R-2611
[1-7]

REVIEW ARTICLE Agricultural Reviews

Talinum fruticosum: A Potential Multi-value Plant: A Review

K. Manikandan[1], T. Balaji[2], V. Dhanushkodi[3]

10.18805/ag.R-2611

ABSTRACT

Talinum fruticosum (L.) Juss. is an underutilized plant which is distributed across world. It survives under varying soil types such as deep fertile soil, shallow rocky soil, salt affected soils, *etc*. Waterleaf occurs from sea level to 1000 m above MSL. Tolerance to drought is added advantage but, yield decreases with increasing water stress. It moderately tolerates salinity and sodicity of both soil and water. This plant can be exploited as plant for phytoremediation as it is capable to accumulate heavy metals, pollutants and minerals. It has significant potential to use it as fodder for cattle considering green biomass and nutritional composition. This plant can also be used as feed to chickens, rabbits and cattle. It is considered as palatable, leafy vegetable owing to nutritional and medicinal properties though it possess lesser amount of anti-nutritious components such saponin, oxalates and tannins. In view of above facts, waterleaf have the potential to be utilized as leafy vegetable for semiarid and humid conditions, quality green fodder for cattle, feed for rabbits and chicken, remediating polluted soils, reclamation and sustainable utilization of salt affected lands, tolerant plant for poor quality water, suitable to shallow soils besides using it as ornamental plant.

Key words: *Talinum fruticosum,* Waterleaf, Leafy vegetable, Phytoremediation, Fodder, Salt affected lands.

Talinum fruticosum (L.) *Juss.* is a non-conventional, herbaceous and glabrous plant (Ezekwe *et al*., 2002) that belongs to the family Talinaceae. It is commonly called as waterleaf, Ceylon spinach, Surinam purslane, Philippine spinach, Espinaca de Java and Sweetheart. This is an edible leafy vegetable with high nutritional properties.

Mostly, it is collected from wild and consumed after cooking. Cultivation of this leafy vegetable is common in Nigeria and Cameroon where it is the income source for small and medium scale farmers. Basically, it is considered as ground vegetation in forest ecosystem but it is perceived as weed in arable lands.

Talinum fruticosum is synonymously referred as *Talinum triangulare* (Jacq.), *Talinum crassifolium* (Jacq.), *Portulaca fruticosa* L. and *Portulaca triangularis* Jacq. It is often confused with *Talinum portulacifolium*, but both are different plant species (Chibili, 1999).

Distribution

Waterleaf is native to tropical America with pantropical distribution (Nyananyo and Olowokudejo, 1986). This plant distributed widely across the world owing to ease establishment and wider adaptability and as a result, it is hard to establish the home range of this plant.

It is observed from Mexico, Southern United States, tropical Africa, Java, India and Asian countries. It was introduced into Java in 1915 from Surinam (Heyne, 1987) by the Bogor Botanic Gardens. Cultivation of this leafy vegetable is also reported from Nigeria, Africa, America and Asia. But in India, cultivation practice for this plant is yet to be standardized.

Habitat

Waterleaf tolerates wide habitat condition and occurs along roadsides, wastelands, forest edges from sea-level up to 1000 m (Tindall, 1983). It tolerates wide rainfall condition and found in regions receiving 500 m to 3000 mm annually. During rainy season, it occurs as under vegetative growth on forest and abandoned farm lands abundantly though it occurs throughout the year.

It adapted well to drought (Lonnie and Michael, 2001) conditions owing to succulence nature. It grows well in fertile soils rich in organic matter but can survive under wide range of soils including infertile and salty soil with moderate growth. It can withstand sodic soil with pH up to 9.4 with less than the actual growth potential (Manikandan and Gayathri, 2022). This hardy plant grows well in shallow soil in rocky outcrops too (Kumar *et al*., 2012).

It produces higher biomass production in hot tropical conditions if other conditions favourable. It avoids waterlogged soils as well as ill drained soils as it is susceptible to collar rot upon exposure to continuous, excessive soil moisture.

[1]Tamil Nadu Rice Research Institute, Aduthurai, Thanjavur-612 101, Tamil Nadu, India.
[2]Department of Soil Science and Agriculture Chemistry, Krishi Vigyan Kendra, Ramanathapuram, Tamil Nadu, India.
[3]Anbil Dharmalingam Agricultural College and Research Institute, Trichy, Tamil Nadu, India.

Corresponding Author: K. Manikandan, Tamil Nadu Rice Research Institute, Aduthurai, Thanjavur-612 101, Tamil Nadu, India.
Email: manikandan.k@tnau.ac.in

How to cite this article: Manikandan, K., Balaji, T. and Dhanushkodi, V. (2023). *Talinum fruticosum:* A Potential Multi-value Plant: A Review. Agricultural Reviews. DOI: 10.18805/ag.R-2611.

Submitted: 24-11-2022 **Accepted:** 08-09-2023 **Online:** 30-09-2023

Morphological description

It is an herbaceous, mucilaginous plant with prominent stem. Stem is erect, succulent, glabrous which is pink at base and green in tip. Leaves are simple and alternate. Inflorescences are terminal and auxiliary. Flowers are complete and bisexual. Petal is purple in colour and stamens are free and numerous. Ovary is superior and green. Fruits are globose, pale green while immature and yellow when mature. Seeds are tiny, black/brown and numerous. Roots are tuberous in nature (Khaing and Moe, 2019). Talinum species is generally self-pollinated but liable for insect pollination (Nya and Eka, 2015).

Propagation

Domestication of this leaf vegetable is well reported from West Africa, South Asia, Southeast Asia, North America and South America. Waterleaf cultivation is considered as a source of income to small-scale farm households (Udoh, 2005).

It is propagated by seeds and cuttings. It can be propagated through stem cuttings in hydroponic media (Kumar and Prasad, 2010). Smaller sized seeds can be sown either directly on soil or in nursery bed. Waterleaf exhibit good germination percentage (>70%) in nursery bags (Ubochi *et al*., 2022). Germination starts on 5th day after sowing. Two to three weeks old seedlings are suitable for transplanting in the main field.

Cuttings made from young shoots (10-15 cm) can be planted directly in field. Stem cuttings of 1 cm of circumference and 10 cm of length was utilized for planting by Fopoussi Tuebue *et al*. (2019).

Okechukwu *et al*. (2014) tested different plant spacing and manuring in field and found that closer spacing of 25 × 10 cm and application of manure @ 30 t ha^{-1} yielded higher. Wider spacing of 60 × 60 cm was adopted by Bhavithra *et al*. (2019) under drip fertigation system.

Transplanted waterleaf seedlings attain 30 cm height in 2-3 weeks and can able to reach heights more than 80 cm (Fontem and Schippers, 2004). Fru *et al*. (2017) observed that waterleaf plant produces more than 40 leaves/plant at 3 weeks after planting.

Waterleaf is a short duration crop and harvest stage obtained quickly in 35-45 days after planting (Rice *et al*., 1986). First harvest requires 3-4 weeks from planting (Oluwole *et al*., 2018). In general, best leafy quality of waterleaf obtained from first 3 harvest and thereafter leaf quality decline appreciably. Under well managed conditions such as adequate irrigation, good manuring and weeding, it can remain for six months in field (Ren *et al*., 2006; Fasuyi, 2007). Depending upon the climatic conditions, soil fertility and management, yield of waterleaf varied between 10-60 t/ha (Uusiku *et al*., 2010).

Fopoussi Tuebue *et al*. (2019) informed that growth of waterleaf is higher in fertilized soils than in the unfertilized soils. Bhavithra *et al*. (2019) harvested 1.6 kg of fresh leaf yield per plot at 30 days after planting which was relatively higher than many other leafy vegetables tested. The maximum leaf length and succulence nature of leaf and stem contributed for the higher biomass production by waterleaf. Purbajanti *et al*. (2019) cultivated Talinum paniculatum with a plant spacing of 50 × 25 cm and harvested 23.62 tons of fresh biomass in 8 weeks.

This hardy plant is tolerant to herbicidal action (Akadiri *et al*., 2017) owing to the poor permeability of herbicides into plant (Rola *et al*., 1999).

Plant composition

Mineral composition of plants varies with stages of crop growth, management practices adopted, soil condition, soil fertility and environmental conditions.

a) Macronutrients

Waterleaf contains rich minerals. Hundred grams of dry waterleaf contains 196.50, 74.60, 70.40, 156.60 and 80.60 mg of P, Ca, Mg, K and Na, respectively (Agunbiade *et al*., 2015). N content of the leaves is varied up to 3.4% (Bhavithra *et al*., 2019) depending upon the soil, environment and management conditions.

Alozie and Ene-Obong (2018) informed that potassium (262 mg/100 g) is relatively higher in waterleaf than the phosphorus (79 mg/100 g) and other minerals (Ca- 100 mg/100 g; Mg- 189 mg/100 g; Na- 47 mg/100 g; Zn- 0.80 mg/100 g and Fe- 3.2 mg/100 g). Similarly, Folarin *et al*. (2001) observed relatively higher proportion of potassium (5471.25 mg/100 g) in *Talinum* species compared to other minerals.

b) Micronutrients

According to Khaing and Moe, (2019) sufficient quantum of micronutrients like iron (1.92%), zinc (1.58%), manganese (0.88%) and copper (0.18%) is present in waterleaf. Similarly, Oluwole *et al*. (2019) reported Cu (0.12 ppm), Zn (0.46 ppm) and Fe (3.16 ppm) from *Talinum fruticosum*. Folarin *et al*. (2001) reported relatively higher concentration of micronutrients in waterleaf *i.e*., zinc (25 mg/100 g), iron (12.25 mg/100 g) and copper (0.93 mg/100 g). Relatively higher proportion of manganese (0.56 mg/kg) in waterleaf was observed by Bhavithra *et al*. (2019).

c) Bioactive components

Leaves and stem of *Talinum fruticosum* contain numerous bioactive compounds (Ameh and Eze, 2010). Amorim *et al*. (2014) extracted 17 compounds from the stem and leaves of *T. triangulare* which includes steroids, acrylamide, propanoic acid, allantoin, malic acid, steroids and phaeophytins. Alkaloids (55.56 mg/100 g), flavonoids (69.80 mg/100 g) and tannins (1.44 mg/100 g) also found in *Talinum fruticosum* (Aja *et al*., 2010).

Antioxidant properties of *Talinum fruticosum* were well ascertained by Liang *et al*. (2011). It contains significant proportion of ascorbic acid (17.39 mg/g) and carotenoids (0.28 mg/g; Bhavithra *et al*., 2019). Allantonin was noticed from the leaves and roots of *Talinum triangulare* by Amorim *et al*. (2014).

Tolerance to salty water

Talinum fruticosum (L.) Juss. is one of the underutilized leafy vegetable which is having significant potential to withstand salty irrigation water. *Talinum fruticosum* can able to tolerate the irrigation water EC up to 6 dS/m and soluble sodium percentage (SSP) up to 40 without any adverse effect on growth and quality of produce (Palukuru Dayana Lakshmi, 2022). Bamidele *et al*. (2007) reported that normal functioning of the crop is affected under saline irrigation which causes reduction in growth rate of waterleaf plants.

Mineral content of the Talinum leaf generally increases with increasing salinity level. Montero *et al*. (2018) studied the effect of salinity on *Talinum triangulare* and observed that salinity had varying effects on total mineral contents. Leaf sodium and potassium content increase with increase in salinity and it did not affect Mg or Ca contents in leaves, while causing significant increase in P content.

Waterleaf contains very low concentrations of nutrients like nitrogen (2.33 mg/100 g), phosphorus (196 mg/100 g) and potassium (78 mg/100 g) under water-stressed conditions compared to the control (Oluwole *et al*., 2018). The nutritive values of waterleaf like crude protein and crude fat showed a decreasing trend with increasing soluble salt and sodicity in irrigation water (Palukuru Dayana Lakshmi, 2022).

Tolerance to soil salinity and alkalinity

Waterleaf exhibits significant tolerance to soil salinity and sodicity. The seedlings of *Talinum fruticosum* (L.) Juss. can able to tolerate salinity levels from 0 to 560 mM NaCl (Bamidele *et al.,* 2007) and found significant growth decrease of seedlings with higher salinity hazard. It survives well in alkaline soil too (Lal, 2008).

Assaha *et al*. (2017) inferred that different levels of NaCl stress (0 to 300 mM NaCl) had significant adverse effect on shoot growth, no effect on root growth, increased proline content and reduction in osmotic potential. The antioxidant enzyme activities and non-enzyme antioxidants showed significant increase only under high salinity.

This plant can able to thrive in soil with pH of 9.4 and higher exchangeable sodium percentage (Manikandan and Gayathri, 2022) and hence, it can be cultivated in alkaline soils too.

Drought tolerance

Talinum traingularae reported to tolerate water stress significantly (Lonnie and Michael, 2001). Waterleaf produce malate under drought conditions which act as osmoticum (Herrera *et al.*, 2015) and hence, achieve less water loss during water stress. Surukite *et al*., (2018) inferred that waterleaf tolerate and produce higher under moderate water stress and produces less under excessive moisture and water stress conditions. Increasing moisture stress reduced the mineral concentration in waterleaf as water stress influence nutrient uptake significantly (Silvestre, 2003).

Utility

Talinum fruitcosum have number of beneficial attributes *viz*., edible nature, medicinal values, fodder utility, ecological values besides aiding soil reclamation. This is also used as ornamental plant across world (Nyffeler and Eggli, 2010).

a) Edible utility

Fresh biomass of waterleaf contains relatively less dry matter and more moisture. Moisture is released from waterleaf while cooking owing to high moisture content (Agunbiade *et al*., 2015). It is primarily used as leaf vegetables either raw in salads or cooked. Further it is also utilized in making soups and thickening sauce.

Ibeawuchi *et al*. (2006) noted that the leaves and young shoots are used to thicken sauce and it is consumed in large quantities in the Southern part of Nigeria.

Talinum fruticosum contains rich crude protein (≈12%), crude fat (≈ 2%), crude fiber (≈18.30%) and carbohydrate (≈>30%) (Adekanmi *et al*., 2020). Higher proportion of potassium and lesser proportion of sodium in waterleaf is a beneficial attribute for human nutrition. It is a rich source of vitamin C, vitamin E, Omega-3 fatty acids, pectin and β-carotene (Ezekwe *et al*., 2001) besides the minerals.

b) Medicinal values

Waterleaf has specific medicinal and therapeutic (Swarna and Ravindhran, 2013) values in humans (Ekpenyong, 1986). Vitamins and minerals of waterleaf contribute to high antioxidant values (Liang *et al*., 2011). Consumption of waterleaf improves bone health as it contains rich calcium and phosphorous. Further, it ensures eye health and reduces the risk of cataract by providing vitamin A. Waterleaf is an excellent dietary source of iron and thus by reduces anemia in humans. It also reduces the risk of developing Alzheimer's disease as it supplies vitamin C.

Research reports are available for diuretic properties, management of gastrointestinal disorders, scabies and high blood pressure. Agnel and Shobanan (2012) reported that leaf and root extracts of waterleaf cure asthma, kid-ney disorders, gout and rheumatoid arthritis. Leaves of Talinum fruitcosum reported to possess anti-inflammatory activities (Esho *et al*., 2021). Further, it helps to enhance liver function as it suppresses oxidative damage of liver cells (Ezekwe *et al*., 2013).

Antioxidant activity and fibre content of this plant aids to cure mild laxative and constipation problem (Joshua *et al*., 2012). High dietary fibre prevents obesity and excess body weight (Mensah *et al*., 2008). This plant has exploited in the treatment of diarrhea (Oguntona, 1998 and Mensor *et al*., 2001).Talinum based diet is suitable for patients of diabetes mellitus as it delays digestion and conversion of starch to simple sugars (Monago and Uwakwe, 2009). It also stimulates digestive system and enhances production of digestive enzymes (Abou Elkhair *et al*., 2014).

c) Fodder and Feed values

Waterleaf acts as green forage for cattle (Oguntibeju and Okaiyeto, 2021) in order to meet the unavailability of green fodder (Meena *et al*., 2018) in many regions especially during summer. Characteristics of *Talinum fruticosum* such as palatability, nutrient composition, fibre proportion, digestibility, *etc*. meet the fodder quality for cattle. *Talinum fruticosum* is a preferred wild fodder for cattle in many African countries. It contains 9.93% crude fibre, 22.73% crude protein, 1.21% crude fat and 12.2% ash content (Babayemi and Adebayo, 2020). Vitamins E is unable to get synthesized by animal's body (Vipin *et al*., 2021) and which is sufficiently available in *Talinum fruticosum*.

Crude protein content of waterleaf is above the essential criteria *i.e*., 7% for both rumen microorganism (Njidda and Isidahomen, 2010) and growth of cattle (Gadbemy, 2018). Fiber content of waterleaf is falling within the acceptable level. Further, neutral detergent fiber (34.49%) and acid detergent fiber content (32.41%) is more or less equal but it contains relatively lesser acid detergent lignin (6.33%).

It is possible to use waterleaf as supplementary feeds to poultry (Agboola *et al*., 2018), rabbits (Anselm and Ubokudom, 2010; Aduku and Olukosi, 1990) and swine (Ezekwe *et al*., 2001). Olayemi *et al*. (2021) inferred that *Talinum fruticosum* can be used as alternative source of feed additive to chicken without deleterious effects on egg laying performance, quality characteristics and storage life.

Phytoremediation

Heavy metal is a significant threat to soil health (Dizaji *et al*., 2016) and waterleaf accumulates pollutant to a significant extent. Hence, this plant has a potential to be used as plant for phytoremediation. It degrades polycyclic aromatic hydrocarbon and total petroleum hydrocarbon from crude oil polluted soils (Okoye *et al*., 2017).

This plant is often tested for phytoremediation of contaminated soil with heavy metals (Rajkumar *et al*., 2009; Uwah *et al*., 2009). Babayemi *et al.* (2017) reported that waterleaf collected from domestic dumpsite contains heavy metals *viz.,* Pb (14.50-20.10), Cd (0.05-0.60), Cr (0.19-2.48), Ni (2.75-7.30) and Co (3.40-6.05 mg/kg of dry matter). Lead in roots and shoots gradually increased as the function of increasing concentration Pb in soil (Kumar *et al*., 2012). Root accumulates higher quantities of heavy metals than the stems (Kumar *et al*., 2012). But, being a leafy vegetable and fodder, waterleaf is generally not recommended for phytoremediation of heavy metal contaminated soils.

Exploitation of salt tolerant and salt accumulated plants is one of the ideal option for management of salt affected soil (Shahid *et al*., 2018) as it produce crop, contributes to farm income besides reclaiming soil sustainably in an eco-friendly way. In this line, *Talinum fruitcosum* can be used for eco-friendly reclamation of alkaline soils (Manikandan and Gayathri, 2022) in a sustainable way.

Anti-nutritional properties

Presence of anti-nutritional component is less preferable as it restricts edible and fodder utility of plants. Oxalate, phenols, saponin, tannin are some of the anti-nutritional compounds present in the leaves and stems of waterleaf.

Tannin content of waterleaf varied between 21.30 mg/ 100 g and 25.90 mg / 100 g while irrigating with saline and sodic water, respectively (Palukuru, 2022). Aja *et al*. (2010) reported that waterleaf composed of 1.48 mg of saponins per 100 g of dry biomass. The total phenol content of waterleaf is less than 6 mg/g in the dry matter of *T. fruitcosum* (Bhavithra *et al*., 2019).

T. triangulare contains higher oxalate content but it is mostly in soluble form. Relatively higher oxalate content causes kidney diseases in humans. Cooked waterleaf has approximately 50 percent less soluble oxalate than raw waterleaf as it is solubilised and removed during cooking. Hence, raw leaves are generally not recommended for human consumption.

CONCLUSION

Waterleaf is an herbaceous, nutritious plant which is underutilized till date all over the world. It thrives well in diverse habitat conditions such as shallow soils to deep fertile soils and semiarid to humid conditions. This palatable plant can withstand drought conditions owing to succulent nature and physiological mechanisms. This multi utility plant accumulates higher proportion of minerals, heavy metals and pollutants and accordingly, this plant can be exploited for phytoremediation of polluted lands, heavy metal contaminated soils and salt affected terrains. Tolerance to saline and alkaline water is added advantage. This plant can also be used as fodder to cattle, feed to chicken and rabbits. Presence of lesser proportion of anti-nutritious elements such as saponin, oxalates and tannins is a concern for utilizing this plant but higher nutritive values, rich bio active compounds, good mineral content and multifarious medicinal properties nullifies this concern for using this plant as edible one.

Considering nutritional value, medicinal properties, fodder values and tolerance to salty soils, waterleaf is considered as a potential leafy vegetable crop for both normal and salt affected lands. In addition, this crop can also be recommended where irrigation water is salty. This nutritious leafy vegetable has significant potential for meeting the green fodder demand of the country as it is palatable, protein rich, higher green biomass yield, possibility of multiple cut and faster growth.

Conflict of interest: None.

REFERENCES

Abou-Elkhair, R., Ahmed, H.A. and Selim, S. (2014). Effects of black pepper (*Piper nigrum*), turmeric powder (*Curcuma longa*) and coriander seeds (*Coriandrum sativum*) and their combinations as feed additives on growth performance, carcass traits, some blood parameters and humoral immune response of broiler chickens. Asian Australasian Journal of Animal Sciences. 27: 847-854.

Adekanmi, A.A., Adekanmi, U.T., Adekanmi, A.S. and Oyekanmi, H.A. (2020). Assessment of proximate composition and phytochemical properties of bitter leaf (*Vernonia Amygdalina*) and waterleaf (*Talinum Triangular*). United International Journal for Research and Technology. 1(9): 13-21.

Aduku, A.O. and Olukosi, J.O. (1990). Rabbit Management in the Tropics: Production, Processing, Utilization, Marketing, Economics, Practical training, Research and Future Prospects, Living Book Services, G.U. Publications, Abuja. 125.

Agboola, B.E., Ologhobo, A.D., Adejumo, I.O. and Adeyemo, G.O. (2018). Response of broiler chickens to Carica papaya and Talinium triangulare leaf meal under normal and subnormal diets. Annual Research and Review in Biology. 23(4): 1-7.

Agnel Arul John, N. and Shobana, G. (2012). Anti-inflammatory activity of *Talinum fruticosum* L. on formalin induced paw edema in albino rats. Journal of Applied Pharmaceutical Science. 2(1): 123-127.

Agunbiade, S.O., Ojezele, M.O. and Alao, O.O. (2015). Evaluation of the nutritional, phytochemical compositions and likely medicinal benefits of vernomia amygdalina, *Talinum triangulare* and ocimum basilicum Leafy-vegetables. Advances in Biological Research. 9(3): 151-55.

Aja, P.M., Okaka, A.N.C., Onu, P.N., Ibiam, U. and Urako, A.J. (2010). Phytochemical composition of *Talinum triangulare* (Waterleaf) Leaves. Pakisthan Journal of Nutrition. 9: 527-530.

Akadiri, M.B., Ayodele, O.P. and Aladesanwa, R.D. (2017). Evaluation of selected Post-Emergence herbicides for weed management in maize at different agroecological zones of Nigeria. World Journal of Agricultural Research. 5(5): 258-264.

Alozie, Y.E. and Ene-Obong, H.N. (2018). Recipe standardization, nutrient composition and sensory evaluation of waterleaf (*Talinum triangulare*) and wild spinach (*Gnetum africanum*) soup “afang” commonly consumed in South-south Nigeria. Food Chemistry. 238: 65-72.

Ameh, G.I. and Eze, C.S. (2010). Phytochemical and ethnobotanical evaluation of the leaves of *Talinum triangulare* (Jacq) Wild. Nigerian Journal of Biotechnology. 21: 50-54.

Amorim, A.D.O., Carvalho, J., Lopes, N.P., Castro, R.N., de Oliveira, M.C.C. and de Carvalho, M.G. (2014). Chemical compounds isolated from *Talinum triangulare* (*Portulacaceae*). Food Chemistry. 160: 204-208.

Anselm, A., Enete and Ubokudom, E.O. (2010). Economics of Waterleaf (*Talinum triangulare*) Production in Akwa Ibom State, Nigeria. Field Actions Science Reports. 4: 1-5.

Assaha, D.V.M., Mekawy, A.M.M., Liu, L., Noori, M.S., Kokulan, K.S., Ueda, A. and Saneoka, H. (2017). Na^+ retention in the root is a key adaptive mechanism to low and high salinity in the glycophyte, *Talinum paniculatum* (Jacq.) Gaertn. *Portulacaceae*. Journal of Agronomy and Crop Science. 203(1): 56-67.

Babayemi, J.O., Olafimihan, O.H. and Nwude, D.O. (2017). Assessment of heavy metals in waterleaf from various sources in Ota, Nigeria. Journal of Applied Sciences and Environmental Management. 21(6): 1163-1168.

Babayemi, O.J. and Adebayo, A.A. (2020). Assessment of nutritive value of selectively grazed forbs by cattle in communal grazing land of Ido Local Government Area, Oyo state, Nigeria. Nigerian Journal of Animal Production. 47(5): 239-253.

Bamidele, J.B., Egharevba, R.K.A. and Okpoh, I.M. (2007). Physiological changes in seedlings of *Talinum triangulare* (Waterleaf) grown in saline conditions. Asian Journal of Plant Sciences. 6: 56-60.

Bhavithra, P., Balakumbahan, R., Paramaguru, P. and Venkatesan, K. (2019). Evaluation of underutilized leafy vegetables for growth and yield. Journal of Pharmacognosy and Phytochemistry. 8(3): 214-217.

Chibili, E.O. (1999). A comparative study of some developmental characteristics in *Talinum fructicosum* (L.) Juss. accessions from stem cuttings in Dschang (Cameroon). Mémoire de Maîtrise. Université de Dschang, Cameroon. 37.

Dizaji, E.F., Kafi, M., Khalighi, A. and Jari, S.K. (2016). Phytoremediation of lead and cadmium by thornless honey locust trees’ (*Gleditsia triacanthos* L. *var. inermis*) in contaminated soil near the Tehran-Karaj highway. Indian Journal of Agricultural Research. 50(6): 579-583.

Ekpenyong, T.E. (1986). Nutrient component of tropical foodstuffs available for rabbit feeding. Journal of Applied Rabbit Res. 9: 14-20.

Esho, B.A., Samuel, B., Akinwunmi, K.F. and Oluyemi, W.M., (2021). Membrane stabilization and inhibition of protein denaturation as mechanisms of the Anti-inflammatory activity of some plant species. Trends in Pharmaceutical Sciences. 7(4): 269-278.

Ezekwe, C.I., Chidinma, R.U. and Okechukwu, P.C.U. (2013), The Effect of Methanol Extract of *Talinum triangulare* (Waterleaf) on the Hematology and Some Liver Parameters of Experimental Rats, Global Journal of Biotechnology and Biochemistry. 8(2): 51-60.

Ezekwe, M.O., Besong, S.A. and Igbokwe, P.E. (2001). Beneficial influence of purslane and waterleaf supplement to human. Federation of American Societies for Experimental Biology. 16(4): A639.

Ezekwe, M.O., Besong, S.A., Igbokwe, P.E. and Ezekwe, E.I. (2002). Beneficial influence of purslane and waterleaf supplementation on cardiovascular disease risk in humans. Federation of American Societies and Experimental Biology Journal. 16(4): A639.

Fasuyi, A.O. (2007). Bio-nutritional Evaluations of three tropical leaf vegetables *Talinum triangulare* as sole dietry protein sources in rat. Food Chemical. 103: 757-765.

Folarin, O.M., Bamiro, F.O. and Esuoso, K.O. (2001). Distribution of nutritive elements in waterleaf (*Talinum triangulare*) and juice mallow (*Corchorus olitorus*). Global Journal of Pure and Applied Sciences. 7(2): 285-290.

Fontem, D.A. and Schippers, R.R. (2004). *Talinum triangulare* (jacq.) Willed [Internet]. Record from PROTA4U [Grubben, G.J.H and Denton, O.A. (Eds.)]. PROTA. (Plant Resources of Tropical Africa Ressources Vegetales de l'Afrique tropicale). http://www.prota4u.org/searcch.asp. Wageningen, Netherlands.

Fopoussi Tuebue, J.C., Basga, S.D., Tematio, P. and Nguetnkam, N.P. (2019). Impact of the mixture of water from cooked bean and human urine on the growth of some common plants in cameroon: Case study of *Talinum fruticosum* L. and *Ocimum gratissimum* L. Asian Journal of Soil Science and Plant Nutrition. 5(1): 1-15.

Fru, B.S., Francis, N.A., Angwafo, T.E. and Precillia, T.N. (2017). Waterleaf (*Talinum triangulare*) response to biochar application in a humid-tropical forest soil. Journal of Soil Science and Environmental Management. 8(5): 95-103.

Gadbemy, S. (2018). Beef Cattle Nutrition Series. Part 3: Nutrient requirement tables. University of Arkansaa, United State Department of Agriculture and county. Cooperating Division of Agicultural Research and Extension. 108.

Herrera, A., Ballestrini, C. and Montes, E. (2015). What is the potential for dark CO_2 fixation in the facultative crassulacean acid metabolism species *Talinum triangulare*. Journal of Plant Physiology. 174: 55-61.

Heyne, K. (1987). Tumbuhan berguna indonesia. Badan Penelitian dan Pengembangan Kehutanan, Departemen Kehutanan. 2: 1188-1189.

Ibeawuchi, I.I., Onweremadu, E.U. and Oti, N.N. (2006). Effects of poultry manure on green (*Amarathus cruentus*) and waterleaf (*Talinum trinagulare*) on Degraded Ultisol of Owerri Southeastern Nigeria. Journal of Animal and Veterinary Advances. 5(1): 53-56.

Joshua, Z.P., Timothy, A.G. and Suleiman, M.M. (2012). The effect of cooking time on the vitamin C, dietary fiber and mineral compositions of some local vegetables. Science World Journal. 7(1): 29-30.

Khaing, Y.Y. and Moe, M.M. (2019). Morphological, Microscopical Characters and Antioxidant activity of Leaves of *Talinum fruticosum* (L.) Juss. In 2nd Myanmar Korea Conference Research Journal. 1: 540-550.

Kumar, A. and Prasad, M.N.V. (2010). Propagation of *Talinum cuneifolium* L. (*Portulacaceae*), an ornamental plant and leafy vegetable, by stem cuttings. Floriculture and Ornamental Biotechnology. 4(S1): 68-71.

Kumar, A., Prasad, M.N.V. and Sytar, O. (2012). Lead toxicity, defence strategies and associated indicative biomarkers in *Talinum triangulare* grown hydroponically. Chemosphere. 89(9): 1056-1065.

Lal, H. (2008). A Textbook of Biochemistry, 1st ed., 2nd Reprint, CBS Publishers and Distributors New Delhi.1-497.

Liang, D., Zhou, Q., Gong, W., Wang, Y., Nie, Z., He, H. and Zhang, J. (2011). Studies on the antioxidant and hepatoprotective activities of polysaccharides from *Talinum triangulare*. Journal of Ethnopharmacology. 136(2): 316-321.

Lonnie, G. and Michael, D.J. (2001). The occurrence and phylogenetics of crassulacean acid metabolism in the *Portulacaceae*. International Journal of Plant Sciences. 162(2): 257-262.

Manikandan, K. and Gayathri, S. (2022). *Talinum fruticosum*: A potential multifunctional plant for diverse soils. Agriculture and Food. 4(12): 42-43.

Meena, B.P., Shirale, A.O., Biswas, A.K., Lakaria, B.L., Jha, P., Gurav, P.P., Wanjari, R.H. and Patra, A.K. (2018). Diversified agriculture for higher productivity and profitability-A review. Agricultural Reviews. 39(2): 104-112.

Mensah, J.K., Okoli, R.I., Ohaju-Obodo, J.O. and Eifediyi, K. (2008). Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnology. 7(14): 2304-2309.

Mensor, L.L., Fabio, S.M., Gildor, G.L., Alexander, S.R, Tereza, C.D., Cintia, S.C. and Suzane, G.L. (2001). Screening of Brazilian plant extracts for antioxidant activity by the use of DPPH free radical methods. Phytother. Res. 15: 127-130.

Monago, C. and Uwakwe, A. (2009). Proximate composition and *in vitro* anti-sickling property of Nigeria *cyperus esculentus* (Tiger nut sedge). Trees Life J. 4(2): 1-6.

Montero, E., Francisco, A.M., Montes, E. and Herrera, A. (2018). Salinity induction of recycling crassulacean acid metabolism and salt tolerance in plants of *Talinum triangulare*. Annals of Botany. 121: 1333-1342.

Njidda, A.A. and Isidahomen, C.E., (2010). Hematology, blood chemistry and carcass characteristics of growing rabbits fed grasshopper meal as a substitute for fish meal. Pakistan Veterinary Journal. 30 (1): 7-12.

Nya, E.J. and Eka, M.J. (2015). Morphological characterization and hybridization of *Talinum triangulare* land races for desirable metric characters in South Eastern Nigeria. The International Journal of Science and Techno ledge. 3(7): 192-197.

Nyananyo, B.L. and Olowokudejo, J.D. (1986). Taxonomic studies in the genus *Talinum* (*Portulacaceae*) in Nigeria. Willdenowia. 455-463.

Nyffeler, R. and Eggli, U. (2010). Disintegrating *Portulacaceae*: A new familial classification of the suborder Portulacineae (*Caryophyllales*) based on molecular and morphological data. Taxon. 59: 227-240.

Oguntibeju, O.O. and Okaiyeto, K. (2021). Therapeutic potentials and pharmacological properties of *Talinum triangulare* (Jacq.) Willd. in the treatment and management of diabetes mellitus and other conditions. Plant Science Today. 8(4): 1098-1106.

Oguntona, T. (1998). Green Leafy Vegetables. In: Nutritional Quality of Plant Food, [Osagie, A.U. and O.U. Eka (Eds.)]. Ambik Press. 120-133.

Okechukwu, G.C., Onyeonagu, C.C. and Asiegbu, J.E. (2014). Dry matter and fresh vegetable yields of waterleaf (*Talinum triangulare* Jacq.) influenced by plant spacing and organic manure rates. International Journal of Agri Science. 4(5): 283-292.

Okoye, N.F., Monago-Ighorodge, C.C. and Akpobasaha, N.A. (2017). Evaluating the use of spiny pigweed (*Amaranthus Spinosus*) and Waterleaf (*Talinum triangulare*) for bioremediation of crude oil polluted soil in ikarama community in bayelsa state Nigeria. Journal of Applied Sciences and Environmental Management. 21(5): 903-910.

Olayemi, W.A., Onipede, G.O., Olatidoye, O.P. and Ajayi, A.A (2021). Effects of some leafy vegetables and their combinations as feed additives on performance, egg quality and shelf-life. International Journal of Innovations in Engineering Research and Technology. 8(8): 21-31.

Oluwole, S.O., Ogun, M.L. and Balogun, O.A. (2018). Effects of different watering regimes on the growth of *Talinum triangulare* Jacq. (Waterleaf). Journal of Research and Review in Science. 5(1): 14-23.

Oluwole, S.O., Ogun, M.L. and Durowoju, S.Y. (2019). Effects of different organic manures on the growth of waterleaf (*Talinum triangulare* Jacq). International Journal of Innovative Science and Research Technology. 4(5): 1123-1129.

Palukuru Dayana Lakshmi. (2022). Studies on the effect of saline and sodic water irrigation on the growth, yield and quality of *Talinum fruticosum* (l.) Juss. and soil properties of Inceptisol. Thesis submitted to Tamil Nadu Agricultural University. Pp: 140.

Purbajanti, E.D., Setyawati, S. and Kristanto, B.A. (2019). Growth, herbage yield and chemical composition of *Talinum paniculatum* (Jacq.). Indian Journal of Agricultural Research. 53(6): 741-744.

Rajkumar, K., Sivakumar, S., Senthilkumar, P., Prabha, D., Subbhuraam, C.V. and Song, Y.C. (2009). Effects of selected heavy metals (Pb, Cu, Ni and Cd) in the aquatic medium on the restoration potential and accumulation in the stem cuttings of the terrestrial plant, *Talinum triangulare* Linn. Ecotoxicology. 18(7): 952-960.

Ren, H., Endo, H.and Hayashi, T. (2006). Antioxidative and Anti-mutagenic activities and polyphenol content of pesticide-free and organically cultivated Green Vegetables using water soluble chitosan as a soil modifier and leaf surface spray. Journal of the Science of Food and Agriculture. 81: 1426-1432.

Rice, R.P., Rice, I.W. and Tindau, H.D. (1986). Fronts and Vegetables in the tropics. 186.

Rola, H., Badowski, M., Bekierz, G. and Naraniecki, B. (1999). Influence of IR-516 on the enhance efficacy of sulfonylurea herbicides-Apyros 75 WG, Chisel 75 WG, Titus 25 WG, Safari 50 DF, Journal of Plant Protection Research. 39 (2): 639-641.

Shahid, S.A., Zaman, M. and Heng, L. (2018). Soil salinity: Historical perspectives and a world overview of the problem. In Guideline for salinity assessment, mitigation and adaptation using nuclear and related techniques, Springer, Cham. 43-53.

Silvestre, M.K. (2003). The effects of water stress on the mineral content of plants. Journal of Australian Crop Science. 12(31): 90-95.

Surukite, O.O., Mautin, L.O. and Olusesan, A.B. (2018). Effects of different watering regimes on the growth of *Talinum triangulare* Jacq. (Water Leaf). Journal of Research and Review in Science. (5): 14-23.

Swarna, J. and Ravindhran, R. (2013). Pharmacognostical and phytochemical evaluation of *Talinum triangulare* (Jacq.) Willd. International Journal of Pharmacy and Pharmaceutical Sciences. 5(2): 249-256.

Tindall, H.D. (1983). Vegetables in the Tropics. Macmillan Press Ltd. 145.

Ubochi, K.C., Nwakuche, A.O. and Ojua, E.O. (2022). Effect of industrial coconut oil effluent irrigation on germination, growth and yield of *Talinum fruticosum* (*Talinaceae*). Asian Plant Research Journal. 10(1): 1-8.

Udoh, E.J. (2005). Technical Inefficiency in Vegetable Farms of Humid Region: An analysis of Dry season vegetable farming of urban women in South zone, Nigeria. Journal of Agriculture and Social Sciences. 1: 80-85.

Uusiku, N.P., Oelofse. A., Duodu, K.G., Bester, M.J. and Faber, M. (2010). Nutritional value of leafy vegetables of sub-Saharan Africa and their potential contribution to human health. Food Compost Analysis. 23: 499-509.

Uwah, E.I., Ndahi, N.P. and Ogugbuaja, V.O. (2009). Study of the Levels of Some Agricultural Pollutants in Soils and Waterleaf (*Talinum triangulare*) Obtained in Maiduguri, Nigeria. Journal of Applied Sciences in Environmental Sanitation. 4(2): 71-78.

Vipin, V.M., Bharadwaj, A. and Verma, A.K. (2021). Vitamins supplementation affecting colostrum composition in murrah buffaloes. Indian Journal of Animal Research. 55 (8): 900-904.