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REVIEW ARTICLE

Leveraging traditional liquid formulations usage in organic agriculture in India - A comprehensive review

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Abstract

In India, the transition from traditional agriculture to inorganic farming in the post-Green Revolution era has led to environmental degradation and adverse climatic changes. Eco-friendly farming method, such as organic farming, offers viable solutions to address these challenges. Organic farming has gained popularity around the world due to consumer recognition for its health benefits and environmental sustainability. The area under organic farming in India has expanded significantly over the years. Indigenous Technical Knowledge (ITK) plays a crucial role in the success of organic farming. ITK integrates traditional wisdom with scientific knowledge, offering locally adaptable, cost-effective and sustainable solutions for organic agriculture. This paper provides an overview of traditionally prepared liquid formulations and their role in organic farming, focusing on their preparation methods, applications and benefits. Various research studies have demonstrated the effectiveness of these traditional liquid formulations in enhancing plant growth, improving yields, protecting crops from pest and disease, enhancing soil fertility, as well as quality of agricultural products. Hence, there is an urgent need for further research, systematic documentation and scientific verification of traditional liquid formulations to ensure its widespread adoption and effectiveness in promoting organic agriculture. An attempt has been made to review the information on the use of traditional liquid formulations, which are crucial for empowering rural communities and addressing the persistent challenges associated with conventional agricultural practices.

Keywords: organic agriculture; plant growth; plant protection; soil fertility; traditional liquid formulations

Introduction

Traditional farming practices in India shifted to inorganic farming after the green revolution, incorporating the widespread application of fertilizer, pesticide, herbicide and fungicide to reduce poverty and increase food production. However, the indiscriminate use of these agricultural inputs has led to the degradation of agricultural lands and environmental pollution. To reduce the issues related to chemical farming, it is necessary to develop the eco-friendly farming technique which is called organic farming.

Over the past decade, organic farming has gained global popularity. With a forecasted growth rate of 16.4% between 2020 and 2025, the organic food market is currently one of the fastest-growing markets in the world. This growth is primarily driven by increased consumer awareness of health benefits and environmental quality. In India, the area under organic cultivation increased from 0.0017 million ha in 2000 to 2.66 million ha in 2020-21 and it will continue to increase (1). In India, organic certified area was reported as approximately 4.72 million ha with production of 1.24 million t, including basmati rice, oil seeds, pulses, sugarcane, fruits, cotton, vegetables, tea, dry fruits, spices, coffee and their value-added products (2).

ITK is an important component in organic farming. It is a combination of scientific knowledge and traditional knowledge that aid in development of technologies that are locally accessible, readily accepted, cost-effective, compelling and credible to rural clients (3). Rural populations depend heavily on ITK for their livelihoods and to manage ecosystem in a sustainable manner (4).

Among the diverse traditional inputs used in organic agriculture, traditional liquid formulations have held a significant place in indigenous farming systems across the globe. These traditional liquid formulations are prepared from plant extracts, animal manures and other organic materials, have been used for centuries to enhance crop growth, to increase quality and quantity of the product and promote soil fertility. By using locally

available resources and drawing upon ancient knowledge systems, traditional liquid formulations offer sustainable and cost-effective solutions for small-scale farmers, particularly in regions where access to commercial fertilizers may be limited (5).

Major traditional liquid formulations include Panchakavya, Jeevamirtham, fish amino acid, egg amino acid, Amirtham solution, coconut buttermilk extract, arappu butter milk extract and 3G extract. The use of these traditional liquid formulations aligns with the principles of organic agriculture, which emphasize closed nutrient cycles, minimal external inputs and the stimulation of the soil biological activities (6). Furthermore, such traditional liquid formulations have power to contribute the bigger goals of agroecological intensification, which seeks to enhance agricultural productivity while preserving natural resources and ecosystem activities (7).

However, precise documentation of these formulation - including their functions, compositions, preparation methods, potential modifications and applications-are often lacking. Much of this knowledge resides in oral traditions, localized languages, cultural practices and the skills of individual communities (8). Given their demonstrated role in enhancing soil fertility (physical, chemical and biological properties), boosting plant growth and yield, improving product quality and reducing pest and disease incidence, there is an urgent need to collect, preserve, scientifically validate and promote the use of traditional liquid formulations in organic agriculture (9).

This paper provides an overview of the influence of various traditional liquid formulations on plant growth, yield parameters, quality attributes and plant protection across a range of crops.

Preparation of traditional liquid formulations

The preparation of traditional liquid formulations is simple, cost-effective,and relies primarily on locally available resources. Panchagavya is composed of 5 cow-derived products: cow dung, cow urine, cow milk, cow curd and cow ghee. These components are mixed in appropriate proportions and allowed to ferment, producing a solution rich in auxins, gibberellins and beneficial microorganisms that improve soil fertility and stimulate plant growth (10). Jeevamirtham is prepared by combining 10 kgs of cow dung, 10 L of cow urine, 2 kgs of jaggery, 2 kgs of pulse flour and a handful of farm soil. These ingredients are mixed in a 200 L drum and the volume is adjusted to 200 L with water. The mixture is stirred in a clockwise direction and kept in a shaded area covered with a damp jute cloth. Regular stirring is performed thrice daily for 10 days before applying the solution to moist soil around the crop root zone (11, 12). Fish amino acid is prepared using fish waste from local markets. Equal amounts of jaggery and fish waste (1 kg each) are combined in an airtight container, thoroughly mixed and stored in a cool, dry place away from sunlight. After fermenting for 15 days, the liquid is filtered and used as a spray. The final product is a viscous fluid with a distinctive aroma (13, 14). Amirtham solution, another organic preparation, enhances soil structure and its capacity to retain water and nutrients. This solution is made by mixing 1 kg of cow dung, 1 L of cow urine, a handful of jaggery and 10 L of water. After thorough mixing, the solution is allowed to ferment for 24 hr in a shaded area covered with a mosquito net. Amirtham acts as a plant growth stimulator and immunity booster (15). Brahmastra is formulated by boiling 10 L of cow urine with 3 kg of neem leaf paste, 2 kg each of karanj, dhatura, custard apple and papaya. The mixture is boiled for several times, cooled for 24 hr and fermented for 48 hr with regular stirring (16). Egg amino acid is prepared by soaking 10 eggs in lemon juice extracted from 20 lemons for 10 days. The eggs are then mashed and 250 g of jaggery is added. The mixture ferments for another 10 days, after which it is filtered. The liquid serves as a plant growth regulator, promoting plant growth and development (13, 14). 3G extract involves blending 18 g of garlic, 9 g of green chili and 9 g of ginger into a paste. The paste is mixed with 1 L of water, stirred thoroughly and filtered before application (3). Coconut buttermilk extract is made by mixing 5 L of buttermilk, 1 L of tender coconut water, one or two coconuts and 500 mL to 1 L of juice from waste fruit. This mixture ferments for seven days and enhances plant growth and flowering (3). Arappu buttermilk extract consists of 5 L of buttermilk, 1 L of tender coconut water, 1-2 kg of arappu leaves and either 500 g of waste fruit or 1 L of juice extracted from waste fruit. This mixture is fermented for seven days and improves plant growth, provides insect resistance and protects against fungal diseases. Its efficacy is comparable to that of gibberellic acid (3).

Effect of traditional liquid formulations on plant growth and yield of crops

The productivity of any crop is largely depend on the input application to that crop, lesser quantity of input application will lead to deficiency and excess quantity of inputs will leads to toxicity. It's better to give input at proper quantity, proper timing, proper place which should not affect the environment. Best option to fulfil all those things is using of traditional liquid formulations on critical stages.

Growth of plants is directly proportional to the nutrient applied on the particular growth stages of plant. Plant attains maximum growth when optimum quantity of nutrients applied at critical stages. It is mandatory to apply right quantity of nutrient to plant. In organic agriculture, apart from soil application of organic manures, foliar application of traditional liquid formulations like panchakavya, jeevamirtham, amirtham solution, fish amino acid, egg amino acid, brahmastra, coconut butter milk extract etc, are used to improve the plant growth by inducing cell division and elongation.

Research evidences pertain to application of various traditional liquid formulations on plant growth and yield are summarized and furnished in Table 1.

Effect of traditional liquid formulations on pest and disease management

Disease

Organic farming systems often have lower levels of soil-borne pathogens and root diseases when compared to inorganic farming systems (17). In organic systems, airborne infections usually do not create significant issues, however there are some exceptions, which including potato late blight and powdery/ downy mildews in vegetable and fruit crops, which are less mobile, are often managed controlled through the use of balanced nutrition and good soil husbandry (18).

Many scientific research proved that the balanced nutrition and good soil health can be given by using traditional liquid inputs on both soil and plant. Traditional liquid formulations generate multiple metabolism like organic acids,

Table 1. Influence of traditional liquid formulations on plant growth and yield attributes in various crops

Traditional liquid formulations / crops	Impact on growth and yield of crops	References
	1.Panchakavya	
Sweet corn	Foliar spray of 3% on 15, 30 and 45 DAS recorded 17% higher grain yield (6100 kg ha^{-1}) over control.	(15)
Bitter gourd	Foliar spray of 5% recorded higher grain yield 41.485 t ha^{-1} which was 44% higher as compared to control.	(41)
Chick pea	Foliar spray 4% at branching and flowering stages registered 28% higher plant height at 90 DAS and 21% higher grain yield over control	(45)
Amaranthus	Foliar spray of 3% increased the 6% plant height and 28% higher green leaf yield over control.	(46)
Rice	Foliar spray 4% on 10, 20, 30 and 45 DAS recorded higher plant height and leaf area index to the tune of 16% and 18% over control in direct seeded rice.	(47)
Senna	Foliar spray of 2% at vegetative and flowering stages increased the plant height at 15.30%, 12.23% and 12.23% higher number of pods $plant^{-1}$ and dry pod yield respectively over control	(48)
Balsam	Seed treatment with 2% panchakavya for 24 hr soaking, germination percentage was observed as 86%. Further, shoot length and root length were also increased at 54% and 79% respectively over control.	(49)
Fenugreek	Foliar application of 4 % panchakavya on pre flowering, pod filling stages recorded higher plant height, number of branches at harvest stages, number of pots $plant^{-1}$, number of seeds $plant^{-1}$ and higher seed yield to the tune of 18%, 38%, 30.57%, 17% and 30.49% respectively as compared to control.	(50)
	2.Jeevamirtham	
Chilli	Number of leaves per plant was 11 under Jeevamirtham at 400 L $acre^{-1}$ applied plot while control was observed only 7.	(11)
Cowpea	Application of Jeevamirtham at 400 L $acre^{-1}$ recorded 16% and 50.28 % of higher plant height and grain yield respectively over control.	(12)
Mango	Application of jeevamirtham at 1000 L ha^{-1}, produced 34% higher fruit yield over control.	(34)
French bean	Application of jeevamirtham at 800 L $acre^{-1}$ produced 32% more yield over control.	(51, 58)
Tomato	Application of jeevamirtham at 1000 L ha^{-1} on 15,30,45,60 DAS recorded significantly a greater number of fruits (33 fruit $plant^{-1}$) over control.	(52, 59)
	3.Fish amino acid (FAA)	
Green gram	Foliar spray of 1.0% FAA recorded 19.5% higher plant height over control.	(14)
Rice	Foliar spray of FAA at 1.0%, registered higher leaf area index, plant height, number of tillers $plant^{-1}$ and grain yield to the tune of 28%, 15.2%, 31% and 26% respectively over control.	(51)
Chrysanthemum	Foliar spray at 3.0% on 60 days after transplanting recorded higher shoot height, leaf length, leaf width, leaf area and leaf weight to the tune of 28.9%, 30.8%, 15.9%, 18.9%, 36.2% and 28.2%, respectively over control.	(52)
Amaranthus	Foliar spray of 1% FAA produced significantly taller plants (11.3 cm) as compared to control.	(53)
Watermelon	Vine length, internode length and number of leaves were higher under 3% FAA treated plants than control. Similarly, foliar spraying of 3% FAA recorded 42% higher yield over control.	(54)
Marigold	Foliar spray of 4% FAA after pinching operation produced 12% more number of flowers $plant^{-1}$ and 89% higher grain yield over control	(60)
	4.Amirtham solution	
Sweet corn	Foliar spray of 3.0% increased the plant height up to 26% over control.	(15)
Okra	Foliar spray of 5.0 Amirtham solutions increased the plant height up to 36% on 4 weeks after sowing over control.	(24)
Polyscias spp.	Foliar spray of 3.0% showed 26% increased plant height and 34% higher root length as compared to control.	(26)
Capsicum annum	Amirtham solution sprayed at 4%, overall plant growth was increased as 32% when compare to control.	(55)
Cow pea	Application of 500 L ha^{-1} recorded 22% higher grain yield (1570 kg ha^{-1}) over control.	(56)
Chilli	Foliar spray of 5.0%, gave germination percentage of 83%, root length of 5.1 cm, shoot length of 14.25 cm.	
Green gram	Application of 500 L ha^{-1} recorded 36% higher grain yield (1780 kg ha^{-1} over control).	(61)
	5.Brahmastra	
Green gram	Foliar spray of 1.5% recorded 29% higher plant height over control.	(14)
Tomato	Foliar spray of 80 mL L^{-1} of water, recorded 23.36 % higher fruit yield over control.	(16, 59)
Potato	Foliar spray of 80mL L^{-1} of water on 45 DAS recorded 28 % higher plant height over control	(21, 64)
Pea crop	Foliar spray of 6% recorded higher plant height of 58.6 cm than control (15.50cm).	(57)
Rice	Foliar spray of 1.0% FAA recorded 24% higher grain yield (3460 kg ha^{-1}) over control.	(62)
	6.Egg amino acid (EAA)	
Green gram	Foliar spray of 0.5% FAA recorded 32% higher grain yield over control.	(14)
Rice	Foliar application of 1% EAA registered 38% higher leaf area index and 34% higher grain yield over control	(51) (63)

hydrogen peroxide and antibiotics that are successful against various pathogenic microorganisms (19). For example, the application of amirtham solution has been shown to enhance crop strength and disease resistance to the crop (15). Coconut butter milk extract helps to increase resistance against fungal diseases, promotes plant growth and acts as an insect repellent. In Bengal gram, the use of coconut butter milk extract was used as seed treatment at the rate of 125mL kg^{-1} was found to prevent fungal diseases.

Arappu buttermilk extract promotes fruiting and flowering due to the presence of fermented curd and *Acacia fragenia* leaves. The buttermilk solution contains beneficial bacteria, lactic acid and yeast, which will increase the leaves' therapeutic value. This combination has been shown to effectively control fungal, bacterial, viral diseases and all types of rotting diseases that occurs in rhizosphere. Arappu - buttermilk solution has been utilized as a seed treatment in groundnut cultivation to control soil borne diseases (20).

Pest

Pests are generally not a major issue in organic agriculture, as plants grows in healthy soil with balanced nutrition tend to be more resilient to pest attack. However, significant pest damage has occasionally been observed in organic crops, especially in vegetables, which are highly susceptible to pest infestations due to inadequate nutrition. Pest problems can be especially severe in large-scale agricultural lands, where several ha of a single crop species may be grown (18).

Pest control using traditional liquid formulations is primarily preventative rather than curative. However, plant protection can still be effectively achieved by supplying balance nutrition and applying natural insect repellents such as Brahmastra, 3G extract, ginger oil, tobacco extract and neem extract. Several scientific studies have highlighted the efficacy of traditional liquid formulations in protecting crops from pest attack.

Brahmastra is a natural insecticide derived from alkaloid-rich leaves. It not only enhances plant resistance, to disease but also supplies nutrients and effectively controls insect pests. In rice cultivation, seed treatment and foliar application of Brahmasta at 15, 30, 45, 60, 75 days after transplanting (DAT) significanty reduced the leaf roller incidence (21). When brahmastra was sprayed at 10% concentration on various plants, it demonstrated an insect repellent index of 0.77 against the diamondback moth (DBM) (22).

3G extract, prepared from garlic, ginger and green chilli paste act as an insect repellent in plant (3). Foliar application of 3G extract in cotton significantly reduced the population of sucking pests such as whiteflies, plant leaf hopper and Aphids (23). In ginger cultivation, the application of ginger oil at a 1% concentration effectively controlled the Bihar hairy caterpillar (24).

Tobacco extract, when applied in brinjal fields, resulted in a 78% reduction in jassid infestation (25). Similarly, in banana cultivation, neem extract application reduced whitefly and mite infestation by 95.96% and 77.74%, respectively (26). In paddy fields, Gandhi bug infestation was controlled by applying a mixture of garlic and tobacco extract at a rate of 200 L per acre (27). Additionally, a study on cotton reported that Tulasi (*Ocimum sanctum*) extract at a 10% concentration reduced *Phenacoccus solenopsis* (mealybug) infestation by up to 96.75% (28). Another study confirmed that garlic and tobacco extract application in paddy fields reduced Gandhi bug incidence by 68%.

Effect of traditional liquid formulations on soil fertility

Earthworm activity in the soil has been found to increase with the application of traditional liquid formulations (29). Panchagavya was a powerful plant growth promoter that improves the biological efficiency of crops. It is used to actuate biological reactions and to protect the plants from disease incidence. Panchagavya improves soil health by increasing macronutrients, micronutrients and beneficial microorganisms in soil. It also improved the water holding capacity of soil because it serves as an organic manure when applied at the rate of 50 L ha^{-1} on soil (3). Furthermore, it promotes the growth and reproduction of beneficial soil microorganisms, thereby enhancing nutrient uptake and overall plant growth (30).

A noticeable increase in soil moisture was observed with the application of jeevamirtham at a rate of 1000 L ha^{-1} compared to the control (31). Continuous application of traditional liquid formulations on the soil, increased the organic carbon, maintain soil pH, electrical conductivity (EC), soluble phosphorus, exchangeable potassium levels and contribute to nutrient storage in the soil over a period of 4 years (32, 33). Specifically, the application of jeevamirtham at 1000 L ha^{-1} resulted in a soil moisture content of 12.56%, bulk density of 1.30 g cm^{-3}, soil pH of 6.76 and organic carbon of 0.92 %, all of which are sufficient to plant growth and development (34).

Fish amino acid serves as an effective soil amendments due to its high water-holding capacity (up to 3%) and its ability to supply enough nitrogen to the plant for optimum uptake (11). Traditional liquid formulations are rich in beneficial microbes such as bacteria, fungi and actinomyces, which not only increase the microorganism population but also stimulated them to perform well (35, 36). The density of bacteria, fungi and actinomyces is generally higher in organic farming systems when compare to inorganic farming (24) mainly due to application of traditional liquid formulations on the soil (37). Furthermore, the use of traditional liquid formulations not only increases the soil micro-organisms and also reduced the soil borne pathogens (38). Further, it releases the macro and micronutrients into the soil solution, resulted in more available form of nutrients to the plants and finally more nutrient uptake in plants (33).

Effect of traditional liquid formulations on quality of products

The nutritional content of food materials depends on the presence of bioactive compounds that contribute to the proper functioning of human physiological processes (39). Comparative studies have shown that produce cultivated using traditional liquid formulations contains significantly higher levels of nutrients than those from conventional farming. Specifically, vitamin C content was 28.7% higher, phenolic compounds increased by 19.3%, iron by 21.1%, magnesium by 29.3% and phosphorus by 13.6% in carrot and potato (40). In bitter gourd, the application of Panchagavya at 5% resulted in a 78% increase in total soluble solids (TSS), reaching 3.856° Brix, as compared to the control. Additionally, ascorbic acid content increased to 1.937 mg per 100 g (41).

Numerous studies have clearly indicated that the total sugar content in organically grown vegetables and fruits is higher than in those grown through conventional (inorganic) methods (40). In fruit crops, increased total sugar not only improves taste but also enhances overall product quality (39). Although crude protein content in organically grown produce treated with traditional liquid formulations tends to be lower than in conventionally grown products, the quality is superior due to the higher concentration of essential amino acids (40). For example, in organically cultivated vegetable crops, protein content was reported as 113 mg/g at 60 DAS and 79 mg/g at 90 DAS (33).

Organic vegetables such as beetroot, carrot, potato and tomato, as well as fruits like apple and cherry, exhibit better taste and aroma. Enhanced sensory qualities have also been observed in bread prepared from organically grown grains (40). One study reported that organically produced fodder had improved palatability, leading to easier intake by livestock and subsequently enhancing both the quality and quantity of animal products such as meat and milk. Furthermore, fruits and vegetables treated with traditional liquid inputs demonstrated longer shelf life compared to those grown using inorganic methods (40). The improved storage quality of these crops, even under varying environmental conditions, is attributed to the ability of traditional liquid formulations to decelerate metabolic processes (39).

Challenges in using traditional liquid formulations

Usage of traditional liquid inputs has its challenges. One of the most significant issues is the lack of comprehensive documentation outlining their composition, functions, mechanisms, potential modifications, operational boundaries and applications (8). Moreover, farmers understanding of organic farming practices, particularly the use of traditional liquid formulations, is limited, with a knowledge gap of 32.10% (42). A substantial gap exists between the preparation of traditional liquid inputs and their efficient application in organic agriculture (43).

Pest and disease management using traditional liquid inputs is often less effective, as these formulations predominantly serve as preventive rather than curative solutions (44). Several studies have identified key challenges associated with their use, including the widespread dominance of inorganic farming in many regions, reduced yields during the transition period to organic cultivation and the extended conversion duration, typically spanning at least three years. Additional constraints include high labor costs, limited knowledge regarding recommended organic practices and the unavailability of improved seeds or pest- and disease-resistant varieties.

The preparation of bio-insecticides often involves complex processes and limited accessibility to essential raw materials. Moreover, marketing challenges persist due to a lack of government incentives, absence of remunerative pricing policies, inadequate purchasing agencies, insufficient marketing infrastructure and the unavailability of proper storage facilities in rural areas. High transportation costs, largely attributed to the long distances to procurement centers, further exacerbate these issues. Additionally, farmers often receive limited guidance and training from field experts, lack access to specialized loan schemes and face minimal institutional support to overcome these barriers effectively (43).

Conclusion

Based on the reviewed literatures, it can be concluded that traditional liquid formulations like panchakavya, Jeevamirtham, Amirtham solution, fish amino acid, egg amino acid, coconut butter milk extract, extract and 3G extract play a vital role in transitioning towards more sustainable agricultural systems in India. By integrating indigenous technical knowledge and organic farming practices, it is possible to mitigate the adverse effects of conventional agriculture, safeguard the environment and ascertain food security for future generations. Research evidence has highlighted the effectiveness of traditional liquid formulations in promoting plant growth, improving yield attributes, protecting crops from diseases and pests, enhancing soil fertility and enhancing the quality of agricultural products. However, there is no systematic evidence what they do, what they are, how they do, how they can be changed and their applications. Further, research should on documentation and validation of indigenous technical knowledge to ensure its widespread adoption and effectiveness. Efforts are needed to collect, preserve and disseminate traditional organic formulations are crucial for empowering rural communities and promoting sustainable agricultural practices.

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Authors' contributions

AS carried out the literature review and drafted and edited the manuscript. TR and SR helped with the final editing. SK and KS participated in the sequence alignment and drafted the manuscript. KV checked and corrected plagiarism.

Compliance with ethical standards

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