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Preface

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Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.



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Table of Contents

Volume-12, Issue-6, June 2026

S.No	Title	Page No.
1	<p>Fecal Egg Count: A Potent Genetic Marker for Parasitic Resistance in Small Ruminants</p> <p>Authors: Dr. Prajakta Jadhav; Dr. A.Y. Devkatte; Dr. B.B. Hajare</p> <p> DOI: https://doi.org/10.25125/ijoeear-jun-2026-1</p> <p> Digital Identification Number: IJOEAR-JUN-2026-1</p>	01-05
2	<p>Enhancing Summer Black Gram Productivity through Combined Herbicide Application: A Growth, Yield and Economic Analysis</p> <p>Authors: Kamaliya Jayraj O.; Rahul R. Pisal; Payal A. Patel; P. Sowjanya Deepthi; Kinjal. A. Shah</p> <p> DOI: https://doi.org/10.25125/ijoeear-jun-2026-2</p> <p> Digital Identification Number: IJOEAR-JUN-2026-2</p>	06-12
3	<p>PM-KUSUM Yojana (Solar Agriculture Pumps): An Exploratory Study in Deoria district of Uttar Pradesh</p> <p>Authors: Vatan Vishwakarma; Dr. Pankaj Kumar Rav; Shubham Mishra; Yusuf Ali</p> <p> DOI: https://doi.org/10.25125/ijoeear-jun-2026-3</p> <p> Digital Identification Number: IJOEAR-JUN-2026-3</p>	13-21
4	<p>Growth and Yield Performance of Snap Beans (<i>Phaseolus vulgaris</i> L.) as Affected by Salt-Based and Molasses-Based JADAM Liquid Fertilizers Using Selected Plant Material Sources</p> <p>Authors: Rizzielyn B. Telmo</p> <p> DOI: https://doi.org/10.25125/ijoeear-jun-2026-4</p> <p> Digital Identification Number: IJOEAR-JUN-2026-4</p>	22-29



Fecal Egg Count: A Potent Genetic Marker for Parasitic Resistance in Small Ruminants

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Abstract— For decades, the severity of parasitic infection in small ruminants has been measured using fecal egg count (FEC). Genetic resistance to parasitic infection varies among individual animals and flocks, making this trait economically important, particularly in small ruminants. Heritability estimates for FEC across different breeds, populations, and time periods range from low to moderate. This paper reviews studies reporting genetic parameter estimates for FEC in different populations. It also focuses on FEC as a genetic marker and a means for selecting small ruminants for parasitic resistance — a threshold trait for which the underlying variable is fecal egg count. Non-genetic factors affecting FEC are also discussed herein.

Keywords— Small ruminants, fecal egg count (FEC), heritability, parasitic resistance, genetic parameter.

I. INTRODUCTION

Parasitic infections in small ruminants, particularly those affecting the gastrointestinal system, are a significant cause of morbidity and mortality, leading to extensive economic losses. These losses are primarily due to reduced growth rates, lower reproductive performance, decreased milk yield, and increased veterinary costs associated with the treatment of infected animals (Gourley et al., 2016). Moreover, gastrointestinal parasites contribute to a reduced ability of livestock to convert feed efficiently into meat and milk, further impacting the profitability of farming operations.

The primary method of managing and impeding parasite infections is the use of anthelmintics. However, the costs of such therapy are high, and another disadvantage is that the application of these drugs may lead to drug-resistant populations of parasites (Charon et al., 2002). There has also been increasing concern regarding residual drugs in animal-derived food products (Gowane et al., 2019). Several studies indicate that the problem of parasitic infection occurs most frequently in small ruminants (Augad et al., 2024; Malathi et al., 2021; Suarez et al., 2021; Shashank et al., 2019).

Gastrointestinal nematodes (GINs) pose a major threat to the production performance of small ruminants. The best strategy to control GINs is to appraise or breed sheep that are tolerant to parasites (Miller et al., 1998; Kemper et al., 2009). Extensive information is available regarding variation in sheep and goat resistance to GINs. The term "resistance" includes passive and active immunity. Passive resistance includes physical or chemical barriers that inhibit parasite entry into the host body. Active resistance involves innate and/or adaptive immune responses generally produced in response to infection (Coustau et al., 2000). McClure (2000) described host resistance as the ability of an individual animal to eradicate a parasitic infection and to prevent reinfection by utilising innate (non-specific) and acquired (learned and parasite-specific) immunity.

This review aims to: (1) summarize published heritability estimates for FEC in small ruminants, (2) discuss non-genetic factors influencing FEC, and (3) evaluate the potential of FEC as a genetic marker for breeding parasite-resistant animals.

II. FEC AS A GENETIC TRAIT

Several studies have reported genetic variation for resistance to parasites (Prince et al., 2010; Karlsson and Greeff, 2012; Assenza et al., 2014; Brown and Fogarty, 2017; Ngere et al., 2018). Selection of animals for parasitic resistance is key for breeding healthy animals and avoiding losses incurred due to parasitic infestation. Genetic selection is expected to alter the population's genetic structure over the long term (Gowane et al., 2019) and can thus be considered an effective way to address the problem. Parasitic resistance is, however, a threshold trait with the underlying variable associated with fecal egg count (FEC). Genetic parameters for FEC have been estimated by different researchers (Boareki et al., 2021; Ngere et al., 2018; Pollott and Greeff, 2004; Bisset et al., 1992).

The heritability estimates for FEC range from low to moderate. Heritability estimates reported in Merino sheep from Australia varied from 0.3 to 0.5 (Woolaston et al., 1991); 0.34 ± 0.08 in Romney sheep (Bisset et al., 1992); 0.23 ± 0.07 in sheep from Fiji (Woolaston et al., 1995); 0.28 ± 0.16 in sheep from Poland (Nowosad et al., 1992); and 0.20 ± 0.07 to 0.42 ± 0.10 in sheep from New Zealand (McEwan et al., 1994; Douch et al., 1995). Commercial sheep from Ontario, Canada, displayed a heritability of 0.12 ± 0.04 (Boareki et al., 2021), while Katahdin sheep showed heritability ranging from 0.23 to 0.46 (Ngere et al., 2018).

In India, researchers have reported moderate heritability of FEC in Avikalin sheep (0.21 ± 0.06) and Malpura sheep (0.18 ± 0.04) (Gowane et al., 2019). Heritability ranged from 0.24 to 0.47 in Muzaffarnagari sheep (Yadav et al., 2006), 0.11 to 0.16 in Jamnapari goats (Mandal et al., 2012), and 0.05 to 0.13 in Barbari goats (Mandal and Sharma, 2008). It was reported to be 0.35 ± 0.18 in Avikalin sheep (Singh et al., 1999).

For ease of reference, these heritability estimates are summarized in Table 1.

TABLE 1
HERITABILITY ESTIMATES OF FECAL EGG COUNT (FEC) IN SMALL RUMINANTS

Breed/Population	Location	Heritability (h^2) \pm SE	Reference
Merino	Australia	0.30–0.50	Woolaston et al. (1991)
Romney	New Zealand	0.34 ± 0.08	Bisset et al. (1992)
Merino	Fiji	0.23 ± 0.07	Woolaston et al. (1995)
Polish sheep	Poland	0.28 ± 0.16	Nowosad et al. (1992)
Commercial sheep	New Zealand	0.20–0.42	McEwan et al. (1994); Douch et al. (1995)
Commercial sheep	Ontario, Canada	0.12 ± 0.04	Boareki et al. (2021)
Katahdin	USA	0.23–0.46	Ngere et al. (2018)
Avikalin	India	0.21 ± 0.06	Gowane et al. (2019)
Malpura	India	0.18 ± 0.04	Gowane et al. (2019)
Muzaffarnagari	India	0.24–0.47	Yadav et al. (2006)
Avikalin	India	0.35 ± 0.18	Singh et al. (1999)
Jamnapari goats	India	0.11–0.16	Mandal et al. (2012)
Barbari goats	India	0.05–0.13	Mandal and Sharma (2008)

III. NON-GENETIC FACTORS AFFECTING FEC

3.1 Age of Sheep

In general, young and growing lambs are more vulnerable to the effects of parasitism than adults. Furthermore, adult ewes are less susceptible to the negative effects of parasitism and better able to cope with infection. Reports also suggest that adult ewes generally have lower FEC than lambs when samples are collected at the same times and on the same pastures. Vanimisetti et al. (2004a) reported that adult ewes, sampled following weaning of their lambs and after artificial parasite challenge, had much lower fecal egg counts than their lambs. German sheep demonstrated fecal egg counts negatively correlated with age of lambs (-0.23 ; $P < 0.001$) (Idris et al., 2012). It has also been reported that development of acquired immunity to parasites is positively related to the age of animals.

However, conflicting findings exist. In a study conducted on Brazilian sheep breeds by McManus et al. (2009), age of the sheep did not affect FEC. Similarly, Dappawar et al. (2018) reported a non-significant effect of age on parasitic infection in kids, young, and adult sheep in a survey of 753 sheep from the Udgir area of Maharashtra, India. These contradictory findings may

reflect differences in breed susceptibility, management practices, sample size, or the specific parasite species prevalent in different geographic regions. Studies reporting non-significant effects may have had lower infection pressures or smaller sample sizes, limiting statistical power to detect age-related differences.

3.2 Sex of Animals

Male sheep are known to be more susceptible to GINs than female sheep when exposed to natural and experimental infections (Barger, 1993). This difference is evident before puberty (Courtney et al., 1985). Different hormonal statuses between sexes affect the immunological responses of sheep to nematodes. Testosterone has immunosuppressive effects, which may explain higher susceptibility in males, while estrogen tends to enhance immune responses. Greater resistance in ewe lambs following secondary challenge infection was reported compared to ram lambs by Yazwinski et al. (1981) and Diaz-Rivera et al. (2000). Klein (2000) also found that male Rhön lambs had higher FEC compared to female lambs. Idris et al. (2012) demonstrated that in German sheep breeds, male lambs were more susceptible to infection than females ($P < 0.001$).

However, Dappawar et al. (2018) reported a non-significant difference between sexes of sheep on FEC in the Udgir area of Maharashtra. Similar results were reported by McManus et al. (2009), where sex of the sheep did not affect FEC. As with age effects, these discrepancies may be attributed to differences in breed, management, infection pressure, or statistical power across studies.

3.3 Birth Type

It has been reported that ewes giving birth to twins or triplets show a higher rise in FEC than ewes with singletons (Bishop and Stear, 2001). In German sheep breeds, multiple-born lambs displayed higher FEC than singleton-born lambs ($P < 0.05$) (Idris et al., 2012). Similar findings were reported by Haile et al. (2007). This may be due to competition among multiples for colostrum, which provides passive immunity to newborns against parasitic infection.

However, Gauly and Erhardt (2001) as well as McManus et al. (2009) did not find a significant effect of birth type on FEC following natural infections. McManus et al. (2009) reported that lambs born as twins had slightly higher levels of FEC than those born as singletons, though their results were statistically non-significant. The lack of statistical significance in some studies may reflect smaller sample sizes or lower statistical power to detect modest birth type effects.

3.4 Season

Nieto et al. (2003) studied lambs from crosses of Corriedale ewes with Bergamasca and Hampshire Down rams and reported that month had a significant effect on FEC ($p < 0.05$). McManus et al. (2009) observed lower FEC during the dry season (May to September) in Brazilian sheep and higher FEC during the rainy season. Dappawar et al. (2018) reported that peak infection was observed during the monsoon, followed by winter, with the lowest infection during summer. Similar results in the Indian context were reported by Swarnkar and Singh (2014) in Rajasthan and by Molla and Bandyopadhyay (2016) in the Bonpala breed of Sikkim. High humidity and temperatures during the monsoon favor the survival and development of nematode larvae on pasture, explaining the seasonal pattern observed across studies.

IV. CONCLUSION

Many traits in farm animals are complex and threshold in nature, meaning they cannot be measured directly. Parasitic resistance is one such trait, and fecal egg count (FEC) is considered a reliable indicator of this trait in livestock. Most research on parasitic resistance has been conducted in sheep and goats, as these species suffer major economic losses due to nematodes. They are more susceptible to gastrointestinal parasites due to the grazing nature of their management systems.

FEC, along with molecular genetic markers, can be effectively used for the selection of disease-resistant animals, thereby benefiting livestock owners. Incorporating FEC into breeding programs offers a sustainable approach to parasite control that reduces reliance on anthelmintics, thereby mitigating the development of drug-resistant parasite populations. For smallholder farmers in resource-limited settings where diagnostic facilities may be unavailable, simplified FEC protocols and genetic selection indices that include FEC as a trait could be developed. Future research should focus on establishing breed-specific FEC reference values, validating genetic markers associated with low FEC, and developing decision-support tools for integrating FEC into routine flock management.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- [1] Assenza, F., Elsen, J. M., Legarra, A., Carré, C., Sallé, G., Robert-Granié, C., & Moreno, C. R. (2014). Genetic parameters for growth and faecal worm egg count following *Haemonchus contortus* experimental infestations using pedigree and molecular information. *Genetics Selection Evolution*, *46*, 1-9.
- [2] Augad, S. P., & Deshmukh, P. S. (2024). Seasonal prevalence of gastrointestinal *Trichuris* species in sheep and goat of Amravati District, Maharashtra, India. *International Journal of Life Sciences*, *12*(1), 75-80.
- [3] Barger, I. A. (1993). Influence of sex and reproduction status on susceptibility of ruminants to nematode parasitism. *International Journal of Parasitology*, *23*, 463-469.
- [4] Bishop, S. C., & Stear, M. J. (2001). Inheritance of fecal egg counts during early lactation in Scottish Blackface ewes facing mixed, natural nematode infections. *Animal Science*, *73*, 389-395.
- [5] Bisset, S. A., Vlassoff, A., Morris, C. A., Southey, B. R., Baker, R. L., & Parker, A. G. H. (1992). Heritability of and genetic correlations among faecal egg counts and productivity traits in Romney sheep. *New Zealand Journal of Agricultural Research*, *35*(1), 51-58. <https://doi.org/10.1080/00288233.1992.10417701>
- [6] Boareki, M. N., Flavio, S., Schenkel, O. W., Aroa Suarez-Vega, Delma, K., & Cánovas, A. (2021). Comparison between methods for measuring fecal egg count and estimating genetic parameters for gastrointestinal parasite resistance traits in sheep. *Journal of Animal Science*, *99*(12), 341. <https://doi.org/10.1093/jas/skab341>
- [7] Brown, D. J., & Fogarty, N. M. (2017). Genetic relationships between internal parasite resistance and production traits in Merino sheep. *Animal Production Science*, *57*, 209-215.
- [8] Charon, K. M., Moskwa, B., Rutkowski, R., Gruszczynska, J., & Swiderek, W. (2002). Microsatellite polymorphism in DRB1 gene (Mhc class II) and its relation to nematode faecal egg count in Polish Heath Sheep. *Journal of Animal and Feed Science*, *11*, 47-58.
- [9] Courtney, C. H., Parker, C. F., McClure, K. E., & Herd, R. P. (1985). Resistance of exotic and domestic lambs to experimental infection with *Haemonchus contortus*. *International Journal of Parasitology*, *15*, 101-109. [https://doi.org/10.1016/0020-7519\(85\)90107-9](https://doi.org/10.1016/0020-7519(85)90107-9)
- [10] Coustau, C., Chevillon, C., & ffrench-Constant, R. (2000). Resistance to xenobiotics and parasites: Can we count a cost? *Trends in Ecology and Evolution*, *15*, 378-383.
- [11] Dappawar, M. K., Khillare, B. S., Narladkar, B. W., & Bhangale, G. N. (2018). Prevalence of gastrointestinal parasites in small ruminants in Udgir area of Marathwada. *Journal of Entomology and Zoology Studies*, *6*(4), 672-676.
- [12] Diaz-Rivera, P., Torres-Hernandez, G., Osorio-Arce, M. M., Hernandez, P., Pullido-Albers, A. R., Becerril-Perez, C. M., & Herrera-Harro, J. G. (2000). Resistance to gastrointestinal parasites in Florida, Pelibuey and cross bred sheep in the Mexican tropics. *Agrosciencia*, *34*, 13-20.
- [13] Gauly, M., & Erhardt, G. (2001). Genetic resistance to gastrointestinal nematode parasites in Rhon sheep following natural infection. *Veterinary Parasitology*, *102*, 253-259.
- [14] Gourley, S. L., Zimmermann, K. S., Allen, A. G., & Taylor, J. R. (2016). The medial orbitofrontal cortex regulates sensitivity to outcome value. *Journal of Neuroscience*, *36*(16), 4600-4613. <https://doi.org/10.1523/JNEUROSCI.4253-15.2016>
- [15] Gowane, G. R., Swarnkar, C. P., Misra, S. S., Kumar, R., Kumar, A., & Prince, L. L. L. (2019). Genetic parameter estimates for fecal egg counts and their relationship with growth in Avikalin and Malpura sheep. *Animals*, *13*(9), 1788-1796.
- [16] Haille, A., Tibbo, M., Baker, R. L., & Rege, J. E. O. (2007). Effects of nongenetic factors on responses to gastro-intestinal nematode infections in Ethiopian sheep. *Tropical Animal Health Production*, *39*(6), 411-417.
- [17] Idris, A., Eva, M., Birgit, S., & Matthias, G. (2012). Gastrointestinal nematode infections in German sheep. *Parasitology Research*, *110*, 1453-1459.
- [18] Karlsson, L. J., & Greeff, J. C. (2012). Genetic aspects of sheep parasitic diseases. *Veterinary Parasitology*, *189*, 104-112.
- [19] Kemper, K. E., Elwin, R. L., Bishop, S. C., Goddard, M. E., & Woolaston, R. R. (2009). *Haemonchus contortus* and *Trichostrongylus colubriformis* did not adapt to long-term exposure to sheep that were genetically resistant or susceptible to nematode infections. *International Journal of Parasitology*, *39*, 607-614.
- [20] Klein, S. L. (2000). The effects of hormones on sex differences in infection: From genes to behavior. *Neuroscience and Biobehavioral Reviews*, *24*, 627-638.
- [21] Malathi, S., Shameem, U., & Komali, M. (2021). Prevalence of gastrointestinal helminth parasites in domestic ruminants from Srikakulam district, Andhra Pradesh, India. *Journal of Parasitic Diseases*, *45*(3), 823-830.
- [22] Mandal, A., & Sharma, D. K. (2008). Inheritance of faecal nematode egg count in Barbari goats following natural *Haemonchus contortus* infection. *Veterinary Parasitology*, *155*(1-2), 89-94.
- [23] Mandal, A., Sharma, D. K., & Roy, R. (2012). Genetic and environmental influences on faecal nematode egg counts of Jamunapari goats in India. *Veterinary Record*, *170*(13), 320-344.
- [24] McClure, S. (2000). *Sheep immunity to gastrointestinal nematode parasites: A review*. The Commonwealth Scientific and Industrial Research Organisation, FD McMaster Laboratory.
- [25] McManus, C., Helder, L., Samuel, R. P., Amaury, A. D. O., Hymerson, C. A., & Cristiano, B. D. M. (2009). Genetic factors of sheep affecting gastrointestinal parasite infections in the Distrito Federal, Brazil. *Veterinary Parasitology*, *166*, 308-313.
- [26] Miller, J. E., Bahirathan, M., Lemarie, S. L., Hembry, F. G., Kearney, M. T., & Barras, S. R. (1998). Epidemiology of gastrointestinal nematode parasitism in Suffolk and Gulf Coast Native susceptibility to *Haemonchus contortus* infection. *Veterinary Parasitology*, *74*, 55-74.

- [27] Molla, S. H., & Bandyopadhyay, P. K. (2016). Prevalence of gastro-intestinal parasites in economically important Bonpala sheep in India. *IOSR Journal of Agriculture and Veterinary Science*, *9*(1), 87-93.
- [28] Ngere, L., Burke, J. M., Morgan, J. L. M., Miller, J. E., & Notter, D. R. (2018). Genetic parameters for fecal egg counts and their relationship with body weights in Katahdin lambs. *Journal of Animal Science*, *96*, 1590-1599.
- [29] Nieto, L. M., Martins, E. N., Macedo, F. A. F., Sakaguti, E. S., & Santos, A. I. (2003). Utilização de um modelo de limiar na estimação da herdabilidade de resistência dos ovinos aos endoparasitos. *Acta Scientiarum Animal Sciences*, *25*, 151-155.
- [30] Pollott, G. E., & Greeff, J. C. (2004). Genotype × environment interactions and genetic parameters for fecal egg count and production traits of Merino sheep. *Journal of Animal Science*, *82*(10), 2840-2851. <https://doi.org/10.2527/2004.82102840x>
- [31] Prince, L. L. L., Gowane, G. R., Swarnkar, C. P., Singh, D., & Arora, A. L. (2010). Estimates of genetic parameters for faecal egg count of *Haemonchus contortus* infection and relationship with growth traits in Avikalin sheep. *Tropical Animal Health and Production*, *42*, 785-791.
- [32] Shashank, J., & Ayodhya, S. (2019). Evaluating the efficacy of ivermectin and levamisole against gastrointestinal nematodes in goats. *Journal of Entomology and Zoology Studies*, *7*(5), 191-193.
- [33] Singh, D., Swarnkar, C. P., Khan, F. A., Jayasankar, J., & Bhagwan, P. S. K. (1999). Heritability of faecal egg counts in Avikalin sheep. *Indian Journal of Animal Sciences*, *69*(11), 983-985.
- [34] Suarez, V. H., Martínez, G. M., & Olmos, L. H. (2021). Epidemiology of goat nematode infections in different ecological regions of Argentina's northwest. *Asian Journal of Research in Biosciences*, *3*(1), 29-37.
- [35] Swarnkar, C. P., & Singh, D. (2014). Influence of annual rainfall on epidemiology of gastrointestinal parasites in sheep flocks of Rajasthan. *Indian Journal of Animal Sciences*, *84*(11), 1171-1176.
- [36] Vanimisetti, H. B., Andrew, S. L., Zajac, A. M., & Notter, D. R. (2004a). Inheritance of fecal egg count and packed cell volume and their relationship with production traits in sheep infected with *Haemonchus contortus*. *Journal of Animal Science*, *82*, 1602-1611. <https://doi.org/10.2527/2004.8261602x>
- [37] Woolaston, R. R., Manuelli, P., Singh, R., Tabunakawai, N., & Le Jambre, L. F. (1995). Breeding to assist control of gastrointestinal parasites of small ruminants in the Pacific Islands. In *Breeding for resistance to infectious diseases in small ruminants* (pp. 79-86).
- [38] Woolaston, R. R., Windon, R. G., & Gray, G. D. (1991). Genetic variation in resistance to internal parasites in Armidale experimental flocks. In *Breeding for disease resistance in sheep* (pp. 1-9).
- [39] Yadav, N., Mandal, A., Sharma, D., Rout, P., & Roy, R. (2006). Genetic studies on faecal egg counts and packed cell volume following natural *Haemonchus contortus* infection and their relationships with liveweight in Muzaffarnagari sheep. *Animal Bioscience*, *19*(11), 1524-1528.
- [40] Yazwinski, T. A., Goode, L., Moncol, D. J., Morgan, G. W., & Linnerud, A. C. (1981). *Haemonchus contortus* resistance in straight bred and crossbred Barbados Blackbelly sheep. *Journal of Animal Science*, *51*, 279-284.



Enhancing Summer Black Gram Productivity through Combined Herbicide Application: A Growth, Yield and Economic Analysis

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Abstract— A field experiment was conducted during the summer season of 2019 at the Hill Millet Research Station, Rajendrapur Farm, N. A. U., Waghai to study the efficacy of combined herbicides in summer black gram (*Vigna mungo* L.). The soil was characterized as clayey, low in available nitrogen, medium in available phosphorus, and fairly rich in available potassium. The study comprised ten weed management treatments: T_1 : Pendimethalin 900 g ha⁻¹ as pre-emergence + one hand weeding (HW) at 30 days after sowing (DAS); T_2 : Sodium acifluorfen + clodinafop-propargyl (ready-mix) 250 g ha⁻¹ as post-emergence at 20 DAS; T_3 : Imazethapyr + pendimethalin (RM) 750 g ha⁻¹ as pre-emergence; T_4 : Imazethapyr + imazamox (RM) 70 g ha⁻¹ as pre-emergence; T_5 : Imazethapyr + propaquizafop (RM) 125 g ha⁻¹ as post-emergence at 20 DAS; T_6 : Quizalofop-p-ethyl 100 g ha⁻¹ post-emergence at 20 DAS; T_7 : Fenoxaprop-p-ethyl 100 g ha⁻¹ post-emergence at 20 DAS; T_8 : Two hand weedings at 20 and 40 DAS; T_9 : Unweeded control; T_{10} : Weed-free treatment. These treatments were evaluated on black gram cv. GU-1, arranged in a Randomized Block Design (RBD) with three replications.

The results indicated that plant population was unaffected by the treatments; however, growth parameters were significantly influenced. T_{10} (weed-free treatment) recorded the tallest plants and highest number of branches, followed by T_1 and T_2 . Yield attributes such as number of pods per plant and pod length showed significant variation, whereas seeds per pod, test weight, and harvest index were not significantly affected. The highest seed yield (1083.33 kg ha⁻¹) and haulm yield (2456.79 kg ha⁻¹) were recorded under T_{10} , closely followed by T_1 , T_2 and T_8 . Economic analysis revealed that although the highest gross returns were obtained under weed-free conditions, the maximum net returns (₹54,812 ha⁻¹) and benefit-cost ratio (1:2.86) were achieved with T_2 treatment. Thus, sodium acifluorfen + clodinafop-propargyl applied at 20 DAS proved to be the most economically viable and efficient weed management practice for summer black gram under South Gujarat conditions.

Keywords— Black gram, Herbicides, Growth, Yield, Economics.

I. INTRODUCTION

Pulses are an integral part of the Indian agricultural economy, ranking after cereals and oilseeds in terms of acreage, production, and economic value. They are a rich source of protein and energy; however, in India, these crops are largely cultivated under resource-poor conditions, resulting in low productivity. This is mainly due to the unavailability of quality seed at the proper

time, cultivation on marginal and sub-marginal lands, imbalanced fertilizer use, and non-adoption of improved crop management practices (Choudhary, 2009; Pooniya et al., 2015).

Among the pulse crops, black gram [*Vigna mungo* (L.) Hepper], commonly known as urd bean or mash, is an important short-duration legume crop cultivated extensively in India. The crop is highly valued for its high protein and phosphoric acid content and forms an integral component of diversified cropping systems due to its adaptability to varied agro-climatic conditions. India is the largest producer of black gram, contributing more than 70 percent of global production, followed by Myanmar and Pakistan. During 2023–24, black gram occupied nearly 4 million ha with a production of approximately 2 million tonnes and an average productivity of 598 kg ha⁻¹ (Anonymous, 2023–24a). Among the major black gram-growing states, Madhya Pradesh ranks first in area and production, followed by Uttar Pradesh and Maharashtra (Anonymous, 2025). In Gujarat, summer black gram was cultivated over an area of 21,354 ha, with a production of 30,368 metric tonnes and an average productivity of 1422.10 kg ha⁻¹ during 2023–24 (Anonymous, 2023–24b).

Weed infestation is one of the major biological constraints limiting black gram production, particularly during the rainy season when favourable environmental conditions encourage rapid weed growth. Weeds compete aggressively with the crop for nutrients, moisture, sunlight, and space during the early stages of crop growth, resulting in poor plant development and substantial yield reduction. The critical period of crop–weed competition in black gram has been reported to occur between 25 and 35 days after sowing (Randhawa et al., 2002). Failure to control weeds during this period may result in yield losses ranging from 43.2 to 64.1 percent, depending on weed density, weed species, and duration of competition (Rathi et al., 2004). Therefore, timely and effective weed management is essential for achieving optimum crop growth and higher productivity.

Various weed management practices, including cultural, mechanical, manual, biological, and chemical methods, are employed in black gram cultivation. Among these, chemical weed control is considered one of the most effective and economical approaches when herbicides are applied at the appropriate dose and time (Dungarwal et al., 2003). However, a single herbicide may not effectively control diverse weed flora. Therefore, herbicide mixtures and sequential applications of pre- and post-emergence herbicides are gaining importance for achieving broad-spectrum weed control, reducing the risk of herbicide resistance, and improving black gram productivity.

II. MATERIALS AND METHODS

A field experiment was conducted during the summer season of 2019 at the Hill Millet Research Station, Rajendrapur Farm, Navsari Agricultural University, to evaluate the efficacy of combined herbicides in summer black gram [*Vigna mungo* (L.) Hepper]. The experimental site was located in the Dang district of Gujarat under the South Gujarat Heavy Rainfall Zone-I (Agro-ecological Situation III). The soil of the experimental field was clayey in texture with near-neutral pH (6.9), EC 0.24 dS m⁻¹, organic carbon 0.90%, medium available nitrogen (245 kg ha⁻¹), medium available phosphorus (23 kg ha⁻¹), and high available potassium (325 kg ha⁻¹).

The experiment was laid out in a Randomized Block Design (RBD) with three replications comprising ten treatments:

- **T₁**: Pendimethalin 900 g ha⁻¹ as pre-emergence (PE) + one hand weeding (HW) at 30 DAS
- **T₂**: Sodium acifluorfen + clodinafop-propargyl (ready-mix) 250 g ha⁻¹ as post-emergence (PoE) at 20 DAS
- **T₃**: Imazethapyr + pendimethalin (RM) 750 g ha⁻¹ as PE
- **T₄**: Imazethapyr + imazamox (RM) 70 g ha⁻¹ as PE
- **T₅**: Imazethapyr + propaquizafop (RM) 125 g ha⁻¹ as PoE at 20 DAS
- **T₆**: Quizalofop-p-ethyl 100 g ha⁻¹ as PoE at 20 DAS
- **T₇**: Fenoxaprop-p-ethyl 100 g ha⁻¹ as PoE at 20 DAS
- **T₈**: Two hand weedings at 20 and 40 DAS
- **T₉**: Unweeded control
- **T₁₀**: Weed-free treatment

The black gram variety Gujarat Urad-1 (GU-1) was sown on 18 February 2019 at a spacing of 45 cm × 10 cm after seed treatment with fungicide and *Rhizobium* culture.

The field was prepared by ploughing, harrowing, and planking to obtain a fine tilth. A basal dose of 20 kg N ha⁻¹ and 40 kg P₂O₅ ha⁻¹ was applied through urea and single super phosphate, respectively. Herbicides were applied using a knapsack sprayer fitted with a flat-fan nozzle calibrated to deliver 500 L water ha⁻¹. Pendimethalin, imazethapyr + pendimethalin, and imazethapyr + imazamox were applied as pre-emergence herbicides, whereas sodium acifluorfen + clodinafop-propargyl, imazethapyr + propaquizafop, quizalofop-p-ethyl, and fenoxaprop-p-ethyl were applied as post-emergence treatments. Thinning and gap filling were carried out to maintain optimum plant population. Five irrigations were provided during the crop season as per crop requirement.

Observations recorded included growth and yield attributes such as plant population, plant height, branches per plant, days to 50% flowering, days to maturity, pods per plant, seeds per pod, pod length, test weight, seed yield, haulm yield, harvest index, protein content, and protein yield. Weed parameters including weed flora, weed population, weed dry weight, weed control efficiency (WCE), and weed index (WI) were also recorded.

The crop was harvested at physiological maturity during the fourth week of May 2019. The harvested produce was sun-dried, manually threshed, and cleaned seed yield was recorded treatment-wise. Economic analysis included computation of gross returns, net returns, and benefit:cost (B:C) ratio based on prevailing market prices and cost of cultivation.

The experimental data were statistically analyzed using analysis of variance (ANOVA) as outlined by Panse and Sukhatme (1985). Treatment means were compared using the critical difference (CD) test at the 5% level of significance. Weed population data were subjected to square-root transformation prior to statistical analysis following the procedure described by Steel and Torrie (1960).

III. RESULTS AND DISCUSSION

3.1 Growth and Growth Attributes

Significant differences in plant height and number of branches per plant were observed among the weed management treatments, whereas plant population at 20 DAS and at harvest, days to 50% flowering, and days to maturity remained non-significant.

Plant height at harvest was significantly influenced by weed management practices. Treatment T₁₀ recorded the highest plant height (51.47 cm), which remained statistically comparable with T₁, T₂, T₆, and T₈, while the lowest plant height (41.40 cm) was observed under T₉. The increased plant height under T₁₀ may be attributed to effective weed control up to 45 DAS, corresponding to the critical crop–weed competition period, which minimized crop–weed competition and provided favourable conditions for crop growth.

The highest number of branches per plant at harvest was also recorded under T₁₀ (6.67), which was statistically comparable with T₂ (5.87), whereas the lowest value (4.07) was observed under T₉. Improved soil physical conditions and a weed-free environment throughout the crop growth period under these treatments might have promoted better crop growth and branching. These results are in agreement with the findings of Kumar and Kundra (2001) and Mishra (2006). The data further indicated that weed management treatments did not exert any significant effect on days to 50% flowering and days to maturity of summer black gram.

TABLE 1
INFLUENCE OF VARIOUS WEED MANAGEMENT TREATMENTS ON GROWTH ATTRIBUTES OF SUMMER BLACK GRAM (*VIGNA MUNGO* L.)

Treatments	Plant height (cm)	Branches per plant	Days to 50% flowering	Days to maturity
T ₁ : Pendimethalin 900 g/ha as PE + 1 HW at 30 DAS	45.53	5.33	40.17	81.13
T ₂ : Sodium acifluorfen + clodinafop-propargyl (RM) 250 g/ha as PoE at 20 DAS	50.6	5.87	39.6	80.6
T ₃ : Imazethapyr + pendimethalin (RM) 750 g/ha as PE	42.93	5.07	40.53	81.53
T ₄ : Imazethapyr + imazamox (RM) 70 g/ha as PE	43.4	4.93	39.2	80.2
T ₅ : Imazethapyr + propaquizafop (RM) 125 g/ha as PoE at 20 DAS	42.47	5	39.6	80.2
T ₆ : Quizalofop-p-ethyl 100 g/ha PoE at 20 DAS	45.53	5.4	40.67	81.67
T ₇ : Fenoxaprop-p-ethyl 100 g/ha PoE at 20 DAS	44.27	5.13	40.17	80.93
T ₈ : Two HW at 20 and 40 DAS	47.27	5.73	40.67	81.67
T ₉ : Unweeded control	41.4	4.07	39	80
T ₁₀ : Weed free	51.47	6.67	40.73	81.73
SEm ±	2.11	0.3	1.13	1.65
CD at 5%	6.27	0.91	NS	NS
CV %	8.04	10.02	4.87	3.54

3.2 Yield and Yield Attributes

The mean data on yield attributes and yield of black gram recorded at harvest revealed a significant effect of different weed management treatments on the number of pods per plant and pod length. T₁₀ recorded the highest number of pods per plant (50.53), which remained statistically comparable with T₂, T₆, and T₈, whereas the lowest number of pods per plant (25.13) was observed under the unweeded control (T₉).

Pod length was also significantly influenced by weed management treatments. The maximum pod length (4.93 cm) was recorded under T₁₀, which was statistically comparable with T₁, T₂, T₆, T₇, and T₈, while the minimum pod length (3.33 cm) was observed under T₉. The improvement in these yield attributes may be attributed to effective weed control, which reduced crop–weed competition and ensured better availability of moisture, nutrients, light, and space for crop growth. Similar findings were reported by Chin and Pandey (1991) and Gogoi et al. (1992). However, the number of seeds per pod and test weight were not significantly affected by the weed management treatments.

All weed management treatments produced significantly higher seed yield compared to the unweeded control (T₉). The highest seed yield (1083.33 kg ha⁻¹) was recorded under T₁₀, which remained statistically comparable with T₁ (947.53 kg ha⁻¹), T₂ (972.22 kg ha⁻¹), and T₈ (996.91 kg ha⁻¹). The lowest seed yield (601.85 kg ha⁻¹) was observed under T₉, possibly due to severe weed infestation causing intense competition for growth resources such as moisture, nutrients, light, and space. These results are in agreement with the findings of Bhandari et al. (2004), Angiras et al. (2006), and Vivek et al. (2008). The post-emergence herbicide applications evaluated in the study effectively controlled weeds and suppressed secondary weed emergence, resulting in lower weed biomass and higher weed control efficiency, which ultimately enhanced the yield potential of black gram.

Similarly, the highest haulm yield (2456.79 kg ha⁻¹) was recorded under T₁₀, which remained statistically comparable with T₁ (2101.85 kg ha⁻¹), T₂ (2212.96 kg ha⁻¹), and T₈ (2262.35 kg ha⁻¹), whereas the lowest haulm yield (1305.56 kg ha⁻¹) was observed under T₉. Effective weed control under these treatments likely reduced crop–weed competition and promoted greater dry matter accumulation and better crop growth. The harvest index ranged from 29.77 to 32.92% across the treatments.

TABLE 2
EFFECT OF VARIOUS WEED MANAGEMENT TREATMENTS ON THE YIELD ATTRIBUTES OF SUMMER BLACK GRAM (*VIGNA MUNGO* L.)

Treatments	Pods per plant	Seeds per pod	Pod length (cm)	Test weight (g)	Harvest Index (%)
T ₁ : Pendimethalin 900 g/ha as PE + 1 HW at 30 DAS	44.1	4.56	4.73	4.04	30.99
T ₂ : Sodium acifluorfen + clodinafop-propargyl (RM) 250 g/ha as PoE at 20 DAS	46.53	4.79	4.7	4.11	30.53
T ₃ : Imazethapyr + pendimethalin (RM) 750 g/ha as PE	33.4	4.67	4.6	4.01	30.86
T ₄ : Imazethapyr + imazamox (RM) 70 g/ha as PE	32	4.31	4.47	3.96	29.77
T ₅ : Imazethapyr + propaquizafop (RM) 125 g/ha as PoE at 20 DAS	30.67	4.24	4.03	4	29.85
T ₆ : Quizalofop-p-ethyl 100 g/ha PoE at 20 DAS	45.93	4.48	4.87	4.06	31.29
T ₇ : Fenoxaprop-p-ethyl 100 g/ha PoE at 20 DAS	34.93	4.68	4.73	3.99	32.92
T ₈ : Two HW at 20 and 40 DAS	46.13	4.73	4.8	4.12	30.68
T ₉ : Unweeded control	25.13	4.15	3.33	3.92	31.73
T ₁₀ : Weed free	50.53	5.01	4.93	4.23	30.65
SEm ±	1.65	0.17	0.1	0.13	1.69
CD at 5%	4.91	NS	0.29	NS	NS
CV %	7.35	6.52	3.77	5.43	9.48

PE = Pre-emergence; PoE = Post-emergence; HW = Hand weeding; RM = Ready-mix; NS = Non-significant

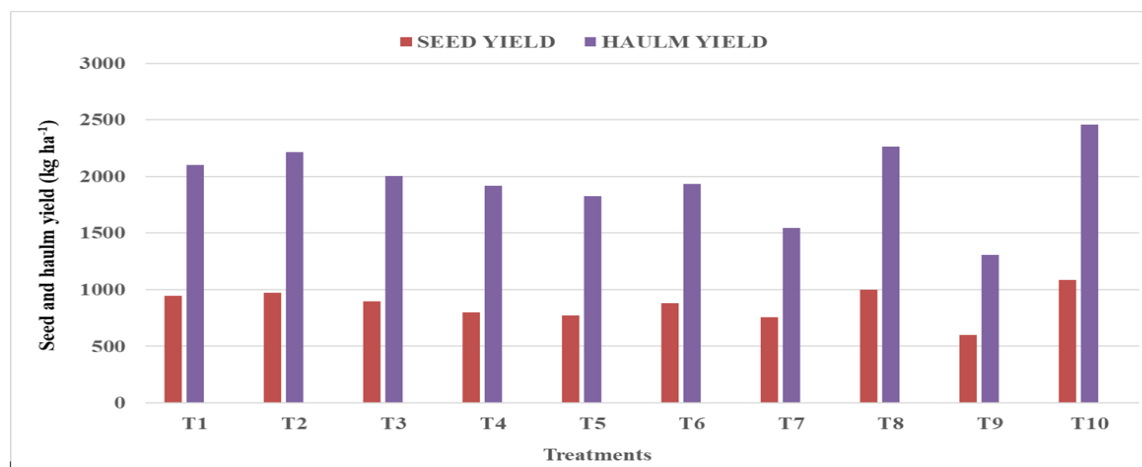


FIGURE 1: Effect of different treatments on seed and haulm yield of Black Gram

3.3 Economics

The highest net return (₹54,812 ha⁻¹) was recorded under treatment T₂ [Sodium acifluorfen + clodinafop-propargyl (RM) at 250 g ha⁻¹ applied as post-emergence at 20 DAS], followed by T₈ (₹50,516 ha⁻¹), T₁₀ (₹49,251 ha⁻¹), and T₃ (₹49,080 ha⁻¹). The lowest net return (₹28,051 ha⁻¹) was observed under the unweeded control treatment (T₉).

The B:C ratio varied considerably across treatments. The highest B:C ratio (1:2.86) was recorded under treatment T₂, followed by T₃ (1:2.60), T₄ (1:2.26), and T₆ (1:2.25). The lowest B:C ratio (1:1.49) was observed under the weed-free treatment (T₁₀), primarily due to higher cultivation costs associated with manual weed control.

TABLE 3
ECONOMICS AS INFLUENCED BY DIFFERENT WEED MANAGEMENT TREATMENTS IN BLACK GRAM

Treatments	Seed income (₹ ha ⁻¹)	Haulm income (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Total cost of cultivation (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B:C ratio
T ₁	63,485	8,407	71,892	23,211	48,681	2.1
T ₂	65,139	8,852	73,991	19,179	54,812	2.86
T ₃	59,969	8,012	67,981	18,901	49,080	2.6
T ₄	53,559	7,679	61,238	18,762	42,476	2.26
T ₅	51,698	7,296	58,994	18,668	40,326	2.16
T ₆	58,935	7,741	66,676	20,535	46,141	2.25
T ₇	50,664	6,173	56,837	19,584	37,252	1.9
T ₈	66,793	9,049	75,842	25,327	50,515	1.99
T ₉	40,324	5,222	45,546	17,495	28,051	1.6
T ₁₀	72,583	9,827	82,410	33,159	49,251	1.49

Note: T₁ to T₁₀ as described in Table 1 and Table 2.

IV. CONCLUSION

Based on one year of field experimentation, it can be concluded that post-emergence application of sodium acifluorfen + clodinafop-propargyl (ready-mix) at 250 g ha⁻¹ at 20 DAS was the most effective weed management practice for summer black gram under South Gujarat conditions. The treatment provided effective control of grassy and broad-leaved weeds, resulting in higher yield attributes, seed yield, and economic returns compared to other herbicidal treatments.

Under conditions of adequate labour availability, maintaining a weed-free crop through regular manual weeding (T₁₀) was found equally effective in achieving higher productivity; however, the high cost of manual weeding reduced its economic viability. Therefore, application of sodium acifluorfen + clodinafop-propargyl (ready-mix) at 250 g ha⁻¹ at 20 DAS may be recommended as an efficient and economically viable weed management strategy for summer black gram in South Gujarat.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

- [1] Angiras, N. N., Kumar, S., & Singh, R. (2006). Effect of planting and weed control methods on weed growth and seed yield of black gram. [Journal name missing].
- [2] Anonymous. (2024a). *ANGRAU - Crop outlook reports of Andhra Pradesh black gram – June to May, 2023-24*. Acharya N. G. Ranga Agricultural University.
- [3] Anonymous. (2024b). *District-wise area, production and yield of important food and non-food crops in Gujarat State*. <https://dag.gujarat.gov.in>
- [4] Anonymous. (2025). *PJTAU - Black gram outlook report - 2025*. Professor Jayashankar Telangana State Agricultural University.
- [5] Bhandari, V., Singh, J., Randhawa, J. S., & Randhawa, R. S. (2004). Studies on weed control in summer black gram (*Phaseolus mungo*). *Indian Journal of Weed Science*, *36*(1&2), 129-130.
- [6] Chin, D. V., & Pandey, J. (1991). Effect of pre- and post-emergence herbicides on weeds and yield of black gram. *Indian Journal of Agronomy*, *36*, 276-277.
- [7] Choudhary, A. K. (2009). Role of phosphorus in pulses and its management. *Indian Farmers' Digest*, *42*(9), 32-34.
- [8] Dunganwal, H. S., Chalot, P. C., & Nagda, B. L. (2003). Chemical weed control in mung bean (*Vigna radiata* L.). *Indian Journal of Weed Science*, *35*, 283-284.
- [9] Gogoi, A. K., Kalita, H., Pathal, A. K., & Deka, J. (1992). Crop-weed competition in rainfed black gram. *Indian Journal of Weed Science*, *24*, 81-83.

- [10] Kumar, K., & Kundra, H. C. (2001). Chemical weed control in summer moong (*Vigna radiata* L.) and summer mash (*Vigna mungo* L.) under flood plains of the Punjab. *Indian Journal of Weed Science*, *33*, 200-202.
- [11] Mishra, J. S., & Chandrabhanu. (2006). Effect of herbicides on weeds, nodulation and growth of *Rhizobium* in summer black gram (*Vigna mungo* L.). *Indian Journal of Weed Science*, *38*(1&2), 150-153.
- [12] Panse, V. G., & Sukhatme, P. V. (1985). *Statistical methods for agricultural workers*. Indian Council of Agricultural Research.
- [13] Pooniya, V., Choudhary, A. K., Dass, A., Bana, R. S., Rana, K. S., Rana, D. S., Tyagi, V. K., & Puniya, M. M. (2015). Improved crop management practices for sustainable pulse production: An Indian perspective. *Indian Journal of Agricultural Sciences*, *85*(6), 747-758.
- [14] Randhawa, J. S., Deol, J. S., Sardana, V., & Singh, J. (2002). Crop-weed competition studies in summer black gram (*Phaseolus mungo*). *Indian Journal of Weed Science*, *34*(3/4), 299-300.
- [15] Rathi, J. P., Tiwari, A. N., & Kumar, M. (2004). Integrated weed management in black gram (*Vigna mungo* L.). *Indian Journal of Weed Science*, *36*(3/4), 218-220.
- [16] Vivek, N. S., Singh, R. R., & Tomar, S. S. (2008). Effect of weed interference on weeds and productivity of black gram (*Phaseolus mungo*). *Indian Journal of Weed Science*, *40*(1&2), 65-67.



PM-KUSUM Yojana (Solar Agriculture Pumps): An Exploratory Study in Deoria district of Uttar Pradesh

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Abstract— The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) Yojana was launched by the Government of India in 2019 to promote the use of solar energy in agriculture, reduce dependence on conventional energy sources, and ensure sustainable irrigation. The present study was conducted in Deoria district of Uttar Pradesh, which had one of the highest numbers of installed solar irrigation pumps under the scheme. A total of 100 beneficiary farmers were selected randomly, and data were collected through a structured interview schedule. The study assessed the knowledge and adoption levels of beneficiary farmers regarding solar agricultural pumps under PM-KUSUM. The findings revealed that respondents possessed a satisfactory level of knowledge about the scheme, with the highest awareness observed regarding the environmental friendliness of solar pumps (MPS 86.20), reduction in irrigation costs (MPS 85.60), and future sustainability (MPS 84.70). The adoption level was also encouraging, as most respondents perceived the scheme as beneficial for farmers (MPS 85.40), ensuring sustainable irrigation (MPS 83.60), and providing a better alternative to diesel and electric pumps (MPS 82.40). However, challenges such as high initial investment costs, delays in registration and subsidy disbursement, limited technical guidance, and reduced efficiency during cloudy weather were reported by farmers. The study concludes that PM-KUSUM has significantly contributed to promoting renewable energy use and improving irrigation facilities among beneficiary farmers. Strengthening extension services, ensuring timely financial support, and providing regular technical assistance can further enhance the effectiveness and adoption of the scheme.

Keywords— PM-KUSUM Yojana, Solar Agriculture Pump, Beneficiary Farmers, Sustainable Agriculture, Farm Income.

I. INTRODUCTION

Agriculture is one of the most critical sectors of the Indian economy and relies heavily on irrigation and energy resources. In India, groundwater serves as the primary source of irrigation, and the majority of irrigation pumps are powered by electricity or diesel. However, rising diesel prices, erratic power supply, and environmental pollution have created numerous challenges for farmers — particularly for small and marginal farmers.

To address these issues, the Government of India launched the 'Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan' (PM-KUSUM) scheme in 2019 to promote the use of solar energy in agriculture. This scheme encourages the adoption of solar-powered irrigation pumps to reduce dependence on traditional energy sources and foster sustainable farming practices. Under 'Component-B' of this scheme, farmers are provided with financial assistance to install standalone solar pumps. Farmers receive a subsidy of up to 60 percent, comprising 30 percent from the Central Government and 30 percent from the State Government. Farmers are required to contribute only 10 percent of the total cost, while the remaining amount can be secured through bank loans.

The Solar Agriculture Pump (PM-KUSUM Yojana) scheme has rapidly expanded across the country, including Uttar Pradesh. According to official government figures, by December 2024 [or projected by December 2025 — please verify], the program had assisted around 21.77 lakh farmers. Under various PM-KUSUM components, a total solar capacity of 10,203 MW has

been deployed. Approximately 9,75,227 solar pumps totaling 4,398.57 MW have been deployed under Component B, which enables independent solar agricultural pumps. About 12,01,552 grid-connected agricultural pumps, totaling 5,829.98 MW of capacity, have been solarized under Component C. These solar pumps lower fuel and power costs, provide farmers with dependable daytime watering, and support sustainable agriculture.

The scheme aims to achieve a total target of 34,800 MW of solar power by March 2026. In India, the PM-KUSUM program is crucial for raising farmers' incomes, promoting the use of renewable energy, and bolstering ecologically friendly farming methods.

In Deoria district of Uttar Pradesh, approximately 901 standalone solar pumps — with a combined capacity of 1.91 MW — have been installed under this scheme. Studies conducted across the district indicate that the level of knowledge and adoption of the Solar Agriculture Pump (PM-KUSUM Yojana) among farmers varies depending on the information they receive, their economic capacity, and their understanding of solar irrigation technology. Farmers who have adopted solar pumps have reported several benefits, such as reduced irrigation costs, improved energy availability for agricultural operations, and better management of farming-related activities. Despite these advantages, many farmers face problems such as lack of information, high installation costs, procedural difficulties, and delays in receiving subsidies. Therefore, the present study was undertaken to assess the knowledge and adoption level of the Solar Agriculture Pump (PM-KUSUM Yojana) among farmers.

II. RESEARCH METHODOLOGY

The ex-post facto research design and survey method were used for this study. The study was conducted in purposively selected Deoria district in the eastern region of Uttar Pradesh, which has one of the highest numbers of installed solar pumps (901) under the scheme. Therefore, Deoria district was considered suitable for conducting the study as it provided adequate respondents and a better scope for assessing the awareness and adoption of the Solar Agriculture Pump (PM-KUSUM Yojana) among farmers.

A total of 100 beneficiary farmers were randomly selected as respondents for the study. Data were collected using a structured interview schedule. Statistical tools such as Mean Percent Score (MPS), ranking method, frequency, and percentage were employed for data analysis.



FIGURE 1: Map of research area showing Deoria district in Uttar Pradesh

III. RESULTS AND DISCUSSION

3.1 Demographic Profile of Respondents

A table presenting the demographic characteristics of the 100 respondents (age, education, landholding size, farming experience, previous pump type).

TABLE 1
DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS (N=100)

Characteristic	Category	Frequency (n)	Percentage (%)
Age	Below 30 years	3	3
	30–45 years	18	18
	46–60 years	40	40
	Above 60 years	39	39
Education	Illiterate	14	14
	Primary (up to Class 5)	6	6
	Middle (Class 6–8)	10	10
	High school (Class 9–10)	15	15
	Intermediate (Class 11–12)	30	30
	Graduate and above	25	25
Landholding	Marginal (< 1 ha)	48	48
	Small (1-2 ha)	32	32
	Semi-medium (2-4 ha)	11	11
	Medium (4–10 ha)	7	7
	Large (>10 ha)	2	2
Farming experience	Less than 5 years	5	5
	5–15 years	20	20
	16–25 years	35	35
	Above 25 years	40	40
Previous pump type	Diesel pump	53	53
	Electric pump	35	35
	No pump previously	12	12

Summary Demographic Profile of Respondents:

The majority of the respondents were middle-aged and elderly farmers, as 40 percent of the respondents were in the age group of 46-60 years, while the least proportion (3 percent) of the respondents was below 30 years.

The highest proportion of respondents who had completed education up to intermediate level was 30 percent, while the lowest proportion of those who had primary education was 6 percent. Hence, most of the respondents had a medium-level education.

The maximum number of respondents was amongst the marginal category of farmers (48 percent), whereas the least was among those of the large category of farmers (2 percent), indicating that the majority of the beneficiary farmers were marginal farmers.

In a bid to consolidate general farmers' perspectives on their experiences of value addition on poultry shells, and their perception and understanding of the value addition processes, a survey was conducted across various poultry farmers.

The result showed that about 40 percent of the farmers had more than 25 years of farming experience, while at the other extreme, the least percentage of farmers had less than 5 years of experience.

3.2 Knowledge Level of Respondents about the Solar Agriculture Pump (PM-KUSUM Yojana)

Table 1 (renumbered as Table 2 in final manuscript) shows the level of knowledge of farmers about the Solar Agricultural Pumps (PM-KUSUM Yojana). The data reveal that most respondents were well informed about different aspects of the scheme and its usefulness in agriculture.

TABLE 2

KNOWLEDGE LEVEL OF RESPONDENTS ABOUT THE SOLAR AGRICULTURE PUMP (PM-KUSUM YOJANA) (N=100)

S. No.	Statement	MPS (%)	Rank (within category)	Overall Rank
A.	Technical Knowledge			
1	Fully aware of solar pump operation	82.5	I	V
2	Operate without help	78.4	III	IX
3	Regular use	80.2	II	VII
4	Follow guidelines	76.8	IV	XI
5	Maintenance is easy	72.3	V	XV
B.	Economical Knowledge			
1	Reduced irrigation cost	85.6	I	II
2	Initial investment is not affordable	65.2	IV	XVIII
3	Increased farm income	83.1	II	IV
4	Cost-effective technology	81.7	III	VI
C.	Social & Psychological Knowledge			
1	Confidence in use	79.6	I	VIII
2	Prefer over diesel/electric	77.2	II	X
3	Social status and recommendation	70.5	III	XVII
D.	Institutional Knowledge			
1	Training received	74.3	II	XIII
2	Extension support	73.8	III	XIV
3	Subsidy motivation	75.1	I	XII
4	After-sales service	71.4	IV	XVI
E.	Sustainability Knowledge			
1	Environmentally friendly	86.2	I	I
2	Continuity in the future	84.7	II	III

Summary of knowledge findings:

Among all knowledge statements, "environmentally friendly" recorded the highest Mean Percent Score (MPS) of 86.2%, ranking first overall, indicating strong awareness of solar pumps' environmental benefits. "Reduction in irrigation costs" ranked

second overall (85.6%), followed by "future sustainability" (84.7%), "increased farm income" (83.1%), and "comprehensive knowledge of operation" (82.5%).

Within the technical knowledge category, "fully aware of solar pump operation" secured the highest MPS (82.5%) and ranked first, indicating that most farmers were familiar with the functioning of the system. "Regular use of solar pumps" obtained an MPS of 80.2% (second within technical knowledge), suggesting that beneficiaries were actively utilizing the technology. "Maintenance is easy" received the lowest MPS (72.3%) in this category, indicating some concerns about upkeep.

Within the economic knowledge category, "reduced irrigation cost" ranked first (85.6%), followed by "increased farm income" (83.1%) and "cost-effective technology" (81.7%). However, "initial investment is not affordable" received a low MPS (65.2%), reflecting farmers' perception of high upfront costs despite the subsidy.

Within the social and psychological knowledge category, "confidence in use" secured the highest MPS (79.6%), showing that beneficiaries felt comfortable operating the technology. "Preference for solar pumps over diesel/electric pumps" obtained an MPS of 77.2%, highlighting the growing acceptance of renewable energy technologies among farmers.

Within the institutional knowledge category, "subsidy motivation" ranked first (75.1%), indicating that government subsidies played a crucial role in motivating farmers to adopt solar pumps. "Training received" (74.3%) and "extension support" (73.8%) followed closely, suggesting moderate levels of institutional support.

Within the sustainability knowledge category, "environmentally friendly" achieved the highest overall MPS (86.2%), indicating that respondents strongly recognized the environmental benefits of solar agriculture pumps. "Continuity in the future" (future sustainability) ranked third overall (84.7%).

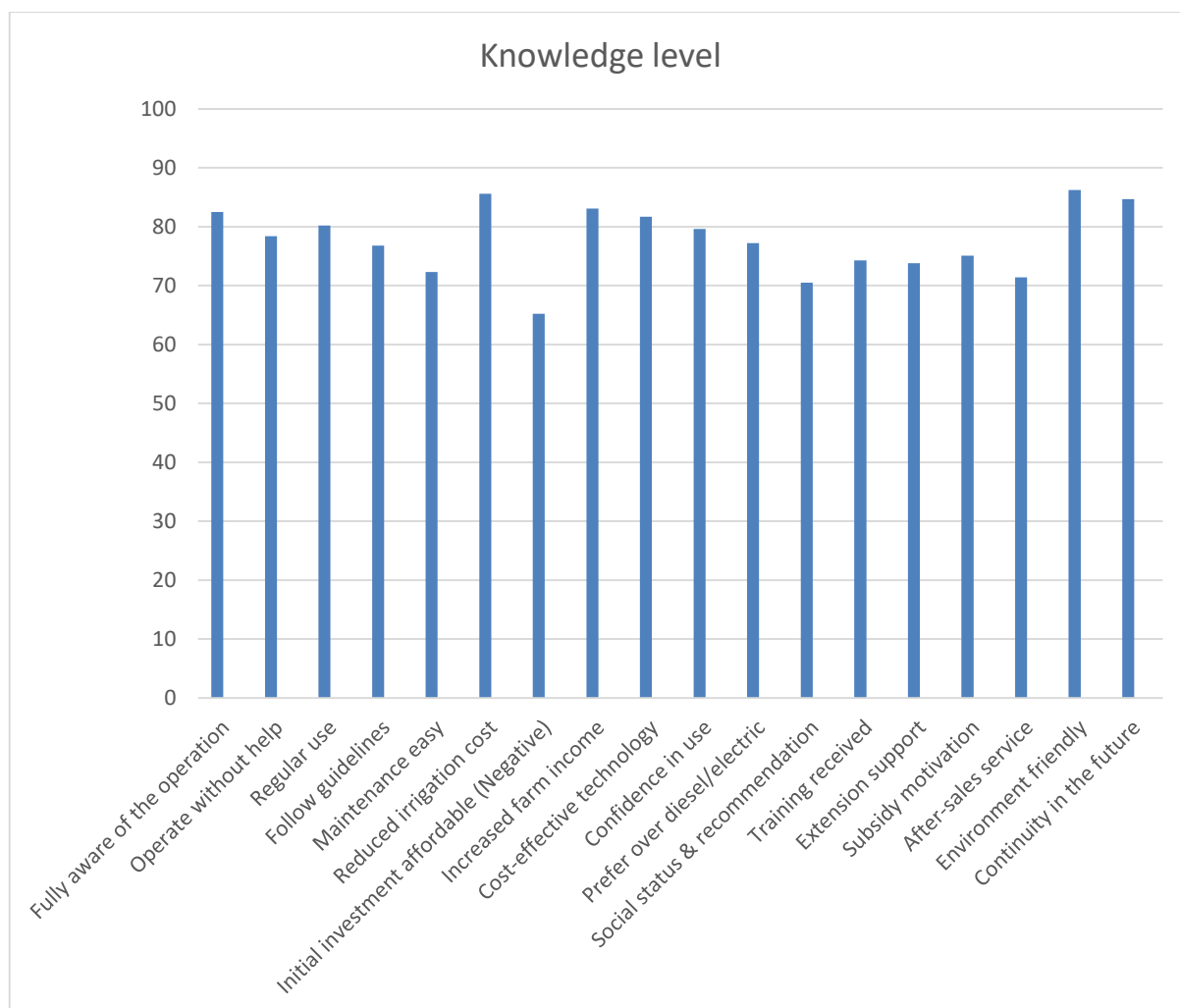


FIGURE 2: Knowledge level of respondents about the Solar Agriculture Pump

3.3 Adoption of Solar Agriculture Pump (PM-KUSUM Yojana) by Respondents

Table 3 indicates the adoption behaviour of respondents towards solar agricultural pumps (PM-KUSUM Yojana). The results show that most farmers had a positive response towards the use of solar pump technology.

TABLE 3
ADOPTION OF SOLAR AGRICULTURE PUMP (PM-KUSUM YOJANA) BY RESPONDENTS (N=100)

S. No.	Statement	MPS (%)	Rank
1	Solar pump is difficult to operate	63.2	XVIII
2	Solar pump is better than diesel/electric	82.4	III
3	Useful in power shortage areas	79.6	VI
4	Provides additional income	78.3	VII
5	Improves living standards	76.5	IX
6	Farmers can sell surplus electricity	70.4	XIV
7	Ensures sustainable irrigation	83.6	II
8	Supports green revolution goals	81.2	IV
9	Performs poorly on cloudy days	68.3	XVI
10	Adequate sunlight essential	74.2	XI
11	Scheme beneficial for farmers	85.4	I
12	Reduces diesel/kerosene use	80.6	V
13	Increases crop production	77.1	VIII
14	Promotes crop diversification	75.4	X
15	Solar pump is eco-friendly	74.1	XII
16	Reduces irrigation costs	73.2	XIII
17	Allows flexible irrigation timing	71.4	XV
18	Wastes government funds	60.2	XX
19	Registration is time-consuming	65.1	XVII
20	Benefits are only available to selected farmers	61.8	XIX

Summary of adoption findings:

The highest Mean Percent Score was recorded for the statement "Scheme beneficial for farmers" (85.4%, Rank I), suggesting that respondents perceive solar pump schemes as highly advantageous in terms of reducing irrigation costs, improving access to water, and enhancing agricultural productivity.

"Ensures sustainable irrigation" ranked second (83.6%, Rank II), demonstrating that farmers recognize the role of solar pumps in providing a reliable and environmentally sustainable source of irrigation, reducing dependence on conventional energy sources and ensuring water availability for crop production.

"Solar pump is better than diesel/electric" ranked third (82.4%, Rank III), followed by "Supports green revolution goals" (81.2%, Rank IV) and "Reduces diesel/kerosene use" (80.6%, Rank V). These rankings reflect farmers' awareness that solar pump technology contributes to modern agricultural development by promoting energy-efficient and eco-friendly farming practices.

Farmers also showed considerable acceptance regarding reduction in fuel consumption, better irrigation during electricity shortages, and improvement in agricultural production. A moderate level of adoption was observed for statements related to crop diversification, irrigation flexibility, environmental safety, and reduction in irrigation expenditure. Respondents also recognized the importance of adequate sunlight for the proper functioning of solar pumps.

Lower scores were found for statements such as "Solar pump is difficult to operate" (63.2%, Rank XVIII), "Registration is time-consuming" (65.1%, Rank XVII), and "Benefits are only available to selected farmers" (61.8%, Rank XIX). The statement "Wastes government funds" received the lowest Mean Percent Score (60.2%, Rank XX), showing that the majority of respondents did not agree with this opinion.

Overall, the findings reveal that farmers generally accepted the PM-KUSUM Yojana and considered solar pumps beneficial for agricultural and economic development.

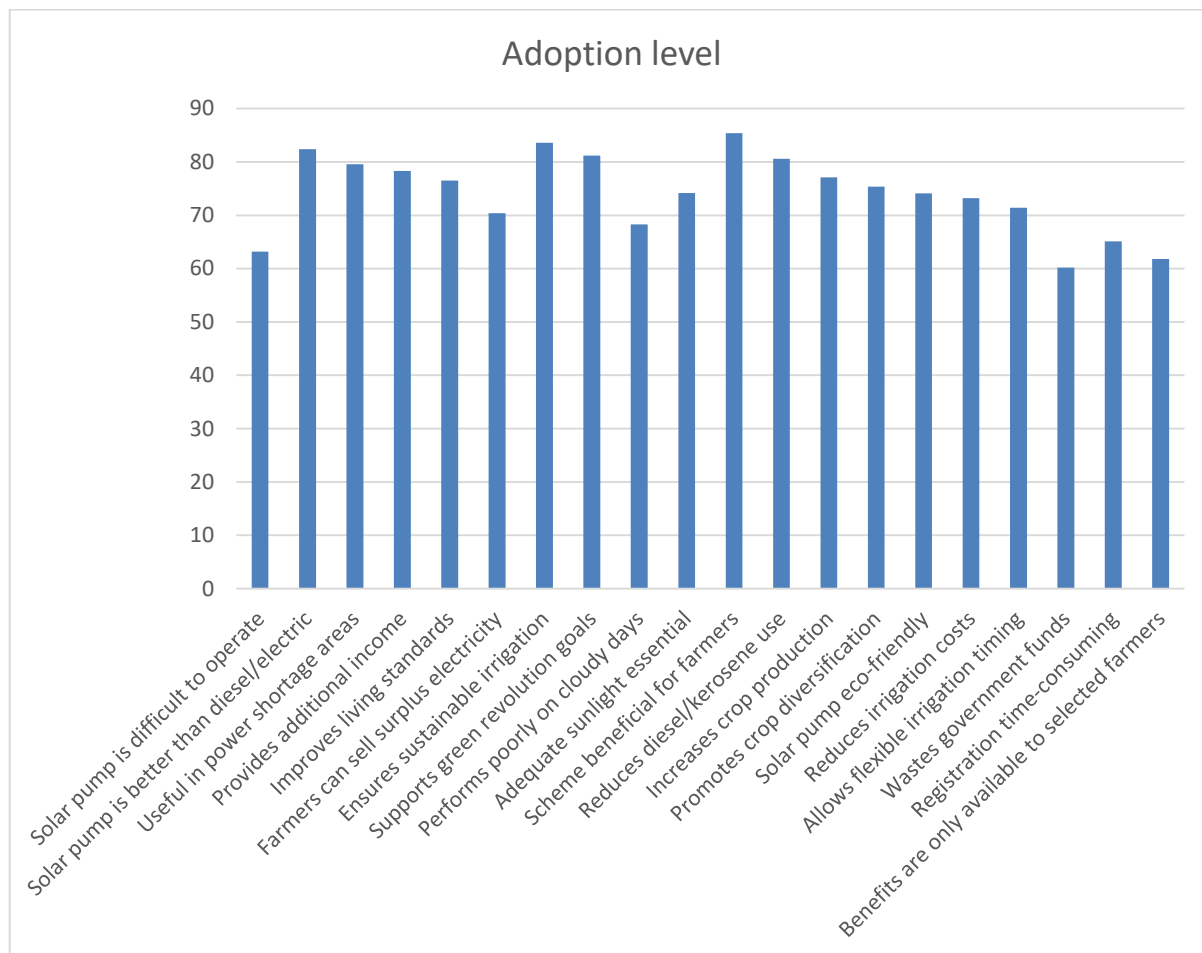


FIGURE 3: Adoption of the Solar Agriculture Pump

IV. DISCUSSION

The findings of this study align with previous research on solar pump adoption in India. The high level of awareness regarding environmental benefits (MPS 86.2%) and reduction in irrigation costs (MPS 85.6%) is consistent with the objectives of the PM-KUSUM scheme, which aims to promote renewable energy and reduce farmer expenses.

However, several challenges identified in this study — including high initial investment costs (MPS 65.2% for "initial investment is not affordable"), delays in registration and subsidy disbursement (MPS 65.1% for "registration is time-consuming"), and reduced efficiency during cloudy weather (MPS 68.3% for "performs poorly on cloudy days") — highlight areas requiring policy attention. These findings are consistent with challenges reported in other studies on renewable energy adoption in agriculture.

The moderate levels of institutional support (training received: MPS 74.3%; extension support: MPS 73.8%) suggest that while government subsidies successfully motivated adoption (MPS 75.1%), there is scope for strengthening extension services and technical guidance to enhance farmer confidence and proper utilization of the technology.

The positive adoption indicators (scheme beneficial: MPS 85.4%; sustainable irrigation: MPS 83.6%; better than diesel/electric: MPS 82.4%) demonstrate that beneficiaries recognize the value of solar pumps despite the challenges. This suggests that the PM-KUSUM scheme has been largely successful in achieving its immediate objectives among adopters.

V. CONCLUSION

The results of this study revealed that farmers covered under the PM-KUSUM scheme possessed a substantial level of awareness regarding solar agricultural pumps and their associated benefits. The majority of farmers recognized that solar pumps help reduce irrigation costs, decrease diesel consumption, and provide a reliable source of energy for agricultural operations. Farmers also perceived solar technology as beneficial for ensuring continued irrigation during power outages and for promoting environmentally sustainable farming practices.

The study further observed that, among the farmers who benefited from the scheme, the inclination toward adopting solar pumps was generally positive. Farmers believed that the scheme had led to improvements in irrigation facilities, boosted agricultural productivity, and reduced dependence on traditional energy sources. Many farmers viewed solar pumps as a cost-effective long-term investment, citing their low operational costs and high suitability for the rural agricultural environment.

Despite these benefits, farmers encountered certain challenges, including high initial investment costs, delays in registration and subsidy disbursement, limited technical guidance, and reduced efficiency during cloudy weather. These challenges acted as impediments to the widespread acceptance and adoption of this technology among certain segments of the farming community.

Overall, the PM-KUSUM scheme has made a significant contribution toward promoting renewable energy within the agricultural sector and improving the farming conditions of beneficiary farmers. The study suggests that enhanced extension support, timely financial assistance, streamlined administrative procedures, and regular technical maintenance services could prove instrumental in boosting both the effectiveness and the adoption rate of this scheme in rural areas.

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CONFLICT OF INTEREST

The author, Vatan Vishwakarma, declares that there are no conflicts of interest regarding the publication of this paper.

REFERENCES

- [1] Bhardwaj, A. K., Singh, R. P., & Sharma, P. (2021). Adoption behaviour of farmers towards solar irrigation pumps in Rajasthan. *Indian Journal of Extension Education*, *57*(3), 78-84.
- [2] Chatterjee, S. (2018). Adoption and performance of solar irrigation pump sets in Indian agriculture. *Agricultural Economics Research Review*, *31*(2), 243-251.
- [3] Choudhary, D., Lal, B., Cheeta, O. N., Jakhar, R. S., & Singh, K. (2022). Constraints in the adoption of solar pumps by the farmers in Jodhpur District of Rajasthan. *The Pharma Innovation Journal*, *11*(1), 623-625.
- [4] Darshan, Y., Ramakrishnan, K., Pushpa, J., & Prabakaran, K. (2021). Knowledge of beneficiaries about Pradhan Mantri Fasal Bima Yojana in Tumkur District of Karnataka. *Madras Agricultural Journal*. <https://doi.org/10.29321/MAJ.10.000543>
- [5] Food and Agriculture Organization. (2023). *The state of food and agriculture*. FAO.
- [6] Gautam, Y., Verma, R. K., & Mishra, S. (2022). Factors affecting adoption of renewable energy technologies among rural farmers. *Indian Research Journal of Extension Education*, *22*(1), 45-51.
- [7] Government of India. (n.d.). *PM-KUSUM*. Ministry of New and Renewable Energy. Retrieved from <https://pmkusum.mnre.gov.in/landing.html>
- [8] IRENA. (2022). *Solar pumping for irrigation: Improving livelihoods and sustainability*. International Renewable Energy Agency.
- [9] Jain, R., Singh, S., & Kumar, P. (2019). Economic feasibility of solar-powered irrigation systems in Indian agriculture. *Agricultural Economics Research Review*, *32*(2), 233-242.
- [10] Jakhar, R. S., Choudhary, R. K., & Meena, B. L. (2022). Adoption pattern of solar irrigation systems among farmers in Rajasthan. *Indian Journal of Agricultural Research*, *56*(4), 412-418.
- [11] Kumar, A., Singh, D. K., & Patel, N. (2023). Awareness and adoption of solar irrigation pumps among farmers in Uttar Pradesh. *International Journal of Agricultural Sciences*, *15*(1), 98-105.
- [12] Kumar, P., Meena, B. S., & Singh, R. (2021). Role of renewable energy technologies in sustainable agricultural development. *Indian Journal of Agricultural Sciences*, *91*(6), 845-850.

- [13] Londhe, S. (2023). *Attitude of farmers towards solar energy utilization in farming systems*. Vasantnao Naik Marathwada Krishi Vidyapeeth.
- [14] Meena, G. L., Choudhary, M., & Sharma, N. K. (2021). Constraints perceived by farmers in the adoption of solar irrigation systems. *The Pharma Innovation Journal*, *10*(9), 1224-1228.
- [15] Ministry of New and Renewable Energy. (2019). *PM-KUSUM scheme guidelines*. Government of India.
- [16] Ministry of New and Renewable Energy. (2025). **Annual report 2024-25**. Government of India.
- [17] Nanded District Administration. (n.d.). *Government of Maharashtra*. Retrieved from <https://nanded.gov.in/>
- [18] Narayanamoorthy, A., Kumar, D. S., & Rajesh, R. (2025). Economic impact of solar-powered irrigation pumps on farm income and electricity savings in India. *Indian Journal of Agricultural Economics*, *80*(1), 67-79.
- [19] Naruka, P. S., Singh, K., & Meena, O. P. (2022). Socio-economic factors influencing the adoption of solar technologies in agriculture. *Indian Journal of Extension Education*, *58*(2), 112-117.
- [20] Patel, R., Sharma, A., & Verma, S. (2024). Impact assessment of PM-KUSUM scheme on agricultural sustainability and farmers' income. *International Journal of Environment and Climate Change*, *14*(3), 521-530.
- [21] Poonia, T. C., Jakhar, R. S., & Choudhary, R. K. (2020). Farmers' perception towards solar energy applications in agriculture. *Journal of Community Mobilization and Sustainable Development*, *15*(2), 267-272.
- [22] Rao, P. V., Reddy, B. S., & Kumar, M. (2021). Renewable energy interventions and rural livelihood security in India. *Journal of Energy and Rural Development*, *8*(1), 34-41.
- [23] Sharma, A., Singh, P., & Verma, A. K. (2023). Adoption of solar-powered technologies in agriculture: A review. *Agricultural Reviews*, *44*(1), 54-63.
- [24] Singh, A. K., Kumar, R., & Yadav, J. P. (2024). Constraints and suggestions regarding the implementation of the PM-KUSUM scheme among beneficiary farmers. *The Pharma Innovation Journal*, *13*(5), 1567-1572.
- [25] Singh, V., Choudhary, D., & Meena, B. L. (2023). Awareness and utilization of solar irrigation pumps under the PM-KUSUM scheme. *Indian Journal of Extension Education*, *59*(4), 91-96.
- [26] Verma, S. K., Patel, M. M., & Yadav, R. (2022). Solar irrigation and sustainable water management in agriculture. *Journal of Water Management*, *30*(3), 145-153.
- [27] Wang, Y., Li, X., Zhang, H., & Chen, J. (2023). Factors influencing farmers' adoption of renewable energy technologies in agriculture: Evidence from rural farming communities. *Renewable Energy*, *205*, 1124-1135.
- [28] Yadav, G. S., Singh, R. K., & Kumar, N. (2021). Role of solar-powered irrigation systems in enhancing farm productivity and income. *International Journal of Current Microbiology and Applied Sciences*, *10*(8), 2145-2152.
- [29] Zade, P. M. (2021). *Attitude of farmers towards solar energy utilization in farming system in Parbhani District of Maharashtra* [Master's thesis, Vasantnao Naik Marathwada Krishi Vidyapeeth].
- [30] Zhang, L., Wang, H., & Liu, Y. (2022). Renewable energy adoption and sustainable agricultural development: Evidence from developing countries. *Energy Policy*, *164*, Article 112890.



Growth and Yield Performance of Snap Beans (*Phaseolus vulgaris* L.) as Affected by Salt-Based and Molasses-Based JADAM Liquid Fertilizers Using Selected Plant Material Sources

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Abstract— This study evaluated the effects of JADAM Liquid Fertilizer (JLF), specifically molasses-based and salt-based formulations, using different plant material sources on the growth, yield, and profitability of snap beans. The experiment was conducted from April to July 2025 at the Vegetable Production Area of Bataan Peninsula State University – Abucay Campus, Bangkal, Abucay, Bataan. A split-plot design following the Randomized Complete Block Design was used, with two JLF formulations as the main plot treatments and three plant material sources (weed, banana trunk, and their combination) as the sub-plot treatments. The experiment was replicated three times.

Results showed that while most growth and yield parameters did not differ significantly among treatments, the molasses-based JADAM liquid fertilizer showed numerical advantages over the salt-based formulation in plant height, flowering, and yield-related traits. A significant interaction ($P < 0.01$) was observed for days to flowering, with molasses-based JLF combined with weed or weed+banana trunk producing the earliest flowering. Among the plant material sources, the banana trunk and the combination of weed and banana trunk produced numerically competitive results. Among treatment combinations, molasses-based JLF combined with banana trunk (J1S2) yielded the highest gross income, net income, and return on investment, making it the most profitable option based on observed trends. Therefore, the use of molasses-based JADAM liquid fertilizer with banana trunk is recommended as a cost-efficient and sustainable fertilizer option for snap bean production, noting that most treatments were statistically comparable in agronomic performance.

Keywords— Growth, JADAM Liquid Fertilizer, Molasses, Plant Material Sources, Snap Beans, Yield.

I. INTRODUCTION

Vegetables and fruits are highly recommended in diets for their nutritional value. Among these, leguminous vegetables are particularly important for low-income countries because of their protein and mineral content, and their potential to increase food security and income [1]. The snap bean (*Phaseolus vulgaris* L.), also known as French bean or green bean, is a legume crop believed to have originated in Latin American countries. It can be grown as a vegetable crop for fresh pods or as a pulse crop for dry seed [2]. Globally, snap beans are considered one of the most important legume vegetable crops, and they contribute a substantial amount of protein to the human diet [2].

In 2019, the global harvested area for snap beans was 33.1 million hectares, with a production of 28.9 million tons [4]. Snap beans are produced mainly in Asia, America, Europe, and Africa [5], [6]. In the Philippines, snap beans, locally known as "habichuelas" or "Baguio beans," are generally cultivated in upland and highland areas. It is recognized as a priority crop by the Department of Agriculture [7]. In 2020, production reached 13,420.83 metric tons, cultivated on 2,974.44 hectares. The Cordillera Administrative Region remains the major producer of snap beans, contributing about 50% of national snap bean production over the past five years [8]. Farmers in these areas consider it an important cash crop and an additional source of income [9], particularly for smallholders and the marginalized.

Conversely, with the soaring costs of farm inputs, mainly fertilizers, farmers are compelled to take risks to sustain production, often resulting in low profits or losses. In addition, the excessive and repetitive use of synthetic fertilizers over time poses risks, including environmental harm, reduced soil fertility, and negative impacts on farmers' health [10]. In the quest for sustainable, cost-effective, and eco-friendly farming practices, organic liquid fertilizers have emerged as a popular alternative to synthetic chemical fertilizers [11].

One such organic liquid fertilizer that is gradually becoming known in the realm of organic farming is JADAM liquid fertilizer (JLF). As a key component of JADAM organic farming, JLF is a versatile fertilizer derived from organic materials via an anaerobic fermentation process known as putrefaction [12]. It can be applied at various stages of plant growth and has been shown to enhance soil microbial activity, increase nutrient availability, and stimulate plant growth. This liquid fertilizer, made from crop residues and wild grass materials, has a balance of N, P, K, Ca, Mg, and other nutrients that crops need [13], thereby reducing farmers' reliance on expensive inputs.

The effectiveness of this liquid fertilizer critically depends on the organic materials used in the fermentation process. Plant materials such as Singapore daisy (*Sphagneticola trilobata*, syn. *Wedelia trilobata*) and banana trunks are suitable for preparing JADAM liquid fertilizer due to their nutrient content and availability. *Sphagneticola trilobata*, commonly known as Singapore daisy or trailing daisy, is an invasive weed used to restore soil fertility and is usually utilized as ground cover, capable of improving soil quality ecologically. Setyowati reported that this weed has high potential as an organic fertilizer owing to its high nitrogen content and its abundant populations around agricultural areas or in uncultivated lands [14]. Similarly, banana trunks, often regarded as agricultural waste, contain appreciable amounts of macronutrients and micronutrients, making them suitable for composting, mulching, and the production of organic fertilizers [15]. Meanwhile, molasses, a carbon-rich substrate, is commonly integrated in the preparation of liquid organic fertilizer. Its natural sugars feed the microbes responsible for fermentation, improving the effectiveness of organic inputs such as plant materials [16].

JADAM liquid fertilizer has been promoted as a low-cost alternative, yet limited empirical studies have evaluated its efficacy on leguminous vegetables, such as snap beans. Furthermore, the comparative effects of molasses as an additive to JADAM liquid fertilizer, as well as the optimal plant material source for JLF preparation under Philippine conditions, remain largely unexplored.

II. MATERIALS AND METHODS

2.1 Experimental Site and Crop:

The experiment was conducted at the Vegetable Production Area of Bataan Peninsula State University-Abucay Campus, Bangkal, Abucay, Bataan. The site had a gently sloping topography and received sufficient sunlight for snap bean growth. The soil was predominantly Antipolo clay soil. Based on rapid soil testing, the soil was low in nitrogen but high in phosphorus and potassium, with a pH of 5.8. The Mayabong pole snap bean variety was used. This variety produces green pods, grows as a climbing type, and can be harvested about 45 to 50 days after sowing under favorable conditions.

2.2 Experimental Design and Treatments:

The study was laid out in a split-plot design following the Randomized Complete Block Design with three replications. The two JLF formulations served as the main plot treatments, while the plant material sources served as subplot treatments. Each plot measured 2.5 m × 3.5 m and contained four rows. The treatment structure is summarized below.

TABLE A
TREATMENT FACTORS AND CODES USED IN THE EXPERIMENT

Factor	Code	Treatment description
Main plot: JLF formulation	J1	Molasses-based JADAM liquid fertilizer
Main plot: JLF formulation	J2	Salt-based JADAM liquid fertilizer or JLF without molasses
Subplot: plant material source	S1	Weed (Singapore daisy)
Subplot: plant material source	S2	Banana trunk
Subplot: plant material source	S3	Weed + banana trunk

Note: J1 and J2 are main plot treatments; S1, S2, and S3 are subplot treatments.

2.3 Preparation and Application of JADAM Liquid Fertilizer:

The JLF treatments were prepared using 1 kg of weed, 1 kg of banana trunk, or a 500 g + 500 g combination (weed + banana trunk). The salt-based formulation used 15 L of unchlorinated water, 90 g of leaf mold soil, and 30 g of rock salt. The molasses-based formulation used the same amount of water and leaf mold soil, but used 1 L of molasses instead of rock salt. The plant materials were chopped into small pieces, placed in clean containers, mixed thoroughly with leaf mold soil and the required additive, covered, and fermented for 30 days. The mixture was stirred every three days.

Treatments were applied as a drench at a rate of 10 mL JLF diluted in 1 L of water. The solution was poured around the base of the plant using a watering can. Application was done twice a week, beginning two weeks after seed emergence and continuing until fruit setting. Applications were made early in the morning or late in the afternoon to reduce stress on the plants.

2.4 Crop Management and Data Collection:

Land preparation included clearing, plowing, harrowing, and incorporation of decomposed animal manure. Seeds were sown at a depth of about 2 cm, with 30 cm between hills and 75 cm between rows. Thinning was done two weeks after emergence, leaving the healthiest plant. Trellising, hilling up, manual weeding, irrigation, pest monitoring, deleafing, harvesting, and postharvest sorting were done as needed. Pods were harvested by hand every 3 to 5 days when they reached an acceptable market size and quality.

Growth data included plant height at harvest, days to flowering, and number of lateral branches. Yield and yield components included the number of pods per plant, pod length, pod diameter, pod weight, fresh pod weight per plant, computed yield per hectare, and cost and return analysis. Data were analyzed using analysis of variance for split-plot RCBD. Differences among means were compared using the Least Significant Difference (LSD) test at the 5% level of significance.

III. RESULTS AND DISCUSSION

3.1 General Field Observations:

During the early phase of the experiment, high temperature and intense sunlight affected seed germination and seedling establishment. Resowing and frequent irrigation were done to reduce heat stress. During the flowering and pod-setting stages, strong winds and rainfall caused some flower shedding and occasional lodging. Drainage canals and hilling up were used to reduce waterlogging, root stress, and lodging.

Several pests were observed during the cropping period. Bean leaf beetle attacked the plants during the vegetative stage, while milkweed bug, stink bug, bean leaf beetle, bean pod borer, and cowpea curculio were observed during flowering and pod production. Bacterial blight was also observed on some pods, but only to a limited extent. Pest and disease management included handpicking, sticky traps, field sanitation, deleafing, removal of damaged plant parts, and one insecticide application when the pest population increased.

3.2 Growth Performance:

3.2.1 Plant Height:

Table 1 presents the average height of sample plants at harvest. Plant height ranged from 262.83 cm (J1S2) to 308.80 cm (J1S1). Analysis of variance revealed no significant differences among JLF formulations, material sources, or their interaction for plant height at harvest. Numerically, plants treated with molasses-based JLF (J1, 286.47 cm) were taller than those treated with salt-based JLF (J2, 272.60 cm). Among material sources, weed alone (S1, 289.59 cm) produced the tallest plants numerically, followed by the combination treatment (S3, 280.27 cm), while banana trunk alone (S2, 268.75 cm) produced the shortest.

Although the differences were not statistically significant, the numerical advantage of J1 and S1 suggests that the molasses-based formulation and Singapore daisy material may provide a favorable nutrient and microbial environment for vegetative growth. Pyakurel et al. [17] reported that molasses combined with organic fertilizer improved soil organic carbon, nitrogen, and spinach yield, while Al-Dhumri et al. [18] found that molasses application increased the availability of N, P, K, organic matter, calcium, and magnesium in soil. Studies on *Sphagneticola trilobata* also support the better numerical performance of the weed-based material. Suci et al. [19] reported that *S. trilobata* compost improved soil chemical properties and significantly increased sweet corn height, leaf number, stem diameter, and leaf area. Similarly, Setyowati et al. [14] found that weed-based compost improved the growth and yield of chili pepper, and Mukhtar et al. [20] reported that *Wedelia* compost improved total N, available P, exchangeable K, Ca, and Mg, as well as soil pH, in acidic soils.

3.2.2 Days to Flowering:

Table 1 presents the average number of days to flowering. Plants treated with molasses-based JLF (J1, 36.89 DAS) flowered numerically earlier than those treated with salt-based JLF (J2, 38.11 DAS). Among material sources, weed alone (S1, 37.33 DAS) and weed+banana trunk (S3, 37.33 DAS) showed numerically earlier flowering than banana trunk alone (S2, 37.84 DAS).

The analysis of variance showed a highly significant interaction ($P < 0.01$) between JLF formulation and plant material source for days to flowering (Table 1a). This indicates that flowering response depended on the specific combination of JLF type and plant material source rather than on either factor alone. The earliest flowering was observed in J1S1 (molasses-based JLF + weed) and J1S3 (molasses-based JLF + weed+banana trunk), both at 36.33 DAS, followed by J2S2 (salt-based JLF + banana trunk) at 37.67 DAS. The longest flowering time was recorded in J2S1 and J2S3 (38.33 DAS).

The early flowering in J1S1 and J1S3 suggests that molasses-based JLF was more effective when combined with weed-based material. This may be related to molasses' role as a readily available carbon source that stimulates microbial activity and nutrient mineralization. Pyakurel et al. [17] and Al-Dhumri et al. [18] both reported improvements in soil nutrient availability following molasses application, while Suci et al. [19] and Mukhtar et al. [20] showed that *S. trilobata* or *Wedelia*-based compost can improve soil fertility. The results also suggest that banana trunk alone did not promote early flowering as consistently as weed-based materials when combined with molasses-based JLF.

TABLE 1

PLANT HEIGHT, DAYS TO FLOWERING, AND LATERAL BRANCHES OF SNAP BEANS APPLIED WITH SALT-BASED AND MOLASSES-BASED JLF USING DIFFERENT PLANT MATERIAL SOURCES

Code	Description	Plant height (cm)	Days to flowering	Lateral branches
J1	JLF with molasses	286.47 a	36.89 a	17.76 a
J2	JLF without molasses	272.60 a	38.11 a	16.49 a
S1	Weed	289.59 a	37.33 a	16.92 a
S2	Banana trunk	268.75 a	37.84 a	18.65 a
S3	Weed + banana trunk	280.27 a	37.33 a	15.80 a
J1S1	JLF with molasses + weed	308.80 a	36.33 a	19.27 a
J1S2	JLF with molasses + banana trunk	262.83 a	38.00 bc	17.30 a
J1S3	JLF with molasses + weed + banana trunk	287.77 a	36.33 a	16.70 a
J2S1	JLF without molasses + weed	270.37 a	38.33 c	14.57 a
J2S2	JLF without molasses + banana trunk	274.67 a	37.67 b	20.00 a
J2S3	JLF without molasses + weed + banana trunk	272.77 a	38.33 c	14.90 a
F-test	Main plot	ns	ns	ns
F-test	Subplot	ns	ns	ns
F-test	A × B	ns	**	ns
CV%	Main plot (JLF)	9.25	2.27	2.16
CV%	Subplot (materials)	8.34	1.18	1.39

*Note: Means with the same letter are not significantly different from each other (LSD, $P < 0.05$). ns = not significant; ** = significant at $P < 0.01$.

TABLE 1 (A)

COMPARISON OF SUBPLOTS AT EACH LEVEL OF THE MAIN PLOT FOR DAYS TO FLOWERING

Material source	J1: molasses-based JLF	J2: salt-based JLF
S1: Weed	36.33 a	38.33 c
S2: Banana trunk	38.00 bc	37.67 b
S3: Weed + banana trunk	36.33 a	38.33 c

Note: Means with the same letter are not significantly different from each other (LSD, $P < 0.05$).

3.2.3 Lateral Branches

Table 1 presents the average number of lateral branches per sample plant. Plants treated with molasses-based JLF (J1, 17.76) produced numerically more branches than those treated with salt-based JLF (J2, 16.49). Among material sources, banana trunk alone (S2, 18.65) obtained the highest number of lateral branches numerically. No significant differences were found for lateral branching; therefore, the observed differences should be interpreted as numerical trends only.

3.3 Yield and Yield Components

3.3.1 Pod Length, Pod Diameter, and Pod Weight

Table 2 presents pod length, pod diameter, and pod weight. Analysis of variance showed no significant treatment effects on any of these parameters. Pod length ranged from 15.04 cm to 15.30 cm across treatment combinations. Pod diameter ranged from 8.87 mm to 9.05 mm. Pod weight ranged from 8.44 g to 9.13 g.

The uniform pod characteristics across treatments suggest that pod quality traits may be less responsive to the tested fertilizer treatments than vegetative growth or flowering. Beshir et al. [3] reported that snap bean pod quality is influenced by cultivar, climate zone, and nitrogen fixation, indicating that pod traits may depend on multiple genetic and environmental factors beyond the fertilizer source. Singh et al. [25] also emphasized that nitrogen fertilization responses in snap beans depend on cropping conditions and soil nutrient status.

TABLE 2

POD LENGTH, POD DIAMETER, AND POD WEIGHT OF SNAP BEANS APPLIED WITH SALT-BASED AND MOLASSES-BASED JLF USING DIFFERENT PLANT MATERIAL SOURCES

Code	Description	Pod length (cm)	Pod diameter (mm)	Pod weight (g)
J1	JLF with molasses	15.21 a	8.98 a	8.85 a
J2	JLF without molasses	15.07 a	8.97 a	9.01 a
S1	Weed	15.09 a	9.02 a	9.12 a
S2	Banana trunk	15.21 a	8.93 a	8.93 a
S3	Weed + banana trunk	15.12 a	8.99 a	8.75 a
J1S1	JLF with molasses + weed	15.14 a	8.98 a	9.11 a
J1S2	JLF with molasses + banana trunk	15.30 a	8.99 a	9.01 a
J1S3	JLF with molasses + weed + banana trunk	15.19 a	8.97 a	8.44 a
J2S1	JLF without molasses + weed	15.04 a	9.05 a	9.13 a
J2S2	JLF without molasses + banana trunk	15.12 a	8.87 a	8.84 a
J2S3	JLF without molasses + weed + banana trunk	15.05 a	9.00 a	9.06 a
F-test	Main plot	ns	ns	ns
F-test	Subplot	ns	ns	ns
F-test	A × B	ns	ns	ns
CV%	Main plot (JLF)	1.03	0.42	6.79
CV%	Subplot (materials)	2.21	1.18	2.91

Note: Means with the same letter are not significantly different from each other. ns = not significant.

3.3.2 Fresh Pod Yield and Computed Yield

Table 3 presents fresh pods per plant, fresh pod weight per plant, and computed yield per hectare. No significant differences were observed for any of these parameters.

For fresh pods per plant, molasses-based JLF (J1, 69.33) produced numerically higher values than salt-based JLF (J2, 65.67). Among material sources, banana trunk alone (S2, 67.83) and weed alone (S1, 67.34) and weed+banana trunk (S3, 67.34) produced comparable numerical values. The highest numerical number of fresh pods was recorded in J1S3 (71.00), followed by J1S1 (68.67) and J1S2 (68.33).

For fresh pod weight per plant, molasses-based JLF (J1, 610.89 g) produced numerically higher values than salt-based JLF (J2, 591.67 g). Weed alone (S1, 614.67 g) produced the highest numerical weight among material sources. Among treatment combinations, J1S1 (628.67 g) produced the highest numerical fresh pod weight.

For computed yield per hectare, molasses-based JLF (J1, 12,833.61 kg/ha) produced numerically higher yield than salt-based JLF (J2, 12,442.08 kg/ha). Among material sources, banana trunk alone (S2, 12,941.67 kg/ha) produced the highest numerical yield, followed by weed+banana trunk (S3, 12,756.25 kg/ha) and weed alone (S1, 12,215.63 kg/ha). Among treatment combinations, J1S2 (molasses-based JLF + banana trunk) produced the highest numerical computed yield (13,508.33 kg/ha), followed by J2S3 (12,978.33 kg/ha) and J1S3 (12,534.17 kg/ha).

Although the computed yield was not significantly affected by the treatments, the highest numerical yield in J1S2 (molasses-based JLF + banana trunk) is agronomically noteworthy. Islam et al. [22] reported that enriched banana pseudostem sap improved nutrient uptake, yield, and quality of sweet corn, while Abro et al. [23] found that banana pseudostem sap improved vegetative growth and yield attributes of onion. Mahalakshmi and Naveena [21] also noted that fermented banana pseudostem waste contains potassium and cellulolytic bacteria that can help improve plant growth.

TABLE 3

FRESH POD NUMBER, FRESH POD WEIGHT, AND COMPUTED YIELD OF SNAP BEANS APPLIED WITH SALT-BASED AND MOLASSES-BASED JLF USING DIFFERENT PLANT MATERIAL SOURCES

Code	Description	Fresh pods per plant	Fresh pod weight (g/plant)	Computed yield (kg/ha)
J1	JLF with molasses	69.33 a	610.89 a	12,833.61 a
J2	JLF without molasses	65.67 a	591.67 a	12,442.08 a
S1	Weed	67.34 a	614.67 a	12,215.63 a
S2	Banana trunk	67.83 a	605.34 a	12,941.67 a
S3	Weed + banana trunk	67.34 a	583.83 a	12,756.25 a
J1S1	JLF with molasses + weed	68.67 a	628.67 a	12,458.33 a
J1S2	JLF with molasses + banana trunk	68.33 a	614.67 a	13,508.33 a
J1S3	JLF with molasses + weed + banana trunk	71.00 a	589.33 a	12,534.17 a
J2S1	JLF without molasses + weed	66.00 a	600.67 a	11,972.92 a
J2S2	JLF without molasses + banana trunk	67.33 a	596.00 a	12,375.00 a
J2S3	JLF without molasses + weed + banana trunk	63.67 a	578.33 a	12,978.33 a
F-test	Main plot	ns	ns	ns
F-test	Subplot	ns	ns	ns
F-test	A × B	ns	ns	ns
CV%	Main plot (JLF)	13.35	19.16	6.58
CV%	Subplot (materials)	7.61	8.91	12.31

Note: Means with the same letter are not significantly different from each other. ns = not significant.

3.3.3 Cost and Return Analysis

The cost and return analysis in Table 4 shows that J1S2 (molasses-based JLF + banana trunk) produced the highest gross income (₱810,499.80), the highest net income (₱629,750.40), and the highest ROI (348.41%). The second-highest ROI was obtained from J2S3 at 334.92%, followed by J1S3 at 316.35%, J2S2 at 314.43%, J1S1 at 314.11%, and J2S1 at 301.50%. Although J1S2 also had the highest total expense (₱180,749.00), its higher numerical yield generated the greatest financial return.

These results indicate that profitability was influenced more by marketable yield than by small differences in production cost. The superior economic performance of J1S2 supports the practical value of combining molasses-based JLF with banana trunk material, even though the yield differences were not statistically significant.

TABLE 4
COST AND RETURN ANALYSIS FOR SNAP BEANS APPLIED WITH MOLASSES-BASED AND SALT-BASED JLF
PREPARED FROM DIFFERENT PLANT MATERIAL SOURCES

Treatment	Total expenses (₱)	Gross income (₱)	Net income (₱)	ROI (%)
J1S1	1,80,509.00	7,47,499.80	5,66,990.40	314.11
J1S2	1,80,749.00	8,10,499.80	6,29,750.40	348.41
J1S3	1,80,629.00	7,52,050.20	5,71,420.80	316.35
J2S1	1,78,924.00	7,18,375.20	5,39,451.40	301.5
J2S2	1,79,164.00	7,42,500.00	5,63,336.20	314.43
J2S3	1,79,044.00	7,78,699.80	5,99,656.00	334.92

Note: ROI = (Net income ÷ Total expenses) × 100. Currency in Philippine Pesos (₱).

IV. CONCLUSION

This study evaluated the effects of molasses-based and salt-based JADAM liquid fertilizers using different plant material sources on the growth, yield, and profitability of snap beans. The results showed that while most growth and yield parameters (plant height, lateral branches, pod length, pod diameter, pod weight, fresh pod number, fresh pod weight, and computed yield) were not significantly affected by the treatments, molasses-based JLF showed numerical advantages over the salt-based formulation in several traits.

A significant interaction ($P < 0.01$) was observed for days to flowering, with the earliest flowering recorded in molasses-based JLF combined with weed (J1S1) and molasses-based JLF combined with weed+banana trunk (J1S3). Among all treatment combinations, molasses-based JLF with banana trunk (J1S2) achieved the highest numerical computed yield and profitability, with a gross income of ₱810,499.80, a net income of ₱629,750.40, and a 348.41% ROI. Based on these observed trends, J1S2 may be considered the most practical and profitable treatment for snap bean production under the conditions of this experiment.

It is important to note that the absence of statistically significant differences for most parameters does not indicate treatment failure; rather, it suggests that the tested JLF formulations and plant material sources were statistically comparable in their agronomic effects. The numerical trends observed, particularly the superior profitability of J1S2, provide useful guidance for farmers seeking cost-effective organic fertilizer options. Future research should include a synthetic fertilizer control to establish the relative performance of JLF treatments compared to conventional practices, and should consider multi-season trials to account for seasonal variability.

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CONFLICT OF INTEREST

The author declares that there are no conflicts of interest about the publication of this study. No financial, personal and professional relationships influenced the conduct and results of the study. All of data and findings from this research were attained and analyzed solely for academic purposes.

REFERENCES

- [1] Agoyi, E. E., Ahomondji, S. E., Butare, L., Nchanji, E. B., Ayi, S., Assogbadjo, A., & Sinsin, B. A. (2023). Prospects of snap beans (*Phaseolus vulgaris* L.) production and commercialization in Benin. *Frontiers in Nutrition*, *10*, Article 1180134. <https://doi.org/10.3389/fnut.2023.1180134>
- [2] Pagal, R. A. L. (2015). *Growth and yield of pole snap beans (Phaseolus vulgaris L.) under organic and conventional production systems in La Trinidad, Benguet* [Bachelor's thesis, Benguet State University].

- [3] Beshir, H. M., Tesfaye, B., Bueckert, R., & Tar'an, B. (2015). Pod quality of snap bean as affected by nitrogen fixation, cultivar, and climate zone under dryland agriculture. *African Journal of Agricultural Research*, *10*(32), 3157-3169. <https://doi.org/10.5897/AJAR2015.9888>
- [4] Food and Agriculture Organization of the United Nations. (2020). *FAOSTAT statistical database*. <https://www.fao.org/faostat/en/>
- [5] Singh, D. K., Singh, D., & Singh, S. S. (2018). Studies of genetic variability, heritability and genetic advance for yield and related traits in French bean (*Phaseolus vulgaris* L.). *Journal of Pharmacognosy and Phytochemistry*, *7*, 236-240.
- [6] Parker, T. A., et al. (2023). Genetic resources and breeding priorities in *Phaseolus* beans: Vulnerability, resilience, and future challenges. *Plant Breeding Reviews*, *46*, 289-420. <https://doi.org/10.1002/9781119874157.ch6>
- [7] Sarmiento, G. P. (2015). Technical efficiency of pole snap bean (*Phaseolus vulgaris* L.) farmers in Nueva Vizcaya, Philippines. *NVSU Research Journal*, *2*(1), 40-45.
- [8] Philippine Statistics Authority. (2020). *Crops statistics of the Philippines: 2016–2020 snapshot*. <https://psa.gov.ph/>
- [9] Gumuwang, E. T. (2025). Enhancing the productivity of bush snap beans (*Phaseolus vulgaris* L.) using organic fertilizer amendments. *International Journal of Agricultural Technology*, *21*(3), 865-878.
- [10] Syamsiyah, J., Minardi, S., Herdiansyah, G., Cahyono, O., & Mentari, F. C. (2021). Physical properties of Alfisols, growth and products of hybrid corn affected by organic and inorganic fertilizer. *Caraka Tani: Journal of Sustainable Agriculture*.
- [11] Live to Plant. (2025). *Organic liquid fertilizers: How to make and use them*. <https://livetoplant.com/organic-liquid-fertilizers-how-to-make-and-use-them/>
- [12] Julien. (2022). *How to make JADAM liquid fertilizers (quick and easy)*. MICROFARM Guide. <https://www.microfarmguide.com/jadam-liquid-fertilizers/>
- [13] Billena, F. M. A. (2019). *JADAM: Ultra-low-cost organic farming* [PowerPoint slides]. Scribd.
- [14] Setyowati, N., Mukhtar, Z., Suriyanti, B., & Simarmata, M. (2014). Growth and yield of chili pepper as affected by weed based organic compost and nitrogen fertilizer. *International Journal on Advanced Science, Engineering and Information Technology*, *4*(2), 121-124. <https://doi.org/10.18517/ijaseit.4.2.382>
- [15] Sundar, S., & Krishnamoorthy, R. (2015). Potential of banana trunk biomass in organic farming: A nutrient-rich bioresource. *International Journal of Agricultural Research*, *10*(1), 1-7.
- [16] El Kurebe, A. (2025). *What is molasses and how is it used in agriculture?* Ashenews Daily. <https://ashenewsdaily.com/>
- [17] Pyakurel, A., Dahal, B. R., & Rijal, S. (2019). Effect of molasses and organic fertilizer in soil fertility and yield of spinach in Khotang, Nepal. *International Journal of Applied Sciences and Biotechnology*, *7*(1), 49-53. <https://doi.org/10.3126/ijasbt.v7i1.23301>
- [18] Al Dhumri, S. A., Al Mosallam, M. S., Zhang, W., Alharbi, S., & Abou Elwafa, S. F. (2022). Application of molasses as an eco innovative approach substitutes mineral nitrogen fertilization and enhances sugar beet productivity. *Waste and Biomass Valorization*, *14*, 287-296. <https://doi.org/10.1007/s12649-022-01873-z>
- [19] Suci, Y. T. E., Mukhtar, Z., Fahrurrozi, F., Setyowati, N., Utami, K. P., Pujiwati, H., & Alnopri. (2025). The use of *Sphagneticola trilobata* and *Melastoma affine* composts to improve certain soil chemical properties and sweet corn growth and yield. *International Journal of Agriculture and Environmental Research*, *11*(1), 185-201. <https://doi.org/10.51193/ijaer.2025.11112>
- [20] Mukhtar, Z., Lifa, L., & Adiprasetyo, T. (2022). Phosphorus availability as affected by the application of organic amendments in Ultisols. *SAINS TANAH: Journal of Soil Science and Agroclimatology*.
- [21] Mahalakshmi, R., & Linnett Naveena, M. (2016). Usage of banana pseudostem waste for the production of potassic biofertilizer using cellulolytic bacteria. *International Journal of Current Microbiology and Applied Sciences*, *5*(8), 336-349.
- [22] Islam, M. S., et al. (2023). Foliar application of enriched banana pseudostem sap influences the nutrient uptake, yield, and quality of sweet corn grown in an acidic soil. *PLoS ONE*, *18*(8), e0285954.
- [23] Abro, S. A., Abro, M. A., Kapri, J. H., Ahmed, N., Ali, H., Parveen, S., & Khoso, A. (2023). Extraction and utilization of banana pseudostem sap as organic liquid biofertilizer on onion (*Allium cepa* L.). *Pakistan Journal of Biotechnology*, *20*(2), 275-280. <https://doi.org/10.34016/pjbt.2023.20.02.839>
- [24] Roosda, A. A., et al. (2021). Liquid organic fertilizer and types of organic mulch toward photosynthesis translocation of green beans (*Phaseolus vulgaris* L.). *IOP Conference Series: Materials Science and Engineering*, *1098*(5), 052004. <https://doi.org/10.1088/1757-899X/1098/5/052004>
- [25] Singh, R., Hochmuth, R. C., de Sá Leitão, D. A. H., & Sharma, L. K. (2024). Nitrogen fertilization in snap beans following a legume in the sandy soils of North Florida. *HortTechnology*, *34*(5), 521-532. <https://doi.org/10.21273/HORTTECH05442-24>



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