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The Use of Liquid Organic Formulations Improves the Growth and Yield of Sesame (*Sesamum indicum* L.) under Organic Cultivation

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ABSTRACT

Background: Sesame (*Sesamum indicum* L.) is a drought-tolerant oilseed vital to developing countries and arid regions. Despite its resilience and rich oil content, yields remain low due to indeterminate growth and poor nutrient and source-sink balance. Organic farming offers a sustainable yield improvement approach, but the effects of foliar organic inputs like Panchagavya, cow urine and vermiwash under organic certified conditions are yet to be fully evaluated.

Methods: A field study was carried out during the 2022 *Kharif* season at the Organic Farming Research and Training Centre, MPKV, Rahuri (semi-arid Inceptisol, pH 7.58). Using a randomized block design with three replications, ten treatments were tested *viz.*: control, cow urine (10%), vermiwash (10%), Panchagavya (3%), humic acid (2.5%), Amritpani (3%), waste decomposer (25%), Jeevamrit (10%), Kunapajala (3%) and cow urine + vermiwash (each 10%). All plots received vermicompost (2 t ha^{-1}) at sowing, with foliar sprays applied at flowering [36 Days After Sowing (DAS)] and capsule initiation [57 Days After Sowing (DAS)]. Data were analysed using ANOVA at $p \leq 0.05$.

Result: Foliar spraying with 3% Panchagavya significantly improved sesame growth, yielding more height, plant spread, branches plant^{-1} and dry matter plant^{-1}, surpassing the control. Cow urine + vermiwash produced similar results. Panchagavya also gave the highest yield traits, more capsules plant^{-1}, higher capsule weight, seeds capsule^{-1}, increased seed weight/ plant^{-1} and seeds plant^{-1}. Test weight was unaffected. Overall, fermented organic foliar inputs, especially Panchagavya, markedly enhanced sesame growth and yield under organic systems.

Key words: Cow urine, Foliar spray, Growth, Liquid organic formulations, Organic cultivation, Panchagavya, Sesame, Vermiwash, Yield attributes.

INTRODUCTION

Sesame (*Sesamum indicum* L.), the "queen of oilseeds," has been cultivated for over 3,000 years in tropical and subtropical regions. With up to 50% oil content, rich nutrition and strong drought tolerance, it supports food security on marginal lands. In 2018, global production reached about 6 million tonnes, led by Sudan, Myanmar and India (Gazali *et al.*, 2020). Sesame is valued for its high oil content (up to 50%), nutrition and drought resilience. However, indeterminate growth and stress susceptibility limit its productivity. Advances in breeding, genomics and agronomy aim to enhance yield and meet growing demand (Nitish *et al.*, 2025; Rauf *et al.*, 2024; Yadav *et al.*, 2022; Elayaraja and Sathiyamurthi, 2020).

India leads in sesame cultivation with 1.78 million ha but records low yields (455 kg ha) due to marginal land and poor management (IOPEPC, 2022). In Maharashtra, varieties such as AKT-64, PKVNT-11 and Phule Til-1 perform well across climates, yet average productivity remains around 290 kg/ha (IOPEPC, 2022; Narwal, 2025). Low soil fertility, lack of high-yielding varieties, marginal land cultivation and weak management practices often limit sesame productivity. Integrated nutrient management (N, P, S) with biofertilizers can significantly improve yield and quality (Ranganatha, 2013; Oloniruha *et al.*, 2021). Adopting improved agronomic practices-optimal plant spacing, timely sowing, integrated nutrient management and organic inputs-can greatly boost yields and profits. Measures such as closer spacing, organo-mineral fertilizers, sulphur use, organic manures and balanced NPK levels enhance land use, seed yield and oil output, improving farmers' income (Yadav *et al.*, 2022; Sangma *et al.*, 2022; Oloniruha *et al.*, 2021; Ranganatha, 2013).

Organic farming enhances ecological balance and soil health, countering the effects of agrochemical overuse. It

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is increasingly viewed as essential for sustaining crop productivity and soil fertility (Lokhande *et al*., 2020; Lateef *et al*., 2021; Soliaman *et al*., 2023). Inputs like Panchagavya, Jeevamrit, Vermiwash, Amritpani and Kunapajala enhance nutrient uptake and pest resistance. Using these fermented organics in sesame cultivation supports sustainable production and improves crop quality (Parameswari *et al*., 2025; Tejaswini *et al*., 2024; Biswas and Das, 2025). Liquid organic formulations and manures enhance sesame growth and yield by supplying nutrients, beneficial microbes and growth regulators. They improve soil fertility, structure and microbial activity, increasing nutrient availability and promoting vigorous plant growth (Das *et al*., 2023; Ramkumar *et al*., 2022; Lakhani, 2024). Foliar sprays of Panchagavya and Vermiwash greatly improved sesame yield, yield traits and oil content. Jeevamrit and Amritpani enhance soil microbes, nutrient cycling and plant health, while Kunapajala's fermented mix of animal and plant residues supplies growth stimulants and beneficial microbes, boosting vigour and pest resistance (Salman *et al*., 2022; Atia *et al*., 2014; Watsh *et al*, 2023). Liquid manures such as cow urine act as nutrient sources and natural bio-pesticides, reducing pests and promoting healthy growth. Humic acid improves soil structure, moisture retention and seed yield. Together, these organic inputs enhance sesame productivity, quality and sustainability while reducing chemical dependence and strengthening soil health and resilience (Kandil, 2015; Watsh *et al*, 2023; Lakhani, 2024).

Based on existing knowledge, a study was conducted during the 2022 *Kharif* season on an organically certified field at the Organic Farming Research and Training Centre (OFRTC), Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, to assess the effects of liquid organic formulations on sesame (*Sesamum indicum* L.) growth, yield, quality, soil health and economic performance through foliar application of liquid manures.

MATERIALS AND METHODS

Experimental site

The study was carried out at the OFRTC, MPKV, Rahuri, on an organically certified field accredited by the Karnataka State Seed and Organic Certification Agency (KSSOCA). MPKV, Rahuri lies at 19°57′N latitude and 74°32′E longitude, at an altitude of 511 m. It is situated in the Scarcity Zone of Western Maharashtra within India's Western Plateau and Hilly Region, characterized by a semi-arid climate with 407-619 mm annual rainfall across 15-45 rainy days.

Soil of experimental site

The experimental field had a uniform topography and was classified as Inceptisol with a clay loam texture and depth >60/ cm. Composite initial soil samples were analysed for physical and chemical properties, showing clay loam texture, alkaline pH (7.58), low organic carbon (0.54%) and low EC (0.31 dS m^{-1}). Nutrient status indicated low nitrogen (171.23 kg ha^{-1}), medium phosphorus (11.85 kg ha^{-1}) and high potassium (386.12 kg ha^{-1}).

Experimental design and treatments

The field experiment was laid out in Randomized Block Design comprising 3 replications and 10 treatments *viz*., T_1: Control (No spray), T_2: Foliar spray of Cow urine @ 10%, T_3: Foliar spray of Vermiwash @ 10%, T_4: Foliar spray of Panchagavya @ 3%, T_5: Foliar spray of Humic acid @ 2.5%, T_6: Foliar spray of Amritpani @ 3%, T_7: Foliar spray of Waste Decomposer @ 25%, T_8: Foliar spray of Jeevamrut @ 10%, T_9: Foliar spray of Kunapajala @ 3%, T_{10}: Foliar spray of Cow urine @ 10% + Vermiwash @ 10%. Notably, the foliar sprays were applied at two stages: flowering (36 DAS) and capsule initiation (57 DAS). Organic manure *i.e*., vermicompost was applied to all treatments @ 2-ton ha^{-1} at the time of sowing for experimentation under organic cultivation.

Cultural operations

Certified seeds of sesame variety JLT-408 with seed rate of 2.5-3.0 kg ha^{-1} from OFRTC, MPKV, Rahuri were sown on July 4, 2022, using line sowing at 30 cm × 10 cm spacing. Gap filling and thinning were done at 10 and 15 DAS. One hand weeding was performed at 25 DAS and three irrigations were given at sowing, pre-flowering and capsule initiation. Seeds were treated with Trichoderma (4 g kg^{-1}) before sowing to manage seed and soil-borne diseases. No major pest or disease incidence occurred, though Neem Ark 5% (20 L ha^{-1} in 80 L water) was sprayed at 30 DAS, followed by Dashparni Ark at 50% flowering and capsule development for pest control. All practices complied with organic certification standards under KSSOCA accreditation.

Biometric observations on growth and yield

Biometric observations were recorded on five randomly selected sesame plants per plot. Growth parameters included plant height, branches, plant spread, dry matter, days to 50% flowering and maturity. Yield attributes measured were number and weight of capsules, seeds per capsule, seed yield per plant and test weight.

Statistical analysis

The experimental data were analysed using Analysis of Variance (ANOVA) as per Panse and Sukhatme (1985). The standard error of means (S.Em±) was calculated for treatmesnts. Critical differences (C.D.) were determined at a 5% significance level wherever results were significant.

RESULTS AND DISCUSSION

Growth parameters

Plant height (cm)

The treatment Panchagavya @ 3% (T_4) resulted in significantly higher plant height (86.13 cm) at harvest, statistically comparable to the Cow urine @ 10% + Vermiwash @ 10% (T_{10}) (85.27 cm). The control plot-no spray (T_1) had the lowest plant height (73.07 cm) (Table 1). The growth-promoting effect of Panchagavya might be attributed to its content of growth hormones like indole acetic acid, gibberellic acid and cytokinin. Similar findings were reported by Sakpal *et al*. (2022) and Munji *et al*. (2010) in sesame.

Plant spread (cm)

The study in Table 1 found that Panchagavya @ 3% (T_4) significantly increased sesame plant spread (29.60 cm) at harvest, which was found at par to the combined treatment of Cow urine @ 10% and Vermiwash @ 10% (T_{10}) (28.27 cm). The control plot (T_1) had the least spread (21.93 cm). Panchagavya's foliar spray is absorbed and transported via phloem, stimulating growth-regulating cells and promoting plant growth, height, leaf area index and spread. A similar outcome was reported by Patil *et al*. (2012).

Number of branches plant^{-1}

Panchagavya @ 3% (T_4) significantly increased the number of branches per sesame plant (5.00) at harvest, comparable to the combined treatment of Cow urine @ 10% and Vermiwash @ 10% (T_{10}) (4.93). The control plot (T_1) had the least number of branches (3.87) (Table 1). The growth-promoting substances in Panchagavya, such as auxin, amino acids and micronutrients, likely contributed to the increased branching. Similarly, the growth enzymes in cow urine and vermiwash may have promoted cell division and multiplication, leading to expanded branching. The similar comparable outcomes were reported by Hiradeve *et al*. (2011); Reshma *et al*. (2019) and Sakpal *et al*. (2022).

Dry matter accumulation plant^{-1}

Panchagavya @ 3% (T_4) significantly increased dry matter production per sesame plant (19.87 g) at harvest, while the combined treatment of Cow urine @ 10% and Vermiwash @ 10% (T_{10}) (18.19 g) was statistically remained at with T_4. The control plot (T_1) had the lowest dry matter accumulation (14.94 g) (Table 1). The beneficial microbes and growth-regulating substances in Panchagavya, such as IAA, GA and cytokinin, likely contributed to the improved dry matter production. According to Yadav and Lourduraj (2006), Panchgavya is reported to include a variety of helpful microbes, including Azotobacter, Azospirillium, Phosphobacteria and Pseudomonas, which support a variety of plant development characteristics. Ample amounts of growth-regulating chemicals such as IAA, GA and cytokinin are also present in panchgavya in addition to these. A similar result was reported by Munji *et al*. (2010) and Patel *et al*. (2013).

Days to 50% flowering and days to maturity of sesame

From the data in Table 1, foliar application of liquid organic formulations had limited impact on sesame days to 50% flowering and maturity. The average days to maturity was 42 and 85 days for days to 50% flowering and maturity of sesame, respectively. Panchagavya @ 3% (T_4) took relatively longer to flower (44 days) and to mature (88 days), while Cow urine @ 10% + Vermiwash @ 10% (T_{10}) flowered and matured in 41 and 86 days, respectively. The control plot (T_1) flowered and matured earliest (38 and 83 days), respectively.

Table 1: Growth parameters of sesame at harvest as influenced by liquid organic formulations.

Treatment	Growth parameters of sesame					
	Plant height (cm)	Plant spread (cm)	No. of branches plant^{-1}	Dry matter accumulation plant^{-1} (g)	Days to 50% flowering	Days to maturity
T_1: Control (No spray)	73.07	21.93	3.87	14.94	38	83
T_2: Foliar spray of cow urine @ 10%	80.40	23.07	4.27	16.63	44	87
T_3: Foliar spray of vermiwash @ 10%	79.33	23.87	4.00	16.44	42	86
T_4: Foliar spray of panchagavya @ 3%	86.13	29.60	5.00	19.87	44	88
T_5: Foliar spray of humic acid @ 2.5%	81.13	26.07	4.47	17.83	43	84
T_6: Foliar spray of amritpani @ 3%	81.10	26.00	4.33	17.54	39	87
T_7: Foliar spray of waste decomposer @ 25%	80.40	23.27	4.13	16.52	44	85
T_8: Foliar spray of jeevamrut @ 10%	80.13	25.47	4.27	17.11	41	85
T_9: Foliar spray of kunapajala @ 3%	80.50	25.60	4.27	17.34	42	85
T_{10}: Foliar spray of cow urine @ 10% + Vermiwash @ 10%	85.27	28.27	4.93	18.19	41	86
S.E.±	1.64	0.94	0.15	0.60	1.36	1.33
C.D. @ 5%	4.88	2.79	0.45	1.79	NS	NS
General mean	80.74	25.31	4.35	17.27	42	85

Number of capsules plant^{-1}

The data in Table 2 showed that the Panchagavya @ 3% (T_4) significantly increased the number of capsules per sesame plant (54.27) at harvest, while Cow urine @ 10% + Vermiwash @ 10% (T_{10}) (51.40) was statistically on par with it. The control plot (T_1) had the lowest number of capsules (36.27). It is well known that the availability of the nutrients N, P, Fe and S are physiologically active and have a direct impact on the production of chlorophyll in plants. The availability of these nutrients upon application to sesame might have ultimately aided in the synthesis of more chlorophyll and photosynthates in the leaves. Panchagavya includes salts rich in N, P, K, S and numerous micronutrients in accessible form which might have helped in flower retention and increased the number of capsules plant^{-1}. Similar results were published by Munji *et al*. (2010) and Kekita *et al*. (2017).

Weight of capsules plant^{-1} (g)

The weight of capsules per sesame plant was significantly higher (16.56 g) when treated with Panchagavya @ 3% (T_4), followed by Cow urine @ 10% + Vermiwash @ 10% (T_{10}) (15.52 g), which was statistically comparable. The control plot (T_1) without foliar spray had the lowest capsule weight (11.38 g) (Table 2). The increased weight might be due to Panchagavya's nutrient-rich composition, growth-promoting substances and improved photosynthesis, hormonal regulation and source-sink relationships. This could lead to increased assimilate diversion to the fruiting region, resulting in higher capsule weight, consistent with findings by Jadhav *et al*. (2014a) and Jadhav *et al*. (2014b).

Number of seeds capsule^{-1}

Panchagavya @ 3% (T_4) significantly increased the number of seeds capsule^{-1} (41.13) in sesame plants, while Cow urine @ 10% + Vermiwash @ 10% (T_{10}) (39.67) was statistically at par with it. The control plot (T_1) had the lowest number of seeds capsule^{-1} (28.73) (Table 2). The increased seed number might be due to nutrients, growth-promoting substances and hormonal regulators in Panchagavya, which could have enhanced flower formation, pollination, fertilization and seed development. This led to improved capsule growth, weight and length, ultimately increasing seed number per capsule, consistent with findings by Mahto and Yadav (2005) and Kekita *et al*. (2017).

Weight of seeds plant^{-1} (g)

The data in Table 2 observed that weight of seeds plant^{-1} (g) of sesame was significantly higher in T_4 treatment (Panchagavya @ 3%) (3.75 g) at harvest, whereas the weight of seeds plant^{-1} of treatment T_{10} (Cow urine @ 10% + Vermiwash @ 10% (3.51 g) at harvest, was found at par concerning superior treatment. The lowest weight of seeds plant^{-1} (g) of sesame was observed in the control plot-no spray (T_1) (2.36 g). The increased seed weight per plant in sesame treated with Panchagavya @ 3% could be due to its higher nutrient availability, growth-promoting substances and enhanced photosynthesis, leading to improved nutrient

Table 2: Yield attributes of sesame at harvest as influenced by liquid organic formulations.

Treatment	Yield attributes of sesame					
	No. of capsules plant^{-1}	Wt. of capsules plant^{-1} (g)	No. of seeds capsule^{-1}	Wt. of seeds plant^{-1} (g)	No. of seeds plant^{-1}	Test weight (g)
T_1: Control (No spray)	36.27	11.38	28.73	2.36	994	2.27
T_2: Foliar spray of cow urine @ 10%	42.80	12.71	31.53	2.86	1220	2.33
T_3: Foliar spray of vermiwash @ 10%	39.93	12.20	31.53	2.86	1220	2.33
T_4: Foliar spray of panchagavya @ 3%	39.93	12.20	30.07	2.75	1133	2.31
T_5: Foliar spray of humic acid @ 2.5%	54.27	16.56	41.13	3.75	1656	2.39
T_6: Foliar spray of amritpani @ 3%	47.53	14.70	36.47	3.20	1525	2.36
T_7: Foliar spray of waste decomposer @ 25%	41.60	12.45	31.27	2.78	1168	2.32
T_8: Foliar spray of jeevamrut @ 10%	44.80	13.81	33.73	2.98	1378	2.35
T_9: Foliar spray of kunapajala @ 3%	45.87	14.47	34.93	3.05	1448	2.43
T_{10}: Foliar spray of cow urine @ 10% + Vermiwash @ 10%	51.40	15.42	39.67	3.51	1814	2.43
S.E.±	1.41	0.44	1.40	0.11	51.81	0.07
C.D. @ 5%	4.19	1.31	4.17	0.33	153.93	NS
General mean	45.38	13.88	34.42	3.04	1416	2.36

uptake, assimilate production and allocation to seeds. Panchagavya's beneficial effects on source-sink relationships could also contribute to the observed increase in seed weight. These findings are consistent with previous studies by Ramaswamy and Vijaykumar (2009) and Munji *et al*. (2010) highlighting the potential benefits of Panchagavya in improving crop productivity.

Number of seeds plant^{-1}

Panchagavya @ 3% (T_4) significantly increased the number of seeds plant^{-1} (1825) in sesame, while Cow urine @ 10% + Vermiwash @ 10% (T_{10}) (1814) was statistically comparable. The control plot (T_1) had the lowest number of seeds plant^{-1} (994) (Table 2). The increased number of seeds plant^{-1} in sesame treated with Panchagavya @ 3% could be attributed to its better nutrient enrichment, growth-promoting substances and improved photosynthesis. These factors enhanced flower formation, pollination, fertilization and seed development, ultimately leading to increased seed production. The beneficial effects of Panchagavya on plant growth and development might have contributed to the observed increased in seed number, consistent with findings by Vijayakumari *et al*. (2012) and Vinutha *et al*. (2023).

Test weight (g)

From the data in Table 2, the test weight of sesame was not significantly affected by various treatments during the *kharif* season, 2022-2023, with a mean test weight of 2.36 g. The test weight ranged from 2.27 g to 2.50 g across different foliar spray treatments. The lack of significant impact on test weight might be due to the inherent genetic characteristics of the sesame variety, which could be less responsive to external treatments. Additionally, test weight is a relatively stable trait, less influenced by environmental factors or management practices. These findings were consistent with previous studies by Singh *et al*. (2015) and Kekita *et al*. (2017), which also reported non-significant effects of treatments on test weight in sesame.

CONCLUSION

Foliar application of liquid organic formulations markedly enhanced vegetative growth and yield attributes of sesame under organic cultivation. Panchagavya at 3 percent emerged as the most effective treatment, boosting plant height (86.1 cm), spread (29.6 cm), branching (5.0 branches plant^{-1}) and dry matter accumulation (19.9 g plant^{-1}) over the unsprayed control. Yield components including capsules per plant (54.3), capsule weight (16.6 g), seeds per capsule (41.1), seed weight per plant (3.8 g) and total seeds per plant (1825) were similarly maximized by Panchagavya, with the combined cow urine (10%) + vermiwash (10%) spray producing comparable improvements. Test weight remained stable across all treatments. These findings demonstrate that targeted foliar sprays of fermented organic inputs can serve as sustainable, cost-effective alternatives to conventional fertilizers in sesame production. We recommend integrating Panchagavya and complementary liquid manures into organic nutrient management schedules to realize higher yields without compromising seed quality. Nevertheless, the above-mentioned result was based on a single crop season examination. To verify the results, the investigation must be conducted again for long terms at least five years at different locations. Future research should evaluate long-term soil health impacts, economic returns and performance across diverse genotypes, multi-location trials and agro-climatic zones.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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