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An archaic, eupeptic but disdain pulse crop *Macrotyloma uniflorum* - A Review

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ABSTRACT
An Archaic pulse "Horsegram" [Macrotyloma uniflorum (Lam.) verdc] is an ignored member of family 'Fabaceae'. It is mainly cultivated in Asian and African countries and could easily be grown in adverse climatic conditions. In our country it has been used from ancient times as ayurvedic medicine for treating diabetes, bronchitis, asthma, obesity, leucoderma, kidney stones, heart diseases and many more. This pulse is rich in proteins, minerals, vitamins and many bioactive compounds such as phenolic acid, phytic acid. Its remarkable ability to grow in harsh conditions like heavy metal massing, dry and drought soil that makes it more demanding pulse crop for future with respect to the era of climate change. Despite of having high nutritional values and medicinal properties this crop has been neglected from a long period. In Uttarakhand Himalayan region it is extensively grown and used as a regular dietery food by regional villagers. Looking at the upcoming uncertain climate situations, the attention of scientists towards the under utilized legumes for finding alternate protein sources have increased. Thus, there is an urgent need to study the enormous nutraceuticals and pharmaceuticals potential and developing improved varieties of the very old legacy of pulse crop.

Keywords: *Macrotyloma uniflorum, Horsegram, Therapeutic agent, Complete nutritional supplement, Underutilized crop, archaic, eupeptic, disdain, nutraceuticals, pharmaceuticals*

I. INTRODUCTION

Since millennia, the second most important group in terms of crop after cereals are legumes (Bhadana *et al.,* 2013). They primarily fulfill the huge demand of protein and nutrients in the developing countries still some of the indigenous legumes are underutilized and less explored. Horsegram [*Macrotyloma uniflorum* (Lam.) verdc] also known as gahat in Kumaon/Garhwal, Kulatha in Sanskrit, Kollu in Tamil etc. in different regions of India is among the most protein rich lentils found on earth (Chahota *et al.,* 2013). This crop belongs to the genus Macrotyloma, Phaseoleae tribe and family Fabaceae. It is grown in the northern, central and southern parts of tropical, sub-tropical and temperate regions of world involving African and Asian countries. This crop is a potent source of protein, carbohydrate and minerals and is resistant to various biotic and abiotic stresses. In present era, the greatest issue on the planet is regarding the food and nutritional security which include the protection of endangered food crops and promoting the production of underutilized food with nutraceutical properties. Instead of depending on few crops and making them adapted according to the climate change scenario, it is better to promote the crop plants that are already adapted to the adverse climate conditions like poor fertile soils, drought and dry seasons (Mabhaudhi *et al*., 2017). Favoured habitat for wild African populations of horse gram which may be a suggestive evidence of preferred ecology for the wild forms (Fuller and Harvey 2006). In India, two species *Macrotyloma uniflorum* and *Macrotyloma ciliatum* are found (Panda *et al.,* 1985) and as per South Asian archaeobotany, horse gram appears to have been widely cultivated across the Gangetic belt during 2500–2000 BC (Fuller and Harvey 2006). Horse gram has been an important crop since the beginning of agriculture in many parts of South Asia and the most widely recovered pulse crop in prehistoric or early historic sites in India (Murphy and Fuller 2017). This legume has been well represented by archaeological finds across India and has been extensively reported from the Northwest in Haryana state, the Western part of Gujarat (the Saurashtra peninsula) and the South Deccan (Karnataka). These regions are also considered as plausible foci of early cultivation or domestication of horse gram (Fuller and Murphy 2018). The regional origins of horse gram are obscure, however, as per the evidence of remnant wild populations, two separate domestication regions, Northwestern and Peninsula regions of India have been identified for the wild progenitors of horse gram (Fuller and Murphy 2018). The plains and hills of low altitude extending Southwards in the Western Ghats in Southwest India are considered as the primary centre of origin and due to counter-migration of human beings from Southern Indian plains and hills, this legume probably diffused to Northern and Western parts of the Indian subcontinent (Krishna 2013; Bhartiya *et al.,* 2015). Evolution of cultivated horse gram from wild progenitors has not been well explored and wild species of *Macrotyloma* from African woods and savannahs are unlikely to have ever contributed to the domesticated gene pool, since this species is not

cultivated in Africa (Fuller and Harvey 2006). Similarly, evidences from grains and cotyledons from Neolithic settlements selected all over the Indo-Gangetic belt seems not to have contributed to the evolution of domesticated Southern Indian horse gram (Krishna 2013). During the course of evolution, modifications from wild to domesticated form (i.e., domestication syndrome) due to selection pressure has occurred, but domestication syndrome has also not been extensively studied in horse gram. The domestication syndrome for pulses mainly includes increase in seed size, reduced pod shattering and loss in germination inhibition (Fuller 2007) and evidences show that in Southern Indian horse gram, reduction of seed dormancy occurred between 2000 and 1200 BC, whereas increase in seed size may have been delayed by 2000–4000 years after domestication (Murphy and Fuller 2017). Among evolutionary rates of these two domestication traits, the non-shattering trait evolved faster than grain size with a higher selection coefficient, whereas grain size increase resulted from selection for increased seedling vigour of larger grains (Purugganan and Fuller 2011).

Indian traditional medicine, seeds of *Macrotyloma uniflorum* are used for treatment of urinary stones (Yadava and Vyas 1994; Ravishankar and Vishnupriya 2012), urinary diseases and piles (Yadava and Vyas 1994), regulate the abnormal menstrual cycle in women (Neelam 2007), act as astringent, tonic (Brink 2006), and also used to treat calculus afflictions, corpulence, hiccups, and worms (Chunekar and Pandey 1998). The soup extract from *kulattha* (*Macrotyloma uniflorum*), called *yusa*, was consumed commonly during the Sutra period (1500–800 BC) are the rasams of today (Achaya 1998). Sprouted seeds, having high nutritional quality, are widely consumed by the indigenous tribal peoples (Bravo *et al.,* 1999). In India, horse gram is a minor legume grown annually on nearly 3.26 lakh ha (Directorate of Economics and Statistics (DES), 2016–2017) of land and constitutes approx. 1–2% of total pulses area mainly in states such as Karnataka, Andhra Pradesh, Tamil Nadu, Odisha, Maharashtra, Chhattisgarh, Bihar, Jharkhand and MP (Singh 2013). A sharp declining trend in acreages, production and productivity levels have been observed from almost the past 2 decades In horse gram as compared to other major pulses grown in India due to social disdain, changing lifestyle and lack of policies to mainstream traditional crops. Owing to their nutritional and medicinal value, there is an increased demand to explore an underutilized legume (Chel-Guerrero *et al.,* 2002; Arinathan *et al.,* 2003) to alleviate malnutrition and reduce risk of various diseases in developing countries. *Macrotyloma uniflorum* is an excellent source of protein (17.9–25.3 %), carbohydrates (51.9–60.9 %), essential amino acids, energy, low content of lipid (0.58–2.06 %), iron (Bravo *et al.,* 1999; Sodani *et al.,* 2004).

In India, only medicinal and nutritional properties have been focused more to study in *Macrotyloma uniflorum* crop. Scientists from the Indian Institute of Chemical Technology (IICT) have found that unprocessed raw *Macrotyloma uniflorum* seeds not only possess anti hyperglycemic properties, but also have qualities which reduce insulin resistance. Legume Research an International Journal is an official journal which promotes the scientific research related to the legumes in India. Chemical control of disease Powdery mildew in *Macrotyloma uniflorum* was reported by (Naik R. Ganesha in 2000). But in present time the biological control methods are needed more for disease control. There are several institutes that are involved in research and development works on *Macrotyloma uniflorum*, like Department Of Food Microbiology, Central Food Technological Research Institute (CFTRI) Mysore, works on molecular aspects of seed germination and storage proteins. Indian Institute of Pulses Research (IIPR) in Kanpur, Uttar Pradesh was established in the year 1983 by the ICAR to carry out basic strategic and applied research on major pulse crops i.e., legumes such as soybean, cluster bean, horse bean, cow pea etc. The molecular diversity of rhizobial isolates of *Macrotyloma uniflorum* and characterization in it's in- vitro condition have also been reported (B.K. Mishra *et al.*, 2017) in Rajasthan region, however the climatic conditions of Rajasthan is hotter as compare to the Kumaun Himalaya. This makes a big difference. Till now no work has been done on altering the rhizospheric microbiome of *Macrotyloma uniflorum* plant for making the plant resistant against a pathogenic disease in Uttarakhand region. This would be a first report on the issue and would help in future in making the crop as important as other legume crop varieties worldwide.

Bioactive peptides of horse gram protein possess antimicrobial activity, antioxidant activity, anticarcinogenic activity, hypocholesterolemic effect, reduced serum triglycerides, increased lean muscle mass, protection against pathogens, regulation of blood glucose levels, and satiety effects (Prasad and Singh 2015). Horse gram seeds are rich in low glycemic carbohydrates, resistant starch, oligosaccharides and dietary fibre than cow pea (*Vigna unguiculata*) and green gram (*Vigna radiata*) (Herath *et al.,* 2018). Carbohydrate of horse gram seed have about 36% starch comprising digestible (85%), resistant (14.47%) and resistant starch associated to insoluble dietary fibres (3.38%) (Bravo *et al.,* 1999). Insoluble dietary fibres of horse gram seeds have positive effects on intestine and colon physiology, besides other homoeostatic and therapeutic functions in human nutrition (Kawale *et al.,* 2005; Sreerama *et al.,* 2012b). Resistant starch is considered as prebiotic among the new generation of dietary fibres, whereas non-digestible carbohydrates of horse gram are helpful in the dietary management of diabetes (Samanta *et al.,* 2011). Moreover, horse gram is highly suitable for human consumption, because 72% of the fatty acids are polyunsaturated comprising linoleic acid and α-linolenic acid

(Mishra and Pathan 2011), which impart a beneficial effect on the functional development of the brain and nervous system (Ryan *et al.,* 2007; Morris *et al.,* 2013). Phytosterol esters of horse gram lipids possess antiulcer and healing effects on acute gastric ulceration produced by alcohol (Jayraj *et al.,* 2000; Berger *et al.,* 2004). It also contains a considerable quantity of water and liposoluble vitamins such as thiamin, riboflavin, niacin and tocopherols (Bolbhat and Dhumal 2012; Longvah *et al.,* 2017). Despite the well-known nutritional and health-promoting effects, horse gram has more anti-nutritional factors like trypsin inhibitor activity (9246 TIU/g), phytic acid (10.2 mg/g), polyphenols (14.3 mgGA/g) and oligosaccharides (26.8 mg/g) than other commonly consumed pulses which have restricted its utilization as human food (Sreerama *et al.,* 2012b). However, some of the commonly known non-nutritive compounds like phytic acid, phenols, tannins are presently being considered as bioactive substances having antioxidant, anticarcinogenic and hypoglycaemic activities therefore, as per consumer preference, retaining or removal of these compounds could be facilitated (Bhatt and Karim 2009). Horse gram has been linked to reduced risk of various diseases and its daily consumption may impart immense nutritional and health benefits due to presence of both nutritive and non-nutritive bioactive substances (Prasad and Singh 2015). Moreover, it has the potential for utilization as nutraceutical, food and forage for malnourished and drought-prone areas of the world (Morris 2008).

Existing health reports also have evidence that phytochemicals present in seed extract of horse gram possess significant antimicrobial activities against some human fungal and bacterial strains. Among them, tannins and phenolic compounds elicited broad spectrum activity against human bacterial pathogens such as *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas argentinensis*, *Pseudomonas* sp., *Bacillus subtilis*, *Vibrio harveyi*, *Salmonella paratyphi*, *Pseudomonas aeruginosa* and *Vibrio mimicus* through cell membrane lysis, inhibition of protein synthesis, proteolytic enzymes and microbial adhesions (Parvathiraj *et al.,* 2015), whereas flavonoids have the potential to be used in treating various skin diseases (Suriyavathana *et al.,* 2018). Fresh and dried sprouts of horse gram also revealed a wide spectrum of potential phytopharmaceuticals possessing antibacterial activity against several human pathogens (Abiraami and Gowrie 2017). Search for new and alternative antimicrobial substances from plant sources is important for therapeutic and protective uses to avoid the problem of drug resistance in human pathogens against commonly used antibiotics (Marimuthu *et al.,* 2016). Potent dietary protective factor for peptic ulcer is also present in horse gram (Jones 1987). Phospholipids, sterol esters and sterols present in horse gram lipid are found to have gastroprotective properties as well as promote the healing of gastric ulceration (Tovey 2015). Phenolic acid (*p*-coumaric acid) in horse gram also exhibited antiulcer activity by attenuating the ulcer elevated levels of malondialdehyde and restored the ulcer depleted levels of reduced glutathione and the antioxidant enzymes superoxide dismutase, catalase, glutathione peroxidise and glutathione reductase (Panda and Suresh 2015), therefore, horse gram extracts could play an important role in protection against ulceration. Alcohol extracts of horse gram seeds exhibited potent anthelmintic activity comparable to standard piperazine citrate against *Pheretima posthuma* (Sreerama *et al.,* 2014) suggesting its use as dietary food for eradicating worms (Singh *et al.,* 2017a, b). Horse gram is known for various health benefits; still this legume is unexplored for many undiscovered phytochemicals and innate health-promoting aspects. Great possibilities exist for isolation, chemo-profiling, pharmacology, biological evaluation, toxicological consequences of functional active ingredients from horse gram and development of drug formulations and functional foods for curing various diseases.

Fig 1: Horsegram beans on the plant

Moreover, it has the potential for further utilization as food and forage for malnourished and drought-prone areas of the world (Morris 2008). Horse gram is also grown as preparatory crop in newly reclaimed lands in many parts of South India to improve soil fertility (Kumar 2006), as a cover crop for soil and water conservation in semi-arid regions as well as was found to be useful in integrated fertility management in dry land agriculture (Reddy *et al.*, 2008). Therefore, it has great significance in sustainable agriculture (Anitha *et al.*, 2006) as well as dry land agriculture, due to this reason Horsegram is the best alternate to be focused which is highly adapted to wide range of temperature regimes that most of the crops fail to sustain.

Fig 2: Horsegram seeds

Origin and Distribution of Horsegram (*M. uniflorum*)

The members of *M. uniflorum* are extensively grown in both India and Africa. Though as a cultivated plant its centre of origin is reffered as India (Purseglove 1974). The world old tropics are considered as the most genetically diverse regions of this crop especially, the Himalayas and the southern part of India (Zeven *et al*., 1982). While some believe it was native plant to African countries and was domesticated to India since prehistoric times and now has become the part of India's important cultivated crop. It has been distributed to different African and Asian countries like India, Pakistan, Sri Lanka, Malaysia, Myanmar, Bhutan, Somalia, South Africa and Sudan etc. It is grown in many other tropical countries as green manure and forage like Australia, Papua New Guinea.

***M. uniflorum* Crop Status global**

The major states where Horsegram is grown are the hills of Uttarakhand, Himachal Pradesh, Orissa, Karnataka, Andhra Pradesh, Madhya Pradesh, Jharkhand, Tamil Nadu, Bihar, West Bengal and Chhattisgarh. In India, The total area covered under Horsegram cultivation was approx. 2.32 lakh ha and 1.05 tonnes of production according to Twelfth Plan (2012-2015). In terms of area and production, Karnataka is on the first position on all India basis contributing 26.72% and 25.71% respectively followed by Odisha (19.46%& 15.48%)and Chhatisgarh (19.29% & 13.29%).The highest yield was recorded in the state of Bihar (959 kg/ha) followed by W.B. (796 kg/ha) and Jharkhand (603 kg/ha) (DES, 2015-16). The varieties mainly used by farmers in Uttarakhand are VL Gahat-8, VL Gahat-10 and VL Gahat-19. It is also cultivated in other countries mainly Sri Lanka, Malaysia, West Indies etc.

Climate, soil type, field preparation and other requirement

Horsegram is extremely drought-resistant crop. Moderately warm, dry climatic conditions are suitable for its optimum growth. It does not grow well on higher altitudes because of cool and wet climate. Horsegram can be cultivated up to an altitude of 1000 m above the sea level. The temperature range of 25-30°C and relative humidity between 50 and 80% is optimum for its growth. Heavy rains during the initial stages of crop growth affect nodule formation owing to poor aeration in the soil. A well-distributed rainfall of about 800 mm is sufficient for its successful cultivation, but it performs well even under low rainfall areas. Generally grown on lateritic soil (poor in fertility) in south India. The crop can be grown on wide range of soils from light to heavy soils which are free from alkalinity. The crop needs minimum field preparations. Only 1-2 ploughings followed by planking provides desirable seed-bed. Sowing Time The main season for sowing horse gram is late August-November. As a fodder crop it is sown during June-August. In Tamil Nadu, it is sown in September-November. In Maharashtra, horse gram is sown as a kharif crop, mixed with bajra or sometimes Niger and also in the Rabi in rice fallows. In M.P. it is a Rabi crop. In northern parts it is grown as kharif crop. In West Bengal the sowing period is October-November. Seed Rate & Spacing Generally sown as broadcast with 40 kg/ha seed rate for dual purpose i.e. grain and fodder. For line sowing 25-30 kg/ha is enough for grain crop. Row Spacing: 40-45 cm during kharif and 25-30 cm during rabi and about 5 cm plant to plant spacing. Seed treatment Seeds must be treated with seed treating fungicide to reduce infection by fungal pathogens found in the soil. Horse gram seeds are treated with carbendazim (bavistin) 2g for every kg of seeds. Now-a-days bio fungicide like Trichoderma viridi is recommended for pulses at the rate of 4g per kg seed. After fungicide treatment seed should be inoculate with Rhizobium and PSB culture @ 5-7 g/kg of seed. Fertilizer management 20 kg nitrogen and 30 kg P2O5 per ha as basal application at the time of sowing 2-5 cm below and in the side of the seed with the help of ferti.-seed drill is enough for good management of crop. Water Management Irrigation should be apply at before flowering and pod formation stage. Weed Management Due to luxuriant growth an early weeding/hoeing is enough for weed. Application of Pendimethalin @ 0.75-1 kg a.i. /ha as pre emergence application. After that, one hand weeding at 20-25 days after sowing.

Plant Protection Measures

S. No.	Pest / Disease	Nature of Damage/ Symptoms	Control Measures
1.	Aphids	The older and nymphs suck the juice from the leaves as a result of it leaves turn brown and crumpled and the plants look diseased.	Spray of Oxydemeton methyl 25 @ 1 ml/liter or Dimethoate 30 EC @ 1.7 ml/liter water
2.	Jassids	The older and nymphs suck the juice from the leaves as a result of it leaves turn brown and crumpled and the plants look diseased with leaf surface uneven. In severe infection leaves dry up and fall and weaken the plants.	
3.	Pod borer	It is a polyphagous insect. Caterpillar creates holes in pods, sometime also feed seeds.	Spray of NPV @ 250 LE/ha. or Quinolphos 25 EC @ 2 ml/liter water
4.	Yellow Mosaic Virus vector-white fly	The symptoms firstly appear on young leaves in the form of yellow, diffused, round spots scattered on the leaf lamina. The infected leaves turn necrotic. The diseased plants usually	i) Grown resistant varieties. ii. Destroy the infected plants. iii.Spray of Oxydemeton

		mature later and bear relatively few flowers and pods. The pods are stunted and mostly remained immature but whenever seeds are form they are small in size.	methyl 25 @ 2 ml/liter or Dimethoate 30 EC @ 1.7 ml/liter water and repeat after 15 days, if necessary.
5.	Root rot	Roots rot and plants show yellowing of the lower-most leaves followed by wilting.	i. Seed treatment with 2 g Captan or Carbindazim/ 2 kg of seed. ii. Avoid early sowing in infested areas

State wise varieties

S. No	State	Recommended varieties
1.	Uttarakhand	VL Gahat-8, VL Gahat-10 and VL Gahat-19
2.	Rajesthan	KS-2, Pratap Kulthi (AK-42)
3.	Andhra Pradesh	Palem-1, Palem-2, Paiyur-2, PHG-9
4.	Tamil Nadu	Paiyur-2
5.	Karnataka	PHG-9, GPM-6, CRIDA-1-18 R
6.	Gujarat	Pratab Kulthi-1 (AK-42), GHG-5
7.	Chhatisgarh	Indira Kulthi-1 , (IKGH01-01)

Source: Seednet GOI, Min. of Agri. & FW, & ICAR-IIPR, Kanpur

Importance of Horsegram in Food and Nutrition

Horsegram (*Macrotyloma uniflorum*) is among those very important but less appreciated pulse crop, which is a remarkably rich source of proteins, minerals and vitamins. They have been a very potent food source in India from ancient times. It provides an instant amount of good energy immediately after consumption. They are not only best for the nutritional values but also the medical properties like treating kidney stones, diabeties, edema, menstrual pains, piles, renal stones, healing wounds and many more. Their seeds are widely used now-a-days for reducing obesity and its related problems, which is a very common problem among rich people due to very unhealthy diet. It burns excessive fat by increasing body temperature and are very good to feed on cold regions. The studies have revealed that diet plays a vital role in reducing stone problems in body. In ayurveda, the Horsegram has recommended to be used as a medicine to cure kidney and bladder stones naturally. The horse gram seeds break down the Calcium phosphate crystals that are responsibe for stone formation. The Horsegram seeds are densely packed with lot of nutrients and vitamins; thiamine, niacin, ascorbic acid and carotene. They also contain most of the essential minerals like Calcium, Molybdenum, Phosphorous and Iron; and Polyphenols that possess high antioxidant properties (Sodani *et al.,* 2004). They help in increasing muscle strength, fortified bones, regulating red blood cell synthesis and also possess antiurolithiatic activity that prevents the synthesis of stones in kidney, bladder and urethra (Chaitanya *et al.,* 2010). Hemagglutinin which is an agent responsible for agglutination of RBCs are abundantely present in Horsegram. Some reports suggested that the lipid extracted from horsegram heals the peptic ulcers in rats (Jayaraj *et al.,* 2000). The bioactive compounds like phytic acid and phenolic acid are potent antioxidants that are present in horsegram seeds they provide protection to the body against diabetes mellitus, variety of cancer and coronary heart diseases (Kumar *et al.,* 2010). The horsegram seeds also possess many wound healing properties like anti inflammatory, potential analgesic activity and pain relieving properties (Muthu kumar *et al.,* 2014). Fever and respiratory problems are also cured by this crop. The methanol extract and oil extracted from Horsegram crops exhibit central and peripheral antinociceptive activity and potent analgesic properties (Bharathi *et al.,* 2015). The seeds also help in diuretic activity and act as diuretic drugs used to treat high blood pressure and heart failure treatments. They excrete water from the body and lower down the blood pressure. The phytochemicals extracted from the seeds includes tannins, proteins, flavonoids, alkaloids and carbohydrates (Mathew *et al.,* 2014). The health benefits of horse gram have gained much popularity from few years its ability to cure various diseases was known by Indian Ayurvedic system but now the western world have understood it too. Still much work is needed to explore this very old legacy by performing pharmacology, biological evaluation, chemoprofile and identifying undenfied phytochemicals to promote and support the programs initiated to promote the underutilized crops for food and nutrition security issues as it has eupeptic pharmaceuticals potential.

***M. uniflorum*: A Potential Food Source for the Future**

M. uniflorum is a complete food source for humans and is a promising food supplement, fulfilling all the demands related to the food, medicine, neutraceutical properties, nutrients and phytochemicals secretions. The Horsegram seed meal is completely non-toxic and safe to feed. Their seeds extract shows significant anti-microbial activity against many pathogenic microbes harmful to humans including *Bacillus subtilis, Escherichia coli, Staphylococcus aureus, Klebsiella sp* and *Pseudomonas aeruginosa* (Gupta *et al.,* 2005). It is highly drought resistant pulse crop and could easily be cultivated in adverse climatic conditions. This crop is not only

resistant to drought but also to various abiotic stress factors such as salinity, heavy metal and heat stress (Sharma *et al.*, 2015a). This remarkable ability of this crop make it vulnerable for future that's why the US National Academy of Sciences has given this crop the status of "Food source for the future" (National Academy of Sciences 1978). It owns an excellent potential of getting the status of a future food legume and contributing to the national and nutrition security (Morris 2008). Currently, it is a minor legume in India as compared to the other pulse crops and grown annually on approx 3.26 lakh ha land area (Directorate of Economics and Statistics 2016–2017), which is only 1-2% of total pulses grown in India (Singh 2013). The traditional mixed cropping in Uttarakhand region involves the farming of twelve food grains also referred as "Barah Anaaja" among which Horse gram is an important member to tackle the drought stress (Zhardhari 2001). Despite of being able to feed the huge masses in drought prone areas and all these medicinal and nutritional values in one crop, this crop has been highly neglected in the global market. India is the only country where horsegram is cultivated on large area and used as a human food. As a result of such negligence a very drastic decline in the production of such a potential crop has been reported from past 2 decades. This is not a good sign towards the protection of food and nutrition security. Currently, it is widely used as food and forage in malnourished and drought prone areas of the world (Morris 2008). But looking at the current difficult environmental situations regarding climate change, poor soil fertility and less water for agriculture it would not be wrong to say that the exploration of *M. uniflorum* plant related to more phytochemical, therapeutic uses must be done as soon as possible for present and the future struggling time.

II. CONCLUSION

After assessing so many benefits in one crop it could be undoubtly concluded that Horsegram is an excellent source of nutrients and medicinal properties. It is very much comparable to other crops infact is better in terms of climate adaptation. It is very important pulse crop as food and forage in many developing countries and has possibility to gain attention in developed countries too. It is a complete food full of bioactive compounds thus should be added to the diet on regular basis. These are not only used for feeding but also contain medicinal and neutraceutical properties which are not easy to find in every crop. They have been widely used from ancient times as ayurvedic medicine in our country it is the time to explore and promote it more to make it a worldwide crop so that more phytochemicals and nutrients could be extracted from them and use for mankind. Also the climate change that our world is facing now could become more difficult in upcoming years regarding less water for irrigation and poor soil quality for that we need to find an alternative that could withstand the tough environmental conditions. The innate quality of horsegram to tackle adverse climatic conditions has already proved itself a very potent crop to invest for future.

REFERENCES

[1]. Abdelrahman, M.; Sawada, Y.; Nakabayashi, R.; Sato, S.; Hirakawa, H.; El-Sayed, M.; Hirai, M.Y.; Saito, K.; Yamauchi, N.; Shigyo, M. Integrating transcriptome and target metabolome variability in doubled haploids of Allium cepa for abiotic stress protection. Mol. Breed. **2015**, 35, 195. [**Google Scholar**]

[2]. Agoramoorthy, G.; Chandrasekaran, M.; Venkatesalu, V.; Hsu, M.J. Antibacterial and antifungal activities of fatty acid methyl esters of the blind-your-eye mangrove from India. Braz. J. Microbiol. **2007**, 38, 739–742. [**Google Scholar**]

[3]. Ahmad, I.; Shagufta. Sulfones: An important class of organic compounds with diverse biological activities. Int. J. Pharm. Pharm. Sci. **2015**, 7, 19–27. [**Google Scholar**]

[4]. Alam, A.M.; Somta, P.; Jompuk, C.; Chatwachirawong, P.; Srinives, P. Evaluation of mungbean genotypes based on yield stability and reaction to mungbean yellow mosaic virus disease. Plant Pathol. J. **2014**, 30, 261–268. [**Google Scholar**]

[5]. Alice, D.; Nadarajan, N. Pluses: Screening Techniques and Assessment for Disease Resistance; All India Coordinated Research Project on MULLaRP; Tamil Nadu Agricultural University: Coimbatore, India; Kasturi Graphics and Printers: Coimbatore, India, 2007. [**Google Scholar**]

[6]. Almajan, G.L.; Barbuceanu, S.F.; Almajan, E.R.; Draghici, C.; Saramet, G. Synthesis, characterization and antibacterial activity of some triazole Mannich bases carrying diphenylsulfone moieties. Eur. J. Med. Chem. **2009**, 44, 3083–3089. [**Google Scholar**]

[7]. Baena-González, E.; Sheen, J. Convergent energy and stress signalling. Trends Plant Sci. **2008**, 13, 474–482. [**Google Scholar**]

[8]. Bandi, H.R.K.; Rao, K.N.; Vamsi Krishna, K.; Srinivasulu, K. Screening of blackgram (Vigna mungo l. Hepper) germplasm for resistance to mungbean yellow mosaic virus under rice fallow situation. Bull. Environ. Pharmacol. Life Sci. **2018**, 7, 125–128. [**Google Scholar**]

[9]. Barnabas, A.D.; Radhakrishnan, G.K.; Ramakrishnan, U. Characterization of a begomovirus causing horsegram yellow mosaic disease in India. Eur. J. Plant Pathol. **2010**, 127, 41–51.

[10]. Bashir, M.; Ahmad, Z.; Mansoor, S. Occurance and distribution of viral diseases of mungbean and mashbean in Punjab, Pakistan. Pak. J. Bot. **2006**, 38, 1341–1351. [**Google Scholar**]

[11]. Bellincampi, D.; Cervone, F.; Lionetti, V. Plant cell wall dynamics and wall-related susceptibility in plant–pathogen interactions. Front. Plant Sci. **2014**, 5, 228. [**Google Scholar**]

[12]. Belyagoubi-Benhammou, N.; Belyagoubi, L.; Gismondi, A.; Di Marco, G.; Canini, A.; Bekkara, F.A. GC/MS analysis, and antioxidant and antimicrobial activities of alkaloids extracted by polar and apolar solvents from the stems of Anabasis articulata. Med. Chem. Res. **2019**, 28, 754–767. [**Google Scholar**]

[13]. Bhadana VP, Sharma PK, Ansari MA, Baishya LK, Punetha P, Datt S, Prakash N, and Rana KS (2013). Food legumes for livelihood and nutritional security in North Eastern Himalayan region: Prospects and constraints. Indian J. Agricultural Sci. 83(9): 899-906.

[14]. Bharathi V and Anand AV (2015). A Review on Macrotyloma uniflorum. American Journal of PharmTech Research 5(3): 125-130.

[15]. Bhat, Z.S.; Rather, M.A.; Maqbool, M.; Hafiz, U.L.L.; Yousuf, S.K.; Ahmad, Z. α-pyrones: Small molecules with versatile structural diversity reflected in multiple pharmacological activities-an update. Biomed. Pharmacother. **2017**, 91, 265–277. [**Google Scholar**]

[16]. Bolouri-Moghaddam, M.R.; Le Roy, K.; Xiang, L.; Rolland, F.; Van den Ende, W. Sugar signalling and antioxidant network connections in plant cells. FEBS J. **2010**, 277, 2022–2037. [**Google Scholar**]

[17]. Chahota RK, Sharma TR, Sharma SK, Kumar N, Rana JC, In: Singh M, Upadhyaya HD and Bisht IS (2013b). Genetic and genomic resources of grain legume improvement, 1st edn. Elsevier, London, pp 293–302.

[18]. Chaitanya DAK, Kumar S, Reddy M, Mukherjee AM, Sumanth MH, and Ramesh DA (2010). Anti urolithiatic activity of Macrotyloma uniflorum seed extract on ethylene glycol induced urolithiasis in albino rats. Journalof Innovative Trends in Pharmaceutical Sciences, 1(5): 216–226.

[19]. Chakraborty, A.; Brantne, A.; Mukainaka, T.; Nobukuni, Y.; Kuchide, M.; Konoshima, T.; Tokuda, H.; Nishino, H. Cancer chemopreventive activity of Achyranthes aspera leaves on Epstein–Barr virus activation and two-stage mouse skin carcinogenesis. Cancer Lett. **2002**, 177, 1–5. [**Google Scholar**]

[20]. Dracheva, L.V.; Dorozhko, E.V.; Avramchuk, O.A.; Korotkova, E.I.; Ryzhkova, E.P.; Hao, L.; Danilova, I.V. Voltammetric study of the antioxidant activity of propionic acid bacteria in liquid cultures. Mosc. Univ. Biol. Sci. Bull. **2009**, 64, 157–160. [**Google Scholar**]

[21]. Durga, K.K.; Varma, V.S.; Reddy, A.V.V. Sources of resistance to wilt and YMV in horse gram. J. Glob. Biosci. **2014**, 3, 280–284. [**Google Scholar**]

[22]. Faivre-Rampant, O.; Thomas, J.; Allègre, M.; Morel, J.B.; Tharreau, D.; Nottéghem, J.L.; Lebrun, M.H.; Schaffrath, U.; Piffanelli, P. Characterization of the model system rice-Magnaporthefor the study of nonhost resistance in cereals. New Phytol. **2008**, 180, 899–910. [**Google Scholar**]

[23]. Ganesan, K.; Xu, B. Polyphenol-rich lentils and their health promoting effects. Int. J. Mol. Sci. **2017**, 18, 2390. [**Google Scholar**]

[24]. Geraldo, R.; Santos, C.S.; Pinto, E.; Vasconcelos, M.W. Widening the Perspectives for Legume Consumption: The Case of Bioactive Non-nutrients. Front. Plant Sci. **2022**, 13, 772054. [**Google Scholar**]

[25]. Gopalan, C.; Rama Sastri, B.V.; Balasubramanian, S.C. Nutritive Value of Indian Foods; Indian Council of Medical Research (ICMR): New Delhi, India; National Institute of Nutrition: Hyderabad, India, 1989; pp. 110–125. [**Google Scholar**]

[26]. Gundersen, R.Y.; Vaagenes, P.; Breivik, T.; Fonnum, F.; Opstad, P.K. Glycine—An important neurotransmitter and cytoprotective agent. Acta Anaesthesiol Scand. **2005**, 49, 1108–1116. [**Google Scholar**]

[27]. Gupta SK, Sharma PK and Ansari SH (2005). Antimicrobial activity of Dolichos biflorus seeds. Indian J Nat Prod 21: 20–21.

[28]. Herbers, K.; Meuwly, P.; Frommer, W.B.; Métraux, J.P.; Sonnewald, U. Systemic acquired resistance mediated by the ectopic expression of invertase: Possible hexose sensing in the secretory pathway. Plant Cell **1996**, 8, 793–803. [**Google Scholar**]

[29]. Hulbert, P.B.; Beuding, E.; Robinson, C.H. Structure and antisehistosomal activity in the nitrofuran series. J. Med. Chem. **1973**, 16, 72. [**Google Scholar**]

[30]. Hussein, H.M.; Ubaid, J.M.; Hameed, I.H. Insecticidal Activity of Methanolic Seeds Extract of Ricinus communis on Adults of Callosobruchus maculatus (Coleoptera: Brauchidae) and Analysis of its Phytochemical Composition. Int. J. Pharmacogn. Phytochem. Res. **2016**, 8, 1385–1397. [**Google Scholar**]

[31]. Iannetta, P.P.M.; Hawes, C.; Begg, G.S.; Maaß, H.; Ntatsi, G.; Savvas, D.; Vasconcelos, M.; Hamann, K.; Williams, M.; Styles, D.; et al. A multifunctional solution for wicked problems: Value-chain wide facilitation of legumes cultivated at bioregional scales is necessary to address the climate-biodiversity-nutrition nexus. Front. Sust. Food Syst. **2021**, 5, 692137. [**Google Scholar**]

[32]. Jayaraj AP, Tovey FI, Lewin MR, and Clark GC (2000). Duodenal ulcer prevalence: experimental evidence for possible role of dietary lipids. Journal of Gastroenterology and Hepatology, 15: 610–616.

[33]. Kano, A.; Gomi, K.; Yamasaki-Kokudo, Y.; Satoh, M.; Fukumoto, T.; Ohtani, K.; Tajima, S.; Izumori, K.; Tanaka, K.; Ishida, Y.; et al. A rare sugar, d-allose, confers resistance to rice bacterial blight with upregulation of defense-related genes in Oryza sativa. Phytopathology **2010**, 100, 85–90. [**Google Scholar**]

[34]. Kasuga, N.C.; Sugie, A.; Nomiya, K. Syntheses, structures and antimicrobial activities of water-soluble silver(i)–oxygen bonding complexes with chiral and racemic camphanic acid (HCA) ligands. Dalton Trans. **2004**, 21, 3732–3740. [**Google Scholar**]

[35]. Kaushik, U.; Aeri, V.; Mir, S.R. Cucurbitacins—An insight into medicinal leads from nature. Pharmacogn. Rev. **2015**, 9, 12–18. [**Google Scholar**]

[36]. Kopka, J.; Schauer, N.; Krueger, S.; Birkemeyer, C.; Usadel, B.; Bergmuller, E.; Dormann, P.; Gibon, Y.; Stitt, M.; Willmitzer, L.; et al. GMD@CSBDB: The Golm Metabolome Database. Bioinformatics **2005**, 21, 1635–1638. [**Google Scholar**]

[37]. Kravchuk, Z.; Vicedo, B.; Flors, V.; Camañes, G.; González-Bosch, C.; García-Agustín, P. Priming for JA-dependent defenses using hexanoic acid is an effective mechanism to protect Arabidopsis against B. cinerea. J. Plant Physiol. **2011**, 168, 359–366. [**Google Scholar**]

[38]. Kumar V, Sinha AK, Makkar HPS and Becker K (2010). Dietary roles of phytate and phytase in human nutrition: a review. Food Chem 120: 945–959.

[39]. Kumar, P.P.; Rao, M.R.K.; Elizabeth, A.A.; Prabhu, K. GC MS analysis of one ayurvedic medicine sahacharadi kashayam. Int. J. Pharm. **2018**, 10, 31214–31230. [**Google Scholar**]

[40]. Kumar, S.; Kumar, P.; Marwaha, R.K.; Narasimhan, B. Synthesis, antimicrobial evaluation and QSAR studies of propionic acid derivatives. Arab. J. Chem. **2017**, 10, S881–S893. [**Google Scholar**]

[41]. Liu, A.; Contador, C.A.; Fan, K.; Lam, H.M. Interaction and regulation of carbon, nitrogen, and phosphorus metabolisms in root nodules of legumes. Front. Plant Sci. **2018**, 9, 1860. [**Google Scholar**]

[42]. Mabhaudhi T, Chimonyo VGP, Chibarabada TP, and Modi AT (2017). Developing a roadmap for improving neglected and underutilized crops: a case study of South africa. Front Plant Sci 8: 2143.

[43]. Malathi, V.G.; John, P. Gemini viruses infecting legumes. In Characterization, Diagnosis & Management of Plant Viruses, Volume 3: Vegetables and Pulse Crops; Rao, G.P., Lava Kumar, P., Holguin-Pena, R.J., Eds.; Stadium Press LLC: Houston, TX, USA, 2008; pp. 97–123. [**Google Scholar**]

[44]. Maravi, D.K.; Kumar, S.; Sahoo, L. NMR-Based Metabolomic Profiling of Mungbean Infected with Mungbean Yellow Mosaic India Virus. Appl. Biochem. Biotechnol. **2022**, 194, 5808–5826. [**Google Scholar**]

[45]. Mathew, Limi Elizabeth, Sindhu G and Helen A (2014). Dolichos biflorus exhibits anti-inflammatory and antioxidant properties in an acute inflammatory model. Journal of Food and Drug Analysis, 22(4): 455–462.

[46]. McManus, M.C. Mechanisms of bacterial resistance to antimicrobial agents. AM J. Health Syst. Ph. **1997**, 54, 1420–1433. [**Google Scholar**]

[47]. Metcalf, R.L.; Metcalf, R.A.; Rhodes, A.M. Cucurbitacins as kairomones for diabroticite beetles. Proc. Natl. Acad. Sci. USA **1980**, 77, 3769–3772. [**Google Scholar**]

[48]. Moghayedi, M.; Ahmadzadeh, H.; Ghazvini, K.H.; Goharshadi, E.K. Neglected antibacterial activity of ethylene glycol as a common solvent. Microb. Pathog. **2017**, 107, 457–461. [**Google Scholar**]

[49]. Morkunas, I.; Gmerek, J. Sucrose-stimulated accumulation of isoflavonoids as a defence response of lupine to Fusarium oxysporum. Plant Physiol. Bioch. **2005**, 43, 363–373. [**Google Scholar**]

[50]. Morris JB (2008). Macrotyloma axillare and M. uniflorum: descriptor analysis, anthocyanin indexes, and potential uses. Genetic Resources Crop Evolution, 55: 5–8.

[51]. Muniyappa, V.; Reddy, H.R. Studies on the yellow mosaic disease of horsegram (Dolichos biflorus L.)—Virus vector relationships. Mysore J. Agric. Sci. **1976**, 10, 605–610. [**Google Scholar**]

[52]. Murthy, S.M.; Devaraj, V.R.; Anitha, P.; Tejavathi, D.H. Studies on the activities of antioxidant enzymes under induced drought stress in vivo and in vitro plants of Macrotyloma uniflorum [Lam.] Verdc. Recent Res. Sci. Technol. **2012**, 4, 34–37. [**Google Scholar**]

[53]. Muthukumar T, Prakash D, Anbarasu K, Kumar BS and Sastry TP (2014). Effect of collagen sponge incorporating Macrotyloma uniflorum extract on full-thickness wound healing by down-regulation of matrix metalloproteinases and inflammatory markers. RSC Adv., 4(109): 64267–64276.

[54]. National Academy of Sciences (1978). Mothbean in tropical legumes: Resources for the future. Washington, DC: National Academy of Sciences.

[55]. Parimala, K.; Meenakumari, K.V.S.; Sudhakar, R.; Durga, K.K. Screening of horsegram genotypes against yellow mosaic virus and powdery mildew diseases. Indian J. Pl. Protect. **2011**, 39, 160. [**Google Scholar**]

[56]. Patel, D.P.; Dabas, B.S.; Sapra, R.S.; Mandal, S. Evaluation of Horsegram (Macrotyloma uniflorum Lam.) Germplasm; National Bureau of Plant Genetic Resources: New Delhi, India, 1995; pp. 37–53. [**Google Scholar**]

[57]. Patnaik, B.R.; Rout, D.N.; Mahapatra, G.N. Studies of oxazole part I: Synthesis and chlorination of some new 2-amino-4-substituted oxazoles and their use as fungicides. J. Indian Chem. Soc. **1978**, 55, 264. [**Google Scholar**]

[58]. Prema, G.U.; Rangaswamy, K.T. Field Evaluation of horsegram germplasm/ genotypes against horsegram yellow mosaic virus (HgYMV) disease and biological transmission of horse gram yellow mosaic virus to different leguminous hosts through white flies. Int. J. Agric. Sci. **2017**, 9, 4934–4939. [**Google Scholar**]

[59]. Purseglove JW (1974). Dolichos uniflorus. In: Tropical Crops: Dicotyledons, Longman, London, pp 263–264.

[60]. Qazi, J.; Ilyas, M.; Mansoor, S.; Briddo, R.W. Legume yellow mosaic viruses: Genetically isolated begomoviruses. Mol. Plant Pathol. **2007**, 8, 343–348. [**Google Scholar**]

[61]. Radhakrishnan, R.; Lee, I.J. Penicillium–sesame interactions: A remedy for mitigating high salinity stress effects on primary and defense metabolites in plants. Environ. Exp. Bot. **2015**, 116, 47–60. [**Google Scholar**]

[62]. Rojas, M.R.; Gilbertson, R.L.; Russell, D.R.; Maxwell, D.P. Use of degenerate primers in the polymerase chain reaction to detect whitefly-transmitted geminiviruses. Plant Dis. **1993**, 77, 340–347. [**Google Scholar**]

[63]. Rouhibakhsh, A.; Priya, J.; Periasamy, M.; Haq, Q.M.I.; Malathi, V.G. An improved DNA isolation method and PCR protocol for efficient detection of multicomponents of begomovirus in legumes. J. Virol. Methods **2008**, 147, 37–42. [**Google Scholar**]

[64]. Samuels, L.; Kunst, L.; Jetter, R. Sealing plant surfaces: Cuticular wax formation by epidermal cells. Annu. Rev. Plant Bio. **2008**, 59, 683–707. [**Google Scholar**]

[65]. Sanger, F.; Nicklen, S.; Coulson, A.R. DNA sequencing with chain-terminating inhibitors. Proc. Natl. Acad. Sci. USA **1977**, 74, 5463–5467. [**Google Scholar**]

[66]. Scalabrin, E.; Radaelli, M.; Rizzato, G.; Bogani, P.; Buiatti, M.; Gambaro, A.; Capodaglio, G. Metabolomic analysis of wild and transgenic Nicotiana langsdorffii plants exposed to abiotic stresses: Unraveling metabolic responses. Anal. Bioanal. Chem. **2015**, 407, 6357–6368. [**Google Scholar**]

[67]. Seidel, V.; Taylor, P.W. In vitro activity of extracts and constituents of Pelagonium against rapidly growing mycobacteria. Int. J. Antimicrob. Agents **2004**, 23, 613–619. [**Google Scholar**]

[68]. Sharma V, Rana M, Katoch M, Sharma PK, Ghani M, Rana JC, Sharma TR and Chahota RK (2015a). Development of SSR and ILP markers in horsegram (Macrotyloma uniflorum), their characterization, cross-transferability and relevance for mapping. Mol Breed 35:102.

[69]. Sharma, S.R.; Varma, A. Control of yellow mosaic of mungbean through insecticides and oil. J. Entomol. Res. **1982**, 6, 130–136. [**Google Scholar**]

[70]. Singh RP (2013). Status paper on pulses. Government of India ministry of agriculture, department of agriculture & cooperation, Bhopal, Madhya Pradesh, p 215.

[71]. Singh, A.; Palariya, D.; Dhami, A.; Prakash, O.; Kumar, R.; Rawat, D.S.; Pant, A.K. Biological activities and phytochemical analysis of Zanthoxylum armatum dc. leaves and bark extracts collected from Kumaun region, Uttarakhand, India. J. Med. Herbs Ethnomed. **2020**, 6, 1–10. [**Google Scholar**]

[72]. Smýkal, P.; Coyne, C.J.; Ambrose, M.J.; Maxted, N.; Schaefer, H.; Blair, M.W.; Berger, J.; Greene, S.L.; Nelson, M.N.; Besharat, N.; et al. Legume crops phylogeny and genetic diversity for science and breeding. Crit. Rev. Plant Sci. **2015**, 34, 43–104. [**Google Scholar**]

[73]. Sodani, S.N.; Paliwal, R.V.; Jain, L.K. Phenotypic stability for seed yield in rainfed Horsegram (Macrotyloma uniflorum [Lam.] Verdc. In Proceedings of the National Symposium on Arid Legumes for Sustainable Agriculture and Trade, Jodhpur, India, 5–7 November 2004; Central Arid Zone Research Institute: Jodhpur, India, 2004; pp. 5–7. [**Google Scholar**]

[74]. Stagnari, F.; Maggio, A.; Galieni, A.; Pisante, M. Multiple benefits of legumes for agriculture sustainability: An overview. Chem. Biol. Technol. Agric. **2017**, 4, 2. [**Google Scholar**]

[75]. Sudhagar, R.; Priyanka, S.; Chockalingam, V.; Sendhilvel, V.; Souframanien, J.; Raja, K.; Kanagarajan, S. Development and Metabolic Characterization of Horse Gram (Macrotyloma uniflorum Lam. (Verdc.)) Mutants for Powdery Mildew Resistance. Agronomy **2022**, 12, 800. [**Google Scholar**]

[76]. Tierens, K.F.; Thomma, B.P.; Brouwer, M.; Schmidt, J.; Kistner, K.; Porzel, A.; Mauch-Mani, B.; Cammue, B.P.; Broekaert, W.F. Study of the role of antimicrobial glucosinolate-derived isothiocyanates in resistance of Arabidopsis to microbial pathogens. Plant Physiol. **2001**, 125, 1688–1699. [**Google Scholar**]

[77]. VanEtten, H.D.; Mansfield, J.W.; Bailey, J.A.; Farmer, E.E. Two classes of plant antibiotics: Phytoalexins versus "phytoanticipins". Plant Cell **1994**, 6, 1191–1192. [**Google Scholar**]

[78]. Vinci, G.; Cozzolino, V.; Mazzei, P.; Monda, H.; Spaccini, R.; Piccol, A. An alternative to mineral phosphorus fertilizers: The combined effects of Trichoderma harzianum and compost on Zea mays, as revealed by 1 H NMR and GC-MS metabolomics. PLoS ONE **2018**, 13, e0209664. [**Google Scholar**]

[79]. Warth, B.; Parich, A.; Bueschl, C.; Schoefbeck, D.; Neumann, N.K.N.; Kluger, B.; Schuster, K.; Krska, R.; Adam, G.; Lemmens, M.; et al. GC–MS based targeted metabolic profiling identifies changes in the wheat metabolome following deoxynivalenol treatment. Metabolomics **2015**, 11, 722–738. [**Google Scholar**]
[80]. Wheeler, B.E.J. An Introduction to Plant Disease; John Wiley: London, UK, 1969; p. 301. [**Google Scholar**]
[81]. Wittstock, U.; Burow, M. Glucosinolate breakdown in Arabidopsis: Mechanism, regulation and biological significance. Arab. Book **2010**, 8, e0134. [**Google Scholar**]
[82]. Zeng, J.; Deng, S.; Wang, Y.; Li, P.; Tang, L.; Pang, Y. Specific inhibition of acyl-coa oxidase-1 by an acetylenic acid improves hepatic lipid and reactive oxygen species (ROS) metabolism in rats fed a high fat diet. J. Biol. Chem. **2017**, 292, 3800–3809. [**Google Scholar**]
[83]. Zeven AC and De Wet JM (1982). Dictionary of cultivated plants and their regions of diversity: excluding most ornamentals, forest trees and lower plants. Pudoc.
[84]. Zhardhari V (2001). Barah Anaaja-twelve food grains: Traditional mixed farming system. LIESA, India, p 19.