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Effect of natural farming, organic farming and integrated crop management practices on yield attributes and productivity of soybean + maize intercropping system under unbunded *Vertisol* of Chhattisgarh plains

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Abstract
The present investigation entitled "Effect of natural farming, organic farming and integrated crop management practices on yield attributes and productivity of soybean + maize intercropping system under unbunded *Vertisol* of Chhattisgarh plains" was conducted during *Kharif* season of 2022 and 2023 at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The soil of experimental field was clayey (*Vertisol*), neutral in reaction (pH 6.85), medium in organic carbon (0.53%), low in available nitrogen (144 kg ha^{-1}), low in available phosphorus (18.4 kg ha^{-1}) and high in available potassium (377 kg ha^{-1}).
The experiment was carried out in randomized block design with five treatments and four replications. The treatments comprised of T_1 – Control (No addition of any inputs except labour for operations including weeding), T_2 - Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa), T_3 - AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS), T_4 - 50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management) and T_5 - 50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management).
The results of the experiment revealed that integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and pest management with chemical pesticides proved to be best for soybean + maize intercropping system in terms yield attributes and productivity and this was followed by integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and pest management with organic/natural pesticides and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS). Higher soybean equivalent yield was registered under AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS).

Keywords: Natural farming, organic farming, integrated crop management

Introduction
Prior to the Green Revolution, agriculture was characterized by low productivity due to reliance on traditional farming methods, minimal use of technology, and dependence on rainfed irrigation. Frequent famines and food shortages were common, leading to widespread malnutrition and poverty. Soil health was poor due to nutrient depletion and limited use of chemical fertilizers. Farmers used low-yielding local seed varieties and had limited access to improved seeds and modern agricultural practices. Inadequate infrastructure, such as poor transportation and storage facilities, compounded these challenges, while government support and investment in agriculture were minimal, further hindering the sector's development. The Green Revolution had a profound positive impact by significantly increasing agricultural productivity and food security worldwide, particularly in developing countries. It introduced high-yielding varieties (HYVs) of crops, advanced irrigation techniques, and modern farming

machinery, which collectively boosted crop yields and reduced food shortages. The use of chemical fertilizers and pesticides improved soil fertility and crop health, leading to more reliable and abundant harvests. This transformation helped alleviate hunger and malnutrition, stimulated rural economies, and provided a foundation for agricultural modernization. As a result, many countries experienced economic growth, improved livelihoods for farmers, and greater resilience against famines and food crises.

Despite its successes, the Green Revolution had several negative impacts, including environmental degradation from the overuse of chemical fertilizers and pesticides, which led to soil and water pollution. The intensive irrigation practices contributed to water scarcity and the depletion of aquifers. The focus on high-yielding varieties reduced agricultural biodiversity, making crops more vulnerable to pests and diseases. Socially, the benefits were unevenly distributed, often favoring wealthier farmers with access to resources, while smallholders and marginal farmers were left behind, exacerbating economic inequalities. Additionally, the shift to monoculture farming increased dependency on specific crops, creating vulnerabilities in the agricultural system. In response to the negative impacts of the Green Revolution, there is an urgent need for natural farming, organic farming, and integrated crop management practices. These sustainable approaches aim to mitigate environmental damage by reducing reliance on chemical inputs and promoting soil health through organic amendments and natural pest control methods. Natural and organic farming enhance biodiversity and resilience against pests and diseases, while integrated crop management combines traditional knowledge with modern techniques to optimize resource use and improve crop yields sustainably. These practices support smallholder farmers by reducing input costs, enhancing food security, and fostering ecological balance, thereby addressing the socio-economic and environmental challenges posed by conventional Green Revolution methods.

Globally, soils contain more carbon than plants and the atmosphere combined. Losing carbon-rich organic matter from soils releases carbon dioxide, a greenhouse gas, which can accelerate climate warming. But by regenerating soils, we can sequester more carbon underground and slow climate warming. In addition to protecting soil, cover crops take carbon out of the atmosphere as they grow and funnel it into the soil. Unlike cash crops that are harvested and removed from the soil, cover crops are left to decompose and contribute to soil formation. While plants are the source of carbon for soils, microbes control its fate by using it as food, thus ensuring that at least some of it will remain in the soil (Wallenstein, 2017) [14]. Thus, it is believed that natural farming is based on the above hypothesis. With different interventions under it- adding microbes, adding cover crop, minimum tillage, multi-cropping, etc. it helps in soil regeneration and ultimately would lead to sustainable agricultural growth. There are several states practicing natural farming. Prominent among them are Andhra Pradesh, Chhattisgarh, Kerala, Gujarat, Himachal Pradesh, Jharkhand, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh and Tamil Nadu. Till now 6.5 lakh ha. area is covered under natural farming in India (Anonymous, 2024) [1].

For farmers with limited access to nutrient supplies, incorporating legumes into cereal-based cropping systems has long been recommended as a way to improve soil fertility and agro-ecological resilience (Snapp *et al.,* 1998; Thierfelder *et al*., 2012) [10, 12]. Cereal-legume based intercropping system is known to increase yield stability and is efficient at resource conservation and maintaining soil fertility. While agriculture directly contributes to 20% of greenhouse gas emissions in the country primarily due to livestock rearing and the use of nitrogenous fertilizers. These fertilizers are also the largest source of nitrate contamination in surface water bodies (Swaney *et al*., 2015) [11]. A new farming system came into light courtesy of Subhas Palekar Natural Farming System (SPNF) that is tailored fit for small and marginal farmer and Indian farmers that uses local indigents for farming like desi cow (*Bos indicus)* urine, cow dung, lime, gram flour and handful of soil and after fermentation it is used for foliar spray or fertigation. According to Subhas Palekar, natural farming components have high microbial load which upon application increase the soil flora that mineralize the soil macro and micro nutrients and make them available for plant use. Conjoint use of cereal-legume intercropping and natural farming systems can be ideal to reduce greenhouse gas emission and increase yield stability while maintaining soil fertility.

Natural farming, as the name implies, means that farmers do not need to purchase fertilizers and pesticides to ensure the growth of crops (Bishnoi *et al*., 2017) [3]. Four pillars or components of natural farming are Beejamrit, Jeevamrit, Acchadana (Mulching) and Whaapasa (Moisture). Natural farming is a resource efficient farming system which minimizes the use of external resources and also restores the quality of soil and water resources. The importance of natural farming is to minimize the use of external inputs to the farm land and enrich soil through the propagation of soil microbes. It encourages the natural symbiosis of soil micro flora and crop plants. The natural inputs used in organic farming and natural farming are easily available, releases nutrients slowly, supplies macro and micro nutrients and provides favourable soil environment for microbial population and soil enzymes. General acceptance of organic farming and natural farming is not only due to the greater demand for pollution-free food but also due to natural advantage in supporting the sustainability in agriculture. Though conventional farming helps in getting substantial yields, indiscriminate use of inorganic fertilizers and continuous farming has resulted in various soil hazards ultimately leading to lower productivity. Additionally, over emphasis on conventional farming has resulted in deterioration of soil and plant health. Restoring soil health by reverting to non-chemical agriculture has assumed great importance to attain sustainability in production. In this search for eco-friendly alternate systems of farming, organic and natural farming are increasingly becoming popular among the farming community with limited use of cow dung and cow urine (Patil *et al.,* 2022) [6].

Adopting integrated nutrient management practices (organic manures, liquid manures with fertilizers) and certified organic agriculture (organic manures and biofertilizers) can reduce reliance on chemical inputs as well as make agriculture environmentally and economically sound. Organic farming is a production system that largely excludes or avoids the use of chemical fertilizers, pesticides, growth regulators, preservatives, livestock feed additives and totally rely on crop residues, animal manures, legumes, green manures, off-farm wastes, mechanical cultivation, mineral nutrient bearing rocks and biological pest control to maintain soil health, supply plant nutrients and minimize insects, weeds and other pests. Organic farming systems rely on the management of soil organic matter to enhance the chemical, biological and physical properties of the soil. Soil fertility management in organic systems depends on biologically-derived nutrient instead of using readily soluble forms of nutrients; less available forms of nutrients such as those in bulky organic materials. This requires the release of nutrients to the plant via the activity of soil microbes and soil animals. Apart from organic farming, another farming system called natural farming also involves similar components, which mainly depend on the use of naturally available inputs (Smith *et al.*, 2020) [9].

Integrated Crop Management (ICM) practices encompass a holistic approach to sustainable agriculture, combining traditional knowledge with modern technology to optimize resource use and improve crop yields. ICM involves a range of strategies such as crop rotation, intercropping, soil fertility management, and the use of organic and inorganic inputs judiciously. It emphasizes the importance of maintaining soil health through organic amendments and minimal tillage, conserving water through efficient irrigation systems, and enhancing biodiversity to naturally control pests and diseases. By integrating these diverse practices, ICM aims to increase productivity, reduce environmental impact, and support smallholder farmers by lowering input costs and promoting long-term agricultural sustainability.

Materials And Methods

The field experiment was conducted during *kharif* 2022 and 2023 at the Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The experiment was laid out in Randomized Block Design with four replications. The treatments comprised of five crop management practices. Soybean was taken as base crop and maize was taken as an intercrop in all the treatments with 4:2 row arrangement. The Soybean variety JS-9752 and maize variety RMH 4212 were taken in the experiment. The spacing used for soybean and maize was 30 cm x 7 cm and 60 cm x 20 cm, respectively. The sowing date of soybean was 5th July and 1st July and harvesting date was 21st October and 20th October during *kharif* 2022 and 2023, respectively. Whereas, the sowing date of maize was 5th July and 1st July and harvesting date was 3rd October and 29th September during *kharif* 2022 and 2023, respectively. Prior to sowing, seeds were treated with Beejamrit @ 2.5 litres for 10 kg seed in treatment 2 and with *Trichoderma* and *Pseudomonas* @ 5 g per kg seed in treatment 3, 4 and 5. The treatment details are presented in Table 1.

Table 1: Treatment details

Notation	Treatment
T_1	Control (No addition of any inputs except labour for operations including weeding)
T_2	Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa)
T_3	AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS)
T_4	50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management)
T_5	50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management)

Nutrient management was done as per the treatment. In case of AI-NPOF treatment 75% of recommended dose of nutrient was applied through organic sources *i.e.* 1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Non-Edible Oil Cakes and two foliar spray of cow urine and vermiwash @ 10% at 30 and 50 DAS while in the treatments of integrated crop management 50% recommended dose of nutrients were applied through organic sources and rest of the 50% through inorganic sources.

RDN for soybean + maize - 25:60:30 kg ha^{-1} $N:P_2O_5:K_2O$ ha^{-1}

Formula of Soybean equivalent yield (SEY) :

$$\text{SEY (q ha}^{-1}) = \frac{\text{Yield of } \textit{maize} \text{ (kg ha}^{-1}) \text{ x price of } \textit{maize} \text{ (Rs kg}^{-1})}{\text{Price of soybean (Rs kg}^{-1})}$$

Result and Discussion

SOYBEAN

Number of pods plant^{-1}

Data pertaining to number of pods plant^{-1} revealed that natural farming, organic farming and integrated crop management practices significantly influenced the number of pods plant^{-1} (Table 2). Integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and use of chemical pesticides for pest management proved to be the best and significantly enhanced the number of pods plant^{-1} (119.5, 117.3 and 118.4) which was comparable with 50% RDN through organic sources + 50% RDN through inorganic sources and pest management with natural/organic pesticides and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS) during both the years and on mean basis, respectively. On the contrary minimum number of pods plant^{-1} was observed in control treatment (79.0, 74.4 and 76.7).

Number of seeds pod^{-1}: Data indicated that number of seeds pod^{-1} influenced significantly due to natural farming, organic farming and integrated crop management practices (Table 2).

Out of the five treatments, integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management) produced the higher number of seeds pod^{-1} (2.78, 2.69 and 2.73) during both the years and on mean basis, respectively and this was statistically at par with rest of the treatments *viz.* 50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management), AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS) and Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa) except control.

Seed index (g)

Data on seed index (g) are presented in Table 2. Seed index was significantly influenced due to natural farming, organic farming and integrated crop management practices.

Integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management) recorded the highest seed index (11.4, 11.0 and 11.2) during both the years and on mean basis, respectively, which was statistically at par with the remaining treatments except control which produced the lowest seed index (9.0, 8.8 and 8.9, respectively).

Seed yield (kg ha^{-1})

Data related to seed yield of soybean are presented in Table 3. Seed yield significantly varied due to natural farming, organic farming and integrated crop management practices.

Among the different treatments, integrated nutrient management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and chemical pesticides for pest management produced significantly higher seed yield (709, 688 and 698 kg ha^{-1}) and was statistically at par with 50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management) which produced seed yield (673, 645 and 659 kg ha^{-1}) during both the years and on mean basis, respectively. However, treatment AI-NPOF package *i.e.* 75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS (618, 630 and 624 kg ha^{-1}) showed comparable seed yield over above mentioned treatments only during second year of experiment and on mean basis. On the other hand, the lowest seed yield was observed in control treatment followed by natural farming treatment.

Stover yield (kg ha^{-1})

The data on stover yield of soybean as influenced by natural farming, organic farming and integrated crop management practices are presented in Table 3. The findings revealed that different treatments had significant effect on stover yield of soybean. Significantly the highest stover yield of soybean (1501, 1467 and 1484 kg ha^{-1}) was noted under integrated crop management with 50% RDN through organic sources + 50% RDN through inorganic sources and pest management with chemical pesticides during both the years and on mean basis, respectively which was at par to 50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management) and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS). On the contrary, the lowest stover yield was observed in control treatment (1120, 1064 and 1092 kg ha^{-1}).

Harvest index (%)

Data regarding harvest index are presented in Table 3. Variation in harvest index due to natural farming, organic farming and integrated crop management practices was found non-significant during both the years as well as on mean basis.

Maize

Number of cobs plant^{-1}

Data on number of cobs plant^{-1} were observed at the time of harvesting and presented in Table 4. This parameter was significantly influenced by natural farming, organic farming and integrated crop management practices.

The highest number of cobs plant^{-1} (1.11, 1.02 and 1.06 during 2022, 2023 and on mean basis, respectively) was observed with integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and chemical pesticides for pest management which was statistically at par with integrated crop management alongwith natural biopesticide application *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS) during both the years and on mean basis, respectively. On the contrary the lowest number of cobs plant^{-1} were recorded in control treatment followed by complete natural farming practices.

Cob length (cm)

Cob length was significantly influenced due to natural farming, organic farming and integrated crop management practices during both the years as well as on mean basis (Table 4).

Among the different treatments, the maximum cob length (19.9, 19.3 and 19.6 cm during 2022, 2023 and on mean basis respectively) was observed under integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and use of chemical pesticides for pest management and was comparable with 50% RDN through organic sources + 50% RDN through inorganic sources and organic/natural pesticides for pest management during during both the years and on mean basis and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS) during second year of investigation. However, the lowest cob length was observed in control treatment.

Cob girth (cm): Cob girth was significantly influenced due to natural farming, organic farming and integrated crop management practices during both the years as well as on mean basis (Table 4). The maximum cob diameter (12.9, 12.0 and 12.5 cm during 2022, 2023 and on mean basis, respectively) was observed from integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and use of chemical pesticides for pest management. However, in 2022 and on mean basis all the treatments were comparable with each other except control. During 2023, it was at par to integrated crop management with 50% RDN through organic sources + 50% RDN through inorganic sources and pest management with organic/natural pesticides and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS). Cob girth was lowest in control treatment.

Number of rows cob^{-1}

Data regarding number of rows cob^{-1} are presented in Table 5. It is revealed from the data that number of rows cob^{-1} (14.1, 13.9 and 14.0) were significantly highest in integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and chemical pesticides for pest management during 2022, 2023 and on mean basis, respectively which was comparable with rest of the treatments except control during 2022. During 2023 and on mean basis, integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and organic/natural pesticides for pest management and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS) were at par with integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and chemical pesticides for pest management. Number of rows cob^{-1} was lowest in control treatment.

Number of grains row^{-1}

The data on number of grains row^{-1} are presented in Table 5 revealed that natural farming, organic farming and integrated crop management practices showed significant variation towards number of grains row^{-1}. Among the different treatments, integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and chemical pesticides for pest management produced the maximum number of grains row^{-1} (30.8, 30.6 and 30.7) during both the years and on mean basis, respectively and was at par to rest of the treatments except control during 2022 and on mean basis. Whereas, during 2023 it remained at par to integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and organic/natural pesticides for pest management and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS). Number of grains row^{-1} was lowest in control treatment.

Number of grains cob^{-1}

The data observed on number of grains cob^{-1} are presented in Table 5. It was observed that different treatments significantly influenced number of grains cob^{-1}. Significantly higher number of grains cob^{-1} (435.0, 425.3 and 430.2 during 2022, 2023 and on mean basis, respectively) were obtained under integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and chemical pesticides for pest management which was statistically at par with 50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management) and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS).

Green cob yield (kg ha^{-1})

Data related to green cob yield of maize are presented in Table 6. During both the years and on mean basis the green cob yield of maize was significantly influenced by natural farming, organic farming and integrated crop management practices**.**

Among the different treatments, highest green cob yield of maize (3836, 3719 and 3777 kg ha^{-1}) was recorded under integrated crop management practices *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management) during both the years and on mean basis, respectively which was statistically at par with 50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management) and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS).

Green fodder yield (kg ha^{-1})

The data regarding green fodder yield of maize are presented in Table 6. Significantly the highest green fodder yield (15630, 15413 and 15522 kg ha^{-1}) was recorded under integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and chemical pesticides for pest management during both the years and on mean basis, respectively which was statistically at par with 50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management) and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS) during both the years and on mean basis.

Soybean Equivalent Yield

The soybean equivalent yield was significantly influenced by different treatments (Table 7).

Among the different treatments, AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS) produced significantly higher soybean equivalent yield of maize (995, 1049 and 1022 kg ha^{-1}) during 2022, 2023 and on mean basis respectively which was statistically at par to integrated crop management with plant protection through chemical means *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources (892 kg ha^{-1}) during 2022. However, the lowest soybean equivalent yield of maize was produced under control treatment (444, 402 and 423 kg ha^{-1}) during 2022, 2023 and on mean basis respectively.

Table 2: Effect of natural farming, organic farming and integrated crop management practices on yield attributes of soybean under soybean + maize intercropping system

Treatment		Number of pods plant^{-1}			Number of seeds pod^{-1}			Seed index (g)		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1	Control (No addition of any inputs except labour for operations including weeding)	79.0	74.4	76.7	2.18	2.12	2.15	9.0	8.8	8.9
T_2	Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa)	92.9	83.3	88.1	2.43	2.36	2.40	9.9	9.4	9.7
T_3	AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS)	110.9	112.1	111.5	2.65	2.57	2.61	10.8	10.5	10.7
T_4	50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management)	115.7	114.7	115.2	2.77	2.64	2.70	11.1	10.8	10.9
T_5	50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management)	119.5	117.3	118.4	2.78	2.69	2.73	11.4	11.0	11.2
SEm±		5.15	5.04	5.09	0.13	0.12	0.12	0.52	0.50	0.51
CD (P=0.05)		15.88	15.52	15.68	0.39	0.38	0.37	1.60	1.55	1.57
CV		7.95	9.92	8.92	9.96	8.74	9.50	9.93	8.96	9.31

Table 3: Effect of natural farming, organic farming and integrated crop management practices on yield and harvest index of soybean under soybean + maize intercropping system

Treatment		Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest index (%)		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1	Control (No addition of any inputs except labour for operations including weeding)	534	501	517	1120	1064	1092	32.30	32.00	32.15
T_2	Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa)	581	563	572	1216	1180	1198	32.30	32.30	32.30
T_3	AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS)	618	630	624	1370	1384	1377	31.10	31.30	31.20
T_4	50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management)	673	645	659	1423	1398	1411	32.10	31.60	31.85
T_5	50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management)	709	688	698	1501	1467	1484	32.10	32.00	32.05
SEm±		29.04	30.11	29.56	65.98	64.74	65.36	1.60	1.59	1.59
CD (P=0.05)		89.49	92.77	91.08	203.31	199.47	201.39	NS	NS	NS
CV		9.33	7.91	8.61	8.95	9.93	8.90	7.25	8.46	8.62

Table 4: Effect of natural farming, organic farming and integrated crop management practices on number of cobs plant^{-1}, cob length (cm) and cob girth (cm) of maize under soybean + maize intercropping system

Treatment		Number of cobs plant^{-1}			Cob length (cm)			Cob girth (cm)		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1	Control (No addition of any inputs except labour for operations including weeding)	0.71	0.53	0.62	14.4	11.9	13.14	10.7	9.0	9.8
T_2	Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa)	0.91	0.79	0.85	15.5	13.3	14.42	11.2	10.3	10.8
T_3	AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS)	1.04	0.93	0.99	15.9	17.2	17.56	12.3	11.5	11.9
T_4	50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management)	1.08	0.98	1.03	19.4	18.6	18.99	12.6	11.7	12.2
T_5	50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management)	1.11	1.02	1.06	19.9	19.3	19.60	12.9	12.0	12.5
SEm±		0.05	0.04	0.04	0.86	0.81	0.83	0.56	0.54	0.55
CD (P=0.05)		0.14	0.13	0.14	2.64	2.50	2.57	1.74	1.68	1.71
CV		9.51	10.07	9.76	9.91	7.88	8.90	10.44	9.98	9.69

Table 5: Effect of natural farming, organic farming and integrated crop management practices on number of rows cob^{-1}, number of grains row^{-1} and number of grains cob^{-1} of maize under soybean + maize intercropping system

Treatment		Number of rows cob^{-1}			Number of grains row^{-1}			Number of grains cob^{-1}		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1	Control (No addition of any inputs except labour for operations including weeding)	11.2	9.9	10.5	23.3	19.6	21.5	260.3	194.0	227.2
T_2	Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa)	12.7	11.4	12.0	26.9	24.4	25.7	342.5	278.2	310.4
T_3	AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS)	13.5	13.2	13.3	30.3	31.9	31.1	408.8	421.1	415.3
T_4	50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management)	13.8	13.7	13.7	30.5	29.9	30.2	422.2	409.6	415.9
T_5	50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management)	14.1	13.9	14.0	30.8	30.6	30.7	435.0	425.3	430.2
SEm±		0.63	0.61	0.62	1.41	1.37	1.39	18.66	17.42	18.05
CD (P=0.05)		1.94	1.89	1.92	4.35	4.22	4.28	57.49	53.66	55.61
CV		9.63	7.92	8.77	6.96	8.91	8.93	8.18	7.87	8.16

Table 6: Effect of natural farming, organic farming and integrated crop management practices on green cob yield and green fodder yield of maize under soybean + maize intercropping system

Treatment		Green cob yield (kg ha^{-1})			Green fodder yield (kg ha^{-1})		
		2022	2023	Mean	2022	2023	Mean
T_1	Control (No addition of any inputs except labour for operations including weeding)	1527	1345	1436	5573	5245	5409
T_2	Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa)	2655	2420	2537	11230	10793	11012
T_3	AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS)	3423	3511	3467	14719	14956	14837
T_4	50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management)	3696	3568	3632	15250	15121	15185
T_5	50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management)	3836	3719	3777	15630	15413	15522
SEm±		151.58	147.8	149.7	627.91	623.07	625.46
CD (P=0.05)		467.07	455.3	461.1	1934.8	1919.9	1927.2
CV		10.01	9.22	10.11	10.06	10.11	10.07

Table 7: Effect of natural farming, organic farming and integrated crop management practices on soybean equivalent yield

Treatment		Soybean Equivalent yield of maize		
		2022	2023	Mean
T_1	Control (No addition of any inputs except labour for operations including weeding)	444	402	423
T_2	Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa)	772	723	748
T_3	AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS)	995	1049	1022
T_4	50% RDN through organic sources + 50% RDN through inorganic sources (organic/natural pesticides for pest management)	859	853	856
T_5	50% RDN through organic sources + 50% RDN through inorganic sources (chemical pesticides for pest management)	892	889	890
SEm±		39.98	40.08	40.02
CD (P=0.05)		123.20	123.50	123.32
CV		9.13	10.16	8.14

* Price of soybean in 2022 = Rs. 43 kg^{-1}
Price of soybean in 2023 = Rs. 46 kg^{-1}
Price of maize green cob in 2022 = Rs. 10 kg^{-1}
Price of maize green cob in 2023 = Rs. 11 kg^{-1}
**Prevailing market price of produce from control (T_1), natural farming (T_2) and organic farming (T_3) treatment has been 25% higher than the ICM treatments (T_4 and T_5) due to premium price of organic produce.

Discussion

The findings on yield attributes and productivity of soybean + maize intercropping system as influenced by natural farming, organic farming and integrated crop management practices revealed that integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and use of chemical pesticides for pest management, integrated crop management alongwith natural biopesticide application *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS) recorded higher yield attributes and productivity as compared to rest of the treatments. Maximum yield found in integrated nutrient management may be due to the fact that inorganic fertilizers releases nutrients for the plants instantly and in readily available forms for the plants during its growth, development and reproductive phases where the nutrient demand is at its peak. Increased yield in INM due to immediate availability of nutrients through inorganic fertilizers along with organic manures ascribed to conductive physical environment that lead to higher nutrient absorption from the native as well as applied sources. This favoured highest nutrient uptake and ultimately resulted in higher yield.

Organic manures improved soil physical, chemical and biological properties and had synergistic relationship with nitrogen and phosphorus thereby mineralizarion of applied nitrogen and phosphorus helped in increasing growth and mean while yield. Organic manures supplied nurients to plant root in balanced amount and stimulate growth, increased organic matter content in soil including the humic substance that affected the nutrient accumulation and promoted root growth which led to better growth and ultimately yield attributes and yield of crop.

Combined application of organic manures and chemical fertilizers played vital role in decomposition and easy release of nutrients and their uptkake by crop which leads to higher dry matter accumulation and its transport in different parts of plant which in turn resulted in higher grain yield. These results are in close agreement with the findings of Prajapat (2015) [7], Awasthi *et al.* (2020) [2], Khaswan *et al.* (2012) [4], Samruthi *et al.* (2019) [8] and Togas *et al.* (2017) [13].

Higher number of seeds pod^{-1} and seed index (g) in soybean and number of rows cob^{-1} and number of grains row^{-1} in maize was also noted under Complete Natural Farming (1. Beejamrit + Ghanjeevamrit + Jeevamrit; 2. Crop residue mulching; 3. Intercropping and 4. Whapasa). This might be due to application of jeevamrit which hastened the decomposition process and increased the availability of mineralized nutrients to the plant which resulted in increased yield attributes. Similar findings have been reported by Pati and Umdale (2016) [5].

Higher soybean equivalent yield was noted under AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS). The higher yield and prevailing market price of produce from organic farming has been 25% higher than the ICM treatments due to premium price of organic produce.

Conclusion

The findings clearly visualized that integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and pest management with chemical pesticides showed the maximum yield attributes and productivity of soybean + maize intercropping system which was followed by integrated crop management *i.e.* 50% RDN through organic sources + 50% RDN through inorganic sources and pest management with organic/natural pesticides and AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS). Highest soybean equivalent yield was recorded under AI-NPOF package (75% RDN through organic sources + two foliar spray of 10% cow urine and vermiwash at 30 and 50 DAS).

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