae	Feb-Jun	Along fields, roadsides
59	*Mimosa pudica* L.	Lazzaboti	Sensitive/Shy plant	Fabaceae	Sep-Jan	Roadsides, levee of crop fields
60	*Monochoria hastata* (L.) Solms.	Panikachu	Leaf Pondweed	Pontederiaceae	Feb-Sep	Stagnant water, moist areas, rice fields
61	*Mukia medaraspatana* (L.) Roem.	Kucchela	Rough bryony	Cucurbitaceae	Jan-Dec	Bank of pond, fallow lands
62	*Nicotiana sylvestris* Speg. & Comes	Bon tamak	Woodland tobacco	Solanaceae	Jan-Apr	Crop fields, roadsides, levee of crop fields
63	*Oenanthe javanica* (Blume) DC.	Pan-turasi	Water Dropwort	Apiaceae	Mar-Aug	Wet grasslands, shallow water
64	*Oldenlandia corymbosa* L.	Khetpapri	Diamond flower	Rubiaceae	Sep-Dec	Levee of crop fields & irrigation channel, fallow lands
65	*Oxalis debilis*Kunth	Not known	Pink-sorrel	Oxalidaceae	Jan-Mar	Roadsides, waste places
66	*Oxalis stricta* L.	Amrul	Indian sorrel	Oxalidaceae	Dec-Apr	Dry sandy to moist areas, levee of crop fields, rice fields
67	*Peperomia pellucida* (L.) H.B.K.	Peperomia, Pitha pata, Shamoli ghash	Shiny bush	Piperaceae	Jul-Dec	Moist areas, bank of ponds, roadsides, fallow lands
68	*Persicaria chinensis* (L.) Gross	Not known	Chinese knotweed	Polygonaceae	Jan-Apr	Waste and fallow lands, roadsides
69	*Phylla nodiflora* (L.) Greene	Nima/Deshi Henchi	Cape weed/Fog fruit	Verbenaceae	Aug-Oct	Roadsides, bank of ponds, levee of crop fields, fallow lands
70	*Phyllanthus amarus* Schumach. & Thonn.	Not known	Sleeping plant	Euphorbiaceae	Apr-Oct	Dry fields, roadsides, waste places
71	*Phyllanthus niruri* L.	Hajar/Sato dana	Gale of the wind	Euphorbiaceae	Aug-Oct	Paddy fields, roadsides, levee of crop fields, fallow lands
72	*Phyllanthus* sp.	Not known	Not known	Euphorbiaceae	Mar-Sep	Paddy fields, roadsides, waste places
73	*Physalis heterophylla* Nees.	Foska Begun	Clammy ground cherry	Solanaceae	Feb-Apr	Crop fields, roadsides
74	*Pilea microphylla* (L.) Liebm.	Not known	Rockweed	Urticaceae	Year-round	On walls and in waste, rocky places
75	*Pimpinella heyneana* (DC.) Benth.	Not known	Not known	Apiaceae	Dec-Mar	Moist areas, grasslands, waste ground, roadsides
76	*Pistia stratiotes* L.	Topa pana	Water lettuce	Araceae	Feb-Sep	Pond, irrigation channel, boro rice fields
77	*Pogostemon auricularis* (L.) Hassk.	Not known	Not known	Lamiaceae	Jul-Sep	Roadsides, waste places
78	*Polygonum hydropiper* (L.) Delarbre	Bishkatali	Water pepper	Polygonaceae	Jan-Sep	Levee of crop fields, irrigation channel, fallow lands, roadsides, bank of ponds
79	*Polygonum lapathifolium* (L.) Delarbre	Agra	Dockleaved persicaey	Polygonaceae	Jun-Aug	Levee of boro rice fields, roadsides, fallow lands
80	*Polygonum plebeium* R. Br.	Khetpakri, Chinaduli ghash	Bistort	Polygonaceae	Jan-Dec	Rabi crops fields, roadsides, bank of ponds, levee of crop fields, play ground, fallow lands
81	*Portulaca oleracea* L.	Nunia shak	Purslane	Portulaceae	Nov-Jun	Roadsides, levee of crop fields, fallow lands

Table 1. Cont.

Sl. No.	Botanical Name	Local Name	English Name	Family	Flowering Period	Habitats
82	*Pteris vittata* L.	Dhekishak	Ladder Brake	Pteridaceae	Year-round	Roadsides, waste & fallow lands
83	*Rorippa indica* (L.) Hiern.	Lai agra, Bansarisha	Indian Field Cress	Brassicaceae	Dec-Mar	Levee of crop fields, roadsides
84	*Rotala indica* (Willd.) Koehne	Not known	Indian toothcup	Lythraceae	Oct-Apr	Moist places, rice fields
85	*Rumex maritimus* L.	Bonpalong	Golden dock	Polygonaceae	Nov-Mar	Roadsides, fallow lands, levee of crop fields
86	*Rungia pectinata* (L.) Nees	Pindi, Punaka-pundu	Comb Rungia	Acanthaceae	Nov-May	Warm moist shady places, roadsides, waste places
87	*Rungia repens* (L.) Nees	Par-patha, Kharmor	Creeping Rungia	Acanthaceae	Jan-Sep	Roadsides, edges of drains
88	*Scoparia dulcis* L.	Bon dhonia	Sweet Broom	Labiatae	Feb-Jun	Bank of ponds, fallow lands, levee of crop fields
89	*Senna occidentalis* (L.) Link.	Bara-chalkesunda, Eski	Negro coffee, septic weed	Fabaceae	May-Oct	Open waste places, fallow lands, roadsides
90	*Senna sophera* (L.) Roxb.	Kalkasunda, Kasundi	Pepper leaved senna	Fabaceae	Jul-Dec	Waste fallow lands, roadsides, along railway tracks and bank of ponds
91	*Senna tora* (L.) Roxb.	Araich	Pot cassia	Fabaceae	Aug-Nov	Mostly in roadsides and waste lands
92	*Sida acuta* Burm. f.	Gazai	Broom weed	Malvaceae	Jul-Dec	Dry habitats, roadsides, fallow lands
93	*Sida rhombifolia* L.	Atibala	Arrowleaf sida	Malvaceae	Oct-Dec	Waste ground, roadsides, rocky area
94	*Sinapis arvensis* L.	Bonsarisha	Wild Mustard	Brassicaceae	Feb-May	Rabi crops fields, roadsides, waste lands
95	*Solanum americacanum* Mill.	Tit Begun	Black nightshade	Solanaceae	Sep-Dec	Crop fields, roadsides, fallow lands
96	*Solanum carolinense* L.	Kata Begun	Horse neetle	Solanaceae	Aug-Oct	Dry fields and waste ground, roadsides, ails of crop fields
97	*Solanum rostratum* Dunal.	Suchalo Begun	Buffalobur nightshade	Solanaceae	Jul-Sep	Roadsides and ails of crop fields, fallow lands
98	*Solanum torvum* Sw.	Katabegun	Pea eggplant	Solanaceae	Aug.-Oct	Roadsides, abandoned farmlands
99	*Spermacoce alata* Aubl.	Not known	Pacific false buttonweed	Rubiaceae	Aug-Sep	Waste areas, cultivated fields
100	*Spermacoce exilis* (Williams) Adams *ex* Burger & Taylor	Not known	Winged false button weed	Rubiaceae	Sep-Oct	Wastelands and garden paths
101	*Sphenoclea zeylanica* Gaertn.	Jhilmorich	Gooseweed	Sphenocleaceae	Sep-Nov	Wetland areas
102	*Stellaria media* (L.) Vill.	Sada Fulki, Tara	Chickweed	Caryophyllaceae	Feb-Aug	Damp waste places, gardens
103	*Tephrosia candida* (Roxb.) DC.	Bilokhoni	White tephrosia	Fabaceae	Aug-Feb	Roadsides
104	*Tragia involucrata* L.	Bichuti	Neetle	Euphorbiaceae	Aug-Nov	Open wastelands, roadsides
105	*Urena lobata* L.	Ghamera	Caesar's weed	Malvaceae	Jul-Nov	Roadsides, bank of ponds, fallow lands
106	*Vicia hirsuta* (L.) Gray	Mashurchana/ Angchi	Hairy Tare/Vetch	Fabaceae	Dec-Mar	Rabi crops fields, levee of crop fields, roadsides, fallow lands
107	*Vicia sativa* L.	Bon masur	Wild lentil	Fabaceae	Jul-Nov	Levee of rabi crop fields, agricultural lands, open grasslands, roadsides, nurseries & gardens

Table 2. Family-wise distribution of the recorded weed species

Sl. No.	Family	Genera	Species	% of taxa in total	Sl. No.	Family	Genera	Species	% of taxa in total
1	Acanthaceae	2	3	3	20	Marsileaceae	1	1	1
2	Amaranthaceae	4	7	7	21	Onagraceae	1	4	4
3	Apiaceae	4	4	4	22	Orobanchaceae	1	1	1
4	Araceae	2	2	2	23	Oxalidaceae	1	2	2
5	Boraginaceae	2	2	2	24	Phrymaceae	1	1	1
6	Brassicaceae	3	3	3	25	Piperaceae	1	1	1
7	Campanulaceae	1	1	1	26	Plantaginaceae	1	1	1
8	Capparaceae	1	1	1	27	Polygonaceae	3	5	5
9	Caryophyllaceae	2	2	2	28	Pontederiaceae	2	2	2
10	Chenopodiaceae	1	1	1	29	Portulaceae	1	1	1
11	Commelinaceae	2	3	3	30	Pteridaceae	1	1	1
12	Convolvulaceae	3	5	5	31	Rosaceae	1	1	1
13	Cucurbitaceae	2	2	2	32	Rubiaceae	2	3	3
14	Dryopteridaceae	1	1	1	33	Rutaceae	1	1	1
15	Euphorbiaceae	4	7	7	34	Scrophulariaceae	1	3	3
16	Fabaceae	7	13	12	35	Solanaceae	3	6	6
17	Lamiaceae	4	4	4	36	Sphenocleaceae	1	1	1
18	Lythraceae	2	2	2	37	Urticaceae	1	1	1
19	Malvaceae	3	4	4	38	Verbenaceae	4	4	4

Table 3. Ethno-botanical uses of weed species recorded from the Bangladesh Agricultural University campus

Sl. No.	Botanical Name	Ethno-botanical uses
1	*Achyranthes aspera*	Medicinal uses – Scorpion bite, cough, asthma, upset stomach, dermatic disorder, abdominal pain, dysentery &bowel complaints, urinary & skin diseases
2	*Alternanthera philoxeroides*	Vegetables; Medicinal uses – Female diseases
3	*Alternanthera sessilis*	Vegetables; Medicinal uses – Lactagogue, febrifuge, intestinal cramps, cooling hair wash, eye diseases, body cool, ulcer
4	*Amaranthus graecizans*	Vegetables
5	*Amaranthus spinosus*	Vegetables; Medicinal uses – Bronchitis, biliousness, blood diseases, burning sensation, hallucination, piles, leprosy, mouthwash, toothache
6	*Amaranthus viridis*	Vegetables; Medicinal uses – Demulcent, diuretic and also in snakebites, skin diseases, blood pressure
7	*Ammania multiflora*	Medicinal uses – Fever, head itching
8	*Anisomeles indica*	Medicinal uses – Muscular pain, aphthae, allergy
9	*Argyreia nervosa*	Lactation of cattle; Medicinal uses – Effect on nervous system
10	*Cardamine flexuosa*	Vegetable
11	*Centella asiatica*	Vegetable; Medicinal uses – Cough, cold, wounds & minor injuries, headache, mental illness
12	*Chenopodium album*	Vegetable; Medicinal uses – Hepatic disorders, spleen enlargement, dysentery, piles & hiccup, laxative, aphrodisiac & tonic, jaundice, urinary diseases
13	*Cleome diffusa*	Not known
14	*Clerodendrum viscosum*	Medicinal uses – Anti-inflammatory, pain-relief, skin diseases, leprosy and bone injury
15	*Coccinia grandis*	Vegetables; Medicinal uses – Psoriasis, ringworm, itching, small pox, skin diseases, ulcer, scabies, diabetes, asthma, bronchitis, dysentery, vomiting, cough and cold
16	*Colocasia esculenta*	Vegetable; Medicinal uses – Jaundice, cut &wounds, antibacterial, hypotensive, menstruation, stomach problems, cysts, poultice to boils, conjunctivitis, constipation, colic, digestive
17	*Commelina benghalensis*	Medicinal uses – Haemorrhage, fever, rabies, emollient, leprosy, epilepsy, diuretic, febrifuge, Snakebites, cancer, ulcer, constipation, boils
18	*Commelina diffusa*	Medicinal uses – Boils, dysentery
19	*Croton bonplandianum*	Medicinal uses – Jaundice, abscesses, headache, venereal sores, cough, fever, vomiting, cholera, venereal sores, scabies
20	*Cuscuta reflexa*	Medicinal uses – Liver diseases, contraceptive, abortifacient, liver disease, hepatitis, bronchitis, antioxidant, dandruff, epilepsy, hair fall, pile
21	*Cyanotis axillaris*	Medicinal uses – Eardrum inflammation, ascites, abortions
22	*Cyathula prostrata*	Medicinal uses – Cough, dysentery, cholera, intestinal worms
23	*Desmodium gangeticum*	Medicinal uses – Antipyretic, anti-catarrhal, astringent, aphrodisiac, tonic, snakebites, scorpion sting, typhoid, fever, piles, asthma, bronchitis, cough, biliousness, dysentery &diarrhoea
24	*Desmodium heterophyllum*	Medicinal uses – Urinary retention, digestive complaints, stomach-aches
25	*Desmodium laxiflorum*	Medicinal uses – Unconsciousness, chronic fevers, vomiting, puerperium, small-pox, dysentery, stomachache, UTI, bronchitis, cough
26	*Desmodium trifolium*	Medicinal uses – Cough, asthma, bilious complaints, abscesses, dysentery, diarrhoea, convulsion, wounds, ulcers, skin diseases
27	*Drymaria cordata* subsp. *diandra*	Medicinal uses – Fever, respiratory chest-ailments, colds, bronchitis, eye troubles
28	*Dryopteris filix-mas*	Medicinal uses – Anti-helminthic, tapeworms
29	*Duchesnea indica*	Medicinal uses – Cancer, empyrosis, snake bite, furuncle
30	*Eichornia crassipes*	Medicinal uses – Gastrointestinal disorders, respiratory tract disorders (including asthma), fever, hair loss, greying of hair, liver disorders (including jaundice), skin disorders, spleen enlargement, cuts &wounds, cancer, hepatoprotective, snake venom neutralizing, anti-inflammatory, antimicrobial
31	*Euphorbia hirta*	Medicinal uses – Cough, asthma, dysentery, urinary tract infection, breast pain, used in worms, bowel complaints, warts
32	*Euphorbia thymifolia*	Medicinal uses – Worm infestation, bowel affections, diarrhoea, amenorrhoea
33	*Glycosmis pentaphylla*	Medicinal uses – Dysentery, cough, fever, jaundice, rheumatism, eczema &skin disease
34	*Heliotropium indicum*	Medicinal uses – Cough, fever, wounds, eye diseases, ulcers, sores, gum boils, skin affections, stings of insects & reptiles, night blindness, aphrodisiac
35	*Hydrocotyle sibthorpioides*	Medicinal uses – Skin disease, asthma, bone fracture, oedema, fever, detoxication, throat pain, psoriasis
36	*Hydrolea zeylanica*	Vegetable; Medicinal uses – Diabetes, wound healing, antiseptic, healing ulcers
37	*Indigofera suffruticosa*	Fodder; Medicinal uses –Febrifuge, antispasmodic, diuretic, abortive, analgesic, purgative, or soothing agent against stomach & urinary problems, jaundice, ulcers

Table 3. Cont.

Sl. No.	Botanical Name	Ethno-botanical uses
38	*Ipomoea alba*	Medicinal uses – Snakebite, boils & wounds, purgative, swelling of legs due to aprain
39	*Ipomoea crassicaulis*	Medicinal uses – Antioxidant, antimicrobial, antibacterial, antifungal, cancer, anticonvulsant, immunemodulatory, anti-diabetic, hepato-protective, anti-inflammatory, anxiolytic, sedative, wound healing, embryo toxic activities
40	*Ipomoea triloba*	Vegetable
41	*Jussiaea gendarussa*	Medicinal uses – Facilitate childbirth, milk ejection, placental expulsion, abortion
42	*Lantana camara*	Medicinal uses – Headaches, fever, flu, coughs, colds toothaches, indigestion boils, swellings &pain of the body, leprosy, ulcer, tuberculosis
43	*Leonurus sibiricus*	Medicinal uses – Emmenagogue, diuretic &vasodilator
44	*Leucus aspera*	Vegetables; Medicinal uses – Psoriasis, chronic skin eruptions, chronic rheumatism, painful swellings, cough &cold
45	*Lindernia antipoda*	Medicinal uses – Intestinal worms (Vermifuge)
46	*Lindernia crustacea*	Medicinal uses – Dysentery, ring worm, indigestion
47	*Lindernia parviflora*	Medicinal uses – Blood dysentery, ephemeral fever of livestock
48	*Lippia alba*	Medicinal uses – Analgesic/anti-inflammatory/antipyretic, sedative, culinary seasoning, diarrhoea & dysentery, cutaneous diseases, hepatic diseases/choleretic/vesicle ache, gastrointestinal disorders, menstrual disorders, antispasmodic, respiratory diseases, syphilis, gonorrhoea
49	*Lobelia radicans*	Medicinal uses – Fever, asthma, rheumatism
50	*Ludwigia decurrens*	Vegetable; Medicinal uses – Various skin, gastrointestinal, wound & bone joint disorders
51	*Ludwigia octovalvis*	Medicinal uses – Rheumatism, dermatitis, boil, ulcer, impetigo, pimple, gastrointestinal complaints e.g. diarrhoea & flatulence
52	*Ludwigia perennis*	Medicinal uses – Astringent, vulnerary & aphrodisiac, colonorrhea, haematuria, ulcers, pharyngopathy, vitiated conditions of vata, gout
53	*Ludwigia adscendens*	Medicinal uses – Fractured bones, chronic rheumatism, cephalalgia, hemiplegia, facial paralysis & eczema, wounds, bruised parts of thebody
54	*Marsilea quadrifolia*	Vegetable; Medicinal uses – Hypertension, headache, nervous disorders, body aches, insomnia, epilepsy
55	*Mazus pumilus*	Medicinal uses – Epilepsy, typhoid, anti-febrile, emmenagogue, aperitive &tonic
56	*Melilotus officinalis* subsp. *alba*	Medicinal uses – Inflammation & swellings, dysentery, diarrhoea
57	*Melochia corchorifolia*	Vegetable; Medicinal uses – Antiasthmatic, anti-inflammatory, anti-gonorrhoea, antibiotic, anti-dysenteric, swellings of abdomen, sores
58	*Merremia umbellata*	Vegetables
59	*Mimosa pudica*	Medicinal uses – Diarrhoea, diabetes, urinary calculi, dysentery, epilepsy, sexual diseases, toothache, leprosy, dysentery, vaginal & uterine complaints, inflammation, leucoderma, fatigue, asthma, blood diseases, jaundice, ulcers, small pox
60	*Monochoria hastata*	Medicinal uses – Bronchitis, asthma, cough & breathlessness
61	*Mukia medaraspatana*	Medicinal uses – Toothache, jaundice, vertigo & biliousness
62	*Nicotiana sylvestris*	Not known
63	*Oenanthe javanica*	Vegetables and feed for fish and small ruminants; Medicinal uses – Stomachache from flatulence, bowel movement
64	*Oldenlandia corymbosa*	Medicinal uses – Clear heat & toxins, activate blood circulation, promote diuresis and relieve stranguria (urinary obstruction), tumours of the digestive tract lymphosarcoma and carcinoma of the liver & larynx, appendicitis, hepatitis, pneumonia, cholecystesis, cellulites, snake bite, skin sores, ulcers, sore throat, bronchitis, gynaecologic infections & pelvic inflammatory diseases
65	*Oxalis debilis*	Medicinal uses – Boils, swelling, labour pain
66	*Oxalis stricta*	Medicinal uses – Stomach infection
67	*Peperomia pellucida*	Medicinal uses – Fever, cold, cough, viral diseases, rheumatic pain, asthma, vaginal infections, kidney infections
68	*Persicaria chinensis*	Vegetable; Medicinal uses – Nerve damage, lymph-node inflammation
69	*Persicaria lapathifolia*	Medicinal uses – Antibacterial activity against Flexner dysentery sticks
70	*Persicaria hydropiper*	Medicinal uses – Toothache, epilepsy, gangrene, rheumatism, gout

71	*Phylla nodiflora*	Medicinal uses – Dysentery, cough, leucorrhoea, dandruff

Table 3: Cont.

Sl. No.	Botanical Name	Ethno-botanical uses
72	*Phyllanthus amarus*	Medicinal uses – Scalp infections, jaundice, fevers, diarrhoea, urinary infections, skin diseases, cold, wounds
73	*Phyllanthus niruri*	Medicinal uses – Gonorrhoea & other ailments of genito-urinary tract, jaundice, dysentery, bruises & wounds, scabby infections,stomach-ache
74	*Phyllanthus* sp.	Not known
75	*Physalis heterophylla*	Medicinal uses – Ear problems, inflammations, cancer, skin diseases, urinary purgative
76	*Pilea microphylla*	Not known
77	*Pimpinella heyneana*	Medicinal uses – Diarrhoea, antiseptic
78	*Pistia stratiotes*	Medicinal uses – Swelling, skin diseases, leprosy & eczema, irregular urination
79	*Pogostemon auricularis*	Medicinal uses – Cough
80	*Polygonum plebeium*	Medicinal uses – Eczema, galactagogue, pneumonia, liver-tonic, heart burn, regular bowl
81	*Portulaca oleracea*	Vegetable; Medicinal uses – Jaundice, diabetes, urinary disorder, menorragia, vomiting, dysentery, haemorrhoids, mouth ulcer, sore nipples, scurvy, disease of kidney, liver, spleen bladder and cardio-vascular system, pyorrhoea, insulin secretion, blood purifier, fever, sun stroke
82	*Pteris vittata*	Fronds are largely used as cushion for cattle sheds; Medicinal uses – Blisters on the tongue, worship at the time of illness.
83	*Rorippa indica*	Medicinal uses – Diuretic, stimulant, anti-scorbutic, asthma, ear diseases, Backache, Body ache
84	*Rotala indica*	Not Known
85	*Rumex maritimus*	Medicinal uses – Catharitic, externally applied to burns
86	*Rungia pectinata*	Vegetables; Medicinal uses – Small pox, pain, swelling
87	*Rungia repens*	Medicinal uses – Skin diseases, fever, cough, expelling worms
88	*Scoparia dulcis*	Medicinal uses – Fever, cough, kidney stone, boils & tumours, pneumonia, malaria, diabetes, gonorrhea
89	*Senna occidentalis*	Medicinal uses – Skin diseases, snakebites, antidote to poison, pain due to thorn prick in legs, foot &mouth diseases of cattle
90	*Senna sophera*	Medicinal uses – Ringworms, gonorrhoea, syphilis, asthma, pox, fever, sore, abscesses, carbuncle
91	*Senna tora*	Medicinal uses – Ringworms, snake bite, skin diseases cough, dermatitis indigestion & stomach complaints, antioxidant
92	*Sida acuta*	Medicinal uses – Rheumatism, stomach ache, diuretic, impotency, skin diseases, snakebites
93	*Sida rhombifolia*	Medicinal uses – Snakebite, skin troubles, diuretic, rheumatism, tuberculosis, stomach-ache, wound, headache, eyes inflammation, debility, arthritis
94	*Sinapis arvensis* L.	Not Known
95	*Solanum americanum*	Medicinal uses – Skin disease, jaundice & hears diseases
96	*Solanum carolinense*	Medicinal uses – Anodyne, antispasmodic, aphrodisiac and diuretic, epilepsy, bronchitis, convulsive disorders, sore throats
97	*Solanum rostratum*	Medicinal uses – Swollen feet, inflammation
98	*Solanum torvum*	Medicinal uses – Antimicrobial , antiviral, immuno-secretory, antioxidant, analgesic and anti-inflammatory, cardiovascular and anti-platelet, aggregation activities, fever, hypertension & various stomach complaints including gastric ulcer
99	*Spermacoce alata*	Medicinal uses – Malaria
100	*Spermacoce exilis*	Medicinal uses – Headache, fever, ulcers
101	*Sphenoclea zeylanica*	Vegetables
102	*Stellaria media*	Vegetables; Medicinal uses – Diabetes, sedative, bleeding piles & urinary complaints, skin diseases
103	*Tephrosia candida*	Medicinal uses – Fish poison
104	*Tragia involucrata*	Medicinal uses – Fever, venereal complaints, itching of skin, headache, enlarged spleen, dipsomania, whooping cough
105	*Urena lobata*	Medicinal uses – Bowel complaints, especially colic, stomach-ache, diarrhoea and dysentery, gonorrhoea, urinary diseases
106	*Vicia hirsuta*	Fodder
107	*Vicia sativa*	Medicinal uses – Snake bite, uterine tonic, emmenagogue, congestive & nervous dysmenorrhoea, amenorrhoea, sterility, menstrual disorders

Sources: Ahmed *et al*., 2008a, b, 2009; Dansi *et al.*, 2008; Gutiérrez *et al.*, 2014; Hastings, 1990; Khan *et al.*, 2013; Kumar and Sane, 2003; Kumar *et al.*, 2019; Lokho and Narasimhan, 2013; Manandlar, 1995; Marandi and Britto, 2015; Minarchenko *et al*., 2017; Nayar *et al.*, 1988; Keat *et al.*, 2010; Oyedeji *et al.*, 2011; Panda and Misra, 2011; Pandey and Singh, 2017; Pant and Samant, 2010; Pascual *et al.*, 2001; Pragada and Rao, 2012; Sahu, 1984; Sarker *et al.*, 2017; Srivastava, 2017; Uddin, 2006; Upreti *et al.*, 2009.

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