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EFFECT OF NATURAL FARMING, ORGANIC FARMING, INTEGRATED CROP MANAGEMENT AND CONVENTIONAL MANAGEMENT PRACTICES ON YIELD AND NUTRIENT BALANCE SHEET IN WHEAT + MUSTARD INTERCROPPING SYSTEM

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ABSTRACT

The present investigation entitled "Effect of Natural Farming, Organic Farming, Integrated Crop Management and Conventional Management Practices on Nutrient Balance of Wheat + Mustard Intercropping System" was conducted under All India Network Programme on Organic Farming (AI-NPOF) during *rabi* season of 2022-23 and 2023-24 at Instructional Research farm, Krishi Nagar Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur (M.P). The soil of experiment was sandy clay loam, neutral in reaction (pH 6.7), low in organic carbon (0.62 %), medium in available nitrogen (281.43 kg ha^{-1}), medium in available phosphorus (20.35 kg ha^{-1}) and medium in available potassium (272.12 kg ha^{-1}). The experiment was carried out in a Randomized block design with six treatments and four replications. The treatment comprises of T1- Control (No addition of any input except labour for operations including weeding), T2- Complete Natural Farming Practices (1. Beejamrit + Ghanjeevamrit + Jeevamrit 2. Crop residue mulching 3. Intercropping 4. Whapasa), T3- Organic Management Practices (AI-NPOF package) (75 % RDN through organic sources + two foliar spray of 10 % cow urine and vermiwash at 30 and 50 DAS), T4-ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural/organic pesticides for pest management), T5-ICM (50 % nutrient through organic and 50 % nutrient through inorganic + need based pesticides) and T6-Conventional management Practices (RDN 120:60:40 Kg ha^{-1} N: P_2O_5: K_2O ha^{-1}). The result of the experiment revealed that net gain (+) or loss (-) of NPK nutrient was recorded under Organic Management Practices N values (19.22 and18.42), P (0.8 and 0.84) and K (47.03 and 45.96) during both the year respectively. Whereas, the lowest values of that net gain (+) or loss (-) of NPK nutrient was recorded under Control (Excluding all inputs except labour for weeding treatment.

Keywords **:** Complete natural farming, organic farming, integrated crop management, conventional management practices.

Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop for the majority of the world's population. It renders valuable contribution in the nutritional security and financial well-being of larger part of global population. It contains 8.0-15.0 % protein, 60-68 % starch, 1.5-2.0 % fat, 2.0-2.5 % cellulose and 1.5-2.0 % minerals and vitamins (B complex and vitamin E) which is used as feed for both humans and animals Sharma (2000) and Rueda-Ayala *et al*. (2011). Globally the total area, production and productivity of wheat are 223.40 m ha, 778.6 mt and 3546 kg ha^{-1} respectively (USDA, 2021), positioning it as the second most extensively produced cereal crop, following maize. Globally, wheat is the most significant staple food grains, fulfilling nearly half of the caloric requirements of the population Ramdas *et al*. (2019). In India, the total area under wheat cultivation is 31.62 million hectares, with a production

of 109.2 million tonnes and an average productivity of 3420 kg per hectare (USDA, 2021). As one of India's principal cereal crops, wheat, a high-energy winter cereal, contributes approximately 35% to the nation's grain supply. In Madhya Pradesh, wheat is cultivated over an area of 10.2 million hectares, yielding 16.52 million tons with a productivity of 3298 kg per hectare (Department of Agriculture, M.P., 2021).

Mustard (*Brassica juncea* L.) is the second most extensively cultivated oilseed crop in India, following groundnut. It is primarily grown for its edible oil, widely used for cooking and frying. India ranks as the third-largest mustard producer globally, with cultivation in 8.06 million hectares, yielding 11.75 million tonnes, with an average productivity of 1458 kg per hectare (Agricultural Statistics at a Glance, 2022). Mustard is grown as a winter crop in the tropical and subtropical regions of India. Indian mustard, a prominent brassica species, is cultivated nationwide under diverse climatic and agro-ecological conditions. In Madhya Pradesh, mustard is grown on 1.23 million hectares, producing 1.69 million tonnes, with a productivity of 1376 kg per hectare (Agricultural Statistics at a Glance, 2022).

For farmers with limited access to nutrient supplies, incorporating legumes and oilseed into cereal-based cropping system has long been recommended as a way to improve soil fertility and agroecological resilience Snapp *et al*. (1998); Thierfelder *et al*. (2012). Cereal-legume based intercropping system is known to increase yield stability and is efficient at resource conservation and maintaining soil fertility.

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. Natural farming means that farmers do not need to purchase fertilizers and pesticides to ensure the growth of crops Bishnoi *et al*. (2017). 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. The natural inputs used in organic farming and natural farming are easily available, releases nutrients slowly, supplies macro and micro nutrients and provides favorable 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).

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.

Nutrient balance in crop production is crucial for achieving optimal growth and yield. Imbalances in essential nutrients can lead to reduced crop productivity, increased susceptibility to diseases and pests, and compromised nutritional quality. Traditional approaches to nutrient management have often focused on the application of fertilizers to provide plants with the necessary elements for growth. However, these practices have sometimes led to nutrient imbalances in the soil, affecting not only crop performance but also environmental sustainability. To address these challenges, contemporary agricultural research has explored innovative approaches aimed at optimizing fertilizer use while preserving nutrient balance. This research investigates the synergistic effects of these two interventions on nutrient uptake, utilization, and distribution within the wheat and mustard plants. The ultimate goal of this study is to contribute to sustainable and efficient production practices that not only increase crop yields but also promote nutrient-balanced crops, aligning with the broader objectives of global food security and nutrition.

Material and Methods

The field experiment was conducted under All India Network Programme on Organic Farming (AI-

NPOF) during *rabi* seasons of 2022-23 and 2023-24 at Instructional Research farm, Krishi Nagar Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur (M.P). The experiment was laid out in a Randomized block design with four replications. The treatment comprises of six crop management practices during the rabi season of 2022-23 and 2023-24. Wheat was taken as base crop and mustard was taken as an intercrop in all the treatment with 8:2 row arrangement. Wheat variety JW-3382 and mustard variety Pusa Agrani were taken in the experiment. The spacing used for wheat and mustard was 22.5 cm row to row. The sowing date of wheat and mustard was 18th November and 10th November and harvesting date 22nd March and 13th March during *rabi* 2022 and 2023, respectively. Prior to sowing, seeds were treated with Beejamrit @ 2.5 litres for 10kg 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 detail

T1	Control (No addition of any input except labour for operations including weeding)
T2	Complete Natural Farming Practices (1. Beejamrit + Ghanjeevamrit + Jeevamrit 2. Crop residue mulching 3. Intercropping 4. Whapasa) [Pre- monsoon dry sowing (PDMS) / Multi- variate cropping (MVC) with multiple crops during fallow + Prophylactic/preventive method of application of Neemaster, Dashparni ark, Brahmaster, Neem seed kernel extract, border crop, trap crop, seed treatment wuth Trichoderma, pseudomonas and Curative application of leaf extracts of Datura,vitex, Agniaster, sour butter milk, 2G/ 3G extract and use of biocontrol agents and mechanical traps)
T3	Organic Management Practices (AI-NPOF package) (75 % RDN through organic sources + two foliar spray of 10 % cow urine and vermiwash at 30 and 50 DAS)
T4	*ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural/organic pesticides for pest management)
T5	*ICM (50 % nutrient through organic and 50 % nutrient through inorganic + need based pesticides)
T6	Conventional management Practices (**RDN 120:60:40 Kg ha^{-1} N: P_2O_5: K_2O)

*ICM-Integrated crop management; **RDN - Recommended Dose of Nutrient

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.e1/3rdFYM + 1/3rd Vermicompost + 1/3rd Non-Edible oil cake and two foliar spray of cow urine and Vermiwash @ 10 % at 30 and 50 DAS while in the treatment of integrated crop management, 50 % nutrient through organic and 50 % nutrient applied through inorganic sources and in Conventional management Practices, 100 % nutrient applied through chemical fertilizers through urea, single super phosphate (SSP) and muriate of potash (MOP) at the rate of 120:60:40 kg NPK ha^{-1} in both the years. Full quantity of P_2O_5 and K_2O were given as basal dose at the time of sowing and nitrogen was applied in three split doses.

Recommended dose of nutrient for Wheat + Mustard- 120:60:40 Kg ha^{-1} N: P_2O_5: K_2O

The crop was grown under irrigated conditions, receiving a total of six irrigations at critical growth stages. Weeds control was managed through two-hand weeding in all treatment plots. Gap filling was performed ten days after sowing to maintain the required plant population. The regular biometric observations were recorded at periodic intervals of 30, 60, 90 days after sowing (DAS) and at the harvest stage. The observations were recorded on soil analysis was done before sowing and after harvesting.

Soil Analysis

The soil samples were collected with the help of Khurpi (Spud) from each plot of the above-mentioned treatments representing the plough layer (0-15 cm) after harvest of crop. composite representative soil samples were obtained from these samples for each treatment. Each composite sample consisted of a mixture of three sub samples from different site of each plot to secure representative sample of the plot selected for sampling. The mass of each collected sample was reduced to about 500 g by adopting the technique of quartering. These soil samples were air-dried, crushed by wooden pestle and mortar and were passed through 2 mm stainless steel sieve and stored in polythene bags at room temperature for analysis. Soil pH was determined in a 1:2.5 soil water suspension by glass electrode pH meter of Jackson. Electrical conductivity of soil suspension used for pH determinations were allowed to settle down and conductivity of supernatant liquid was determined by using conductivity meter. The results are expressed in dS/m at 25°C. Organic Carbon by Walkley and Black method Walkley and Black (1934). Available nitrogen (N) in soil was determined by adapting the alkaline permanganate method of Subbiah and Asija(1956). Available

phosphorus content of soil was estimated by extraction procedure as described by Olsen et. al. The absorbance of blue color was read after 10 minutes, on spectrophotometer at 660 nm wavelength. Available Potassium (K) in soil was extracted with neutral normal ammonium acetate with flame photometer.

Plant Analysis

The sample of seed and stover/straw from each treatment after the sun drying were dried in oven at 60 ^{0}C till constant weight was obtained and then grinded separately in a Willey grinding Mill and were analyzed for estimation of N, P and K content at harvest.

Table 2 : Methodology adopted for plant analysis.

parameters	Methodology	Reference
Nitrogen	Kjeldhal method	Piper (1966).
Phosphorus	Vanadomolybdate Phosphoric yellow color method	Piper (1966).
Potassium	flame photometer	Piper (1966).

$$\text{Uptake of NPK by grain} = \frac{\%\text{ of NPK concentration in grain x grain yield (kg/ha)}}{100}$$

$$\text{Uptake of NPK by Straw/Stover} = \frac{\%\text{ of NPK concentration in straw/stover X straw/stover yield (kg/ha)}}{100}$$

Total uptake:

Total uptake of N, P and K was calculated for each treatment separately by using the following formula.

Total nitrogen uptake (kg ha^{-1}) = N uptake by grain + N uptake by straw/stover (Wheat+ mustard)

Uptake of N, P and K by wheat and mustard crop was expressed in kg ha^{-1}

Nutrient Balanced Sheet

Based on apparent gain or loss of nutrient, an attempt was made to establish fate of nutrient available in soil, added through different sources and crop removals in one season. The nutrient balance sheet was worked out as follows:

Expected nutrient balance (D) = (A+B) – C

Where,

A = Initial nutrient status of soil

B = Nutrient added as per treatment (Through fertilizer)

C = Nutrient taking by crop

Apparent gain /loss (F) = E -D

Where,

E = Actual nutrient balance, The available nutrient status of soil after harvest of the crop

Actual gain / loss (G) = E – A

Results and Discussion

Grain yield of wheat (kg ha^{-1})

Grain yield significantly varied due to natural farming, organic farming, integrated crop management and conventional farming practices. Among the different treatments, Conventional management practices (RDN @120:60:40 Kg ha^{-1} of N: P_2O_5: K_2O) produced significantly higher grain yield and was statistically at par with integrated crop management (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides) which produced grain yield during both the years and on pooled basis. However, the lowest grain yield was observed in control treatment followed by natural farming and organic farming practices.

Straw yield of wheat (kg ha^{-1})

The finding revealed that different treatments had significant effect on straw yield of wheat. Significantly the highest straw yield was noted under Conventional management practices during both the years and on pooled basis was at par with integrated crop management with 50 % nutrient through organic + 50 % nutrient through inorganic sources + need based pesticides. On the contrary, the lowest straw yield was observed in control treatment followed by natural farming, organic management practices and Integrated crop management ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides).

Seed yield of mustard (kg ha^{-1})

The maximum seed yield of mustard obtained under conventional management practices during both the year and on the basis of pooled data. It was significantly superior over rest of the treatments, except ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides). Treatment control produces lowest seed

yield during both the year and on the basis of pooled data.

Stover yield of mustard (kg ha^{-1})

The highest stover yield was recorded under conventional farming practices (RDN 120:60:40 Kg ha^{-1} of N: P_2O_5: K_2O) during both the years and on a pooled basis which was statistically at par with 50 % RDN through organic + 50 % RDN through inorganic sources along with need- based pesticides. However, the lowest stover yield was recorded in control treatment during both the years and on pooled basis.

Soil Analysis

Available N, P and K

Data revealed that the availability of N, P and K in soil after harvest of wheat + mustard intercropping system (*Rabi* season 2022-23 and 2023-24) was significantly influenced by the various treatments during both the years and on a pooled analysis.

Organic management practices showed the highest value of available N, available P and available K during both the years and on a pooled basis, respectively, which was comparable with rest of the treatments except control. The lowest value of available N, P and K is found under control.

Plant Studies

N, P and K content in wheat grain (%)

Nitrogen, phosphorus and potassium content in wheat grain varied non-significantly due to natural farming, organic farming, integrated management practices and conventional management practices during both the years and on pooled basis.

Table 3: Grain yield and straw yield of wheat as influenced by different management practices

S. No	Treatment	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
		2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T_1	Control (Excluding all inputs except labour for weeding)	1112	1246	1179	1903	2368	2135
T_2	Complete Natural Farming Practices	1364	1552	1458	2336	3265	2800
T_3	Organic Management Practices	2122	2253	2187	3632	3898	3765
T_4	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	2528	2620	2574	4328	4166	4247
T_5	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	3016	3083	3050	5213	4936	5074
T_6	Conventional Management Practices	3095	3143	3119	5413	5069	5241
	Sem+_	40	38	28	70	92	249
	CD (P=0.05)	122	116	81	211	277	907

Table 4: Seed yield and stover yield of mustard as influenced by different management practices

S. No.	Treatment	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
		2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T_1	Control (Excluding all inputs except labour for weeding)	270.00	284.00	277.00	685.60	743.50	714.55
T_2	Complete Natural Farming Practices	329.00	380.35	354.68	836.82	893.50	865.16
T_3	Organic Management Practices	548.00	396.29	472.14	1393.02	1072.50	1232.76
T_4	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	565.00	671.00	618.00	1435.49	1531.75	1483.62
T_5	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	1028.00	1010.00	1019.00	2621.34	2488.50	2554.92
T_6	Conventional Management Practices	1079.00	1110.00	1094.50	2893.90	2730.44	2812.17
	SEm+_	23.01	53.04	28.91	97.79	187.06	105.54
	CD (p=0.05)	69.35	159.88	83.49	294.78	563.86	304.82

Table 5: Effect of different management practices on available nitrogen, phosphorus and potassium in soil at harvest

S. No.	Treatment	Available N (Kg ha^{-1})			Available P (Kg ha^{-1})			Available K (Kg ha^{-1})		
		2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled
T_1	Control (Excluding all inputs except labour for weeding)	269.95	267.13	268.54	16.05	16.25	16.15	287.50	286.60	287.05
T_2	Complete Natural Farming Practices	297.75	296.23	296.99	19.33	19.63	19.48	305.40	303.83	304.61
T_3	Organic Management Practices	300.65	299.85	300.25	21.15	21.19	21.17	319.15	318.08	318.61
T_4	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	296.98	296.48	296.73	20.08	20.83	20.45	313.88	310.68	312.28
T_5	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	296.85	296.53	296.69	19.90	20.05	19.98	314.43	313.43	313.93
T_6	Conventional Management Practices	294.75	293.60	294.18	19.45	19.65	19.55	312.50	310.63	311.56
	SEm+_	0.54	1.05	0.59	0.24	0.41	0.24	0.55	1.25	0.68
	CD (P=0.05)	1.64	3.15	1.70	0.73	1.24	0.69	1.66	3.76	1.97

Initial Soil N, P and K 281.43, 20.35 and 272.12 kg ha^{-1}, respectively

A perusal of data revealed that higher nitrogen content (%) in wheat grain observed in control treatment (1.61 %) during the first year and under complete natural farming practices (1.610 and 1.607 %) during the second year and pooled basis.

As regards to phosphorus content, higher phosphorus content (%) was recorded under control treatment (0.427 %) during the first year whereas in second year it was found high (0.428 %) under integrated crop management (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides) but high phosphorus content noted under complete natural farming in pooled analysis.

The highest potassium content (0.53 %) in wheat grain recorded under Organic management practices during the first year but it was found maximum in control treatment during second year and pooled analysis the lowest nitrogen, phosphorus and potassium content in wheat grain recorded under conventional management practices during both the years and pooled basis.

N, P and K content in wheat straw (%)

N, P and K content (%) in wheat straw was not significantly influenced by all the treatment during both the years and on a pooled basis. The finding revealed that higher nitrogen content (%) in wheat straw was observed in control treatment (0.385 and 0.378 %) during the first year and pooled basis and in second year it was found high in complete natural farming (0.374 %). However, the lowest was observed in conventional management practices.

Higher phosphorus content (0.162 and 0.170 %) was recorded under complete natural farming practices during the first year and on a pooled basis, on the other hand, in second year higher phosphorus content (0.186 %) was recorded in Organic management practices. However, the lowest (0.151 %) was found in control treatment during the first year and under conventional management treatment (0.160 and 0.157 % during the second year and pooled basis.

The highest potassium content in wheat straw (1.095, 1.086 and 1.09 %) was recorded under control treatment during both the years and pooled basis. However, the lowest was recorded (1.076 %) under ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides) and (1.052 and 1.071 %) under Organic management practices during the second year and pooled basis.

Table 6: Effect of different management practices on N, P and K content in wheat grain

S. No.	Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
		2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled
T_1	Control (Excluding all inputs except labour for weeding)	1.610	1.600	1.605	0.427	0.416	0.421	0.529	0.535	0.532
T_2	Complete Natural Farming Practices	1.604	1.610	1.607	0.420	0.424	0.422	0.518	0.522	0.520
T_3	Organic Management Practices	1.606	1.603	1.604	0.414	0.420	0.417	0.530	0.520	0.525
T_4	ICM (50 % nutrient through organic and 50 % nutrient through inorganic	1.609	1.603	1.606	0.414	0.428	0.421	0.526	0.525	0.525

	sources + natural pesticides)									
T_5	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	1.589	1.610	1.600	0.414	0.408	0.411	0.519	0.522	0.521
T_6	Conventional Management Practices	1.586	1.595	1.591	0.405	0.408	0.406	0.509	0.520	0.515
	SEm+_	0.017	0.026	0.016	0.005	0.020	0.010	0.007	0.026	0.013
	CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 7: Effect of different management practices on N, P and K content in wheat straw

S. No.	Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
		2022-23	2023-24	Pooled	2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled
T_1	Control (Excluding all inputs except labour for weeding)	0.385	0.371	0.378	0.151	0.178	0.165	1.095	1.086	1.090
T_2	Complete Natural Farming Practices	0.372	0.374	0.373	0.162	0.178	0.170	1.092	1.074	1.083
T_3	Organic Management Practices	0.375	0.371	0.373	0.155	0.186	0.170	1.089	1.052	1.071
T_4	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	0.374	0.364	0.369	0.153	0.176	0.165	1.092	1.063	1.078
T_5	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	0.366	0.355	0.361	0.159	0.167	0.163	1.076	1.073	1.075
T_6	Conventional Management Practices	0.366	0.341	0.353	0.155	0.160	0.157	1.087	1.079	1.083
	SEm+_	0.008	0.022	0.011	0.014	0.014	0.010	0.004	0.044	0.022
	CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 7: Effect of different management practices on N, P and K content in wheat straw

S. No.	Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
		2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled
T_1	Control (Excluding all inputs except labour for weeding)	0.385	0.371	0.378	0.151	0.178	0.165	1.095	1.086	1.090
T_2	Complete Natural Farming Practices	0.372	0.374	0.373	0.162	0.178	0.170	1.092	1.074	1.083
T_3	Organic Management Practices	0.375	0.371	0.373	0.155	0.186	0.170	1.089	1.052	1.071
T_4	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	0.374	0.364	0.369	0.153	0.176	0.165	1.092	1.063	1.078
T_5	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	0.366	0.355	0.361	0.159	0.167	0.163	1.076	1.073	1.075
T_6	Conventional Management Practices	0.366	0.341	0.353	0.155	0.160	0.157	1.087	1.079	1.083
	SEm+_	0.008	0.022	0.011	0.014	0.014	0.010	0.004	0.044	0.022
	CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

N, P and K content in mustard seed (%)

Nitrogen, phosphorus and potassium content in mustard seed varied non-significantly due to natural farming, organic farming, integrated management practices and conventional management practices during both the years and on pooled basis.

Control treatment recorded the highest nitrogen content (2.160, 2.164 and 2.162 %) in mustard seed during both the years and on a pooled basis. However, the lowest (2.129, 2.130 and 2.130 %) was recorded under conventional management practices.

Higher phosphorus content was recorded under control treatment (0.489 and 0.486 %) during the first year and pooled basis whereas it was maximum under complete natural farming practices during the second year of experiment. However, the lowest (0.464, 0.461 and 0.463 %) was recorded under conventional management practices during both the years and pooled data, respectively.

The highest potassium content (0.595 and 0.590 %) in mustard seed was recorded under control treatment during first year and pooled basis, whereas the organic management practices showed highest (0.588%) during the second year. However, the lowest potassium content (0.574, 0.571 and 0.573 %) under integrated crop management (50 % nutrient through organic and 50 % nutrient through inorganic sources

need based pesticides) in mustard seed was recorded under during both the years and pooled basis, respectively.

N, P and K content in mustard stover (%)

N, P and K content (%) in mustard stover was non- significant influenced by the natural farming practices, organic farming practices, integrated crop management practices and conventional management practices during both the years and on a pooled basis.

The findings revealed that higher nitrogen (0.279, 0.274 and 0.272 %), phosphorus (0.207, 0.206 and 0206 %) and potassium content (0.829, 0.828 and 0.828 %) in mustard stover was observed under control treatment during both the year and on pooled basis respectively, except nitrogen content during first year showed under complete natural farming practices.

The lowest nitrogen content (0.252, 0.256 and 0.254 %) was observed in ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides), phosphorus content (0.181, 0.184 and 0.183 %) under conventional management practices during first year and under ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides) during second year and pooled basis and potassium content (0.800, 0.797 and 0.801 %) under conventional management practices during first year and pooled analysis and under ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides) during second year of experiment.

Nutrient Balance Sheet

Apparent gain (+) or loss (-)

The result revealed that apparent gain (+) of N nutrient was recorded under Complete natural farming Practices gave higher N positive value of apparent N (31.14 and 35.91) during first year and second year respectively. Whereas, application of ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides) gave more negative N apparent value (-44.62 and-42.67) respectively.

In case of phosphorus apparent gain (+) of P nutrient was recorded under Control (Excluding all inputs except labour for weeding) gave higher P positive value of apparent P (7.42 and 5.71) during first year and second year respectively. Whereas, application ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides) gave more negative P apparent value (-34.93 and -39.57) respectively.

Apparent gain (+) of k nutrient was recorded under Conventional management practices gave higher K positive value of apparent K (80.56 and 75.16) during first year and second year respectively. Whereas, Control (Excluding all inputs except labour for weeding) treatment gave negative K apparent value (-34.93 and -39.57) respectively during both the year.

Table 8: Effect of different management practices on N, P and K content in mustard seed

S. No.	Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
		2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled
T_1	Control (Excluding all inputs except labour for weeding)	2.160	2.164	2.162	0.489	0.483	0.486	0.595	0.584	0.590
T_2	Complete Natural Farming Practices	2.141	2.159	2.150	0.483	0.486	0.485	0.590	0.582	0.586
T_3	Organic Management Practices	2.138	2.149	2.143	0.481	0.476	0.479	0.588	0.588	0.588
T_4	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	2.139	2.131	2.135	0.472	0.479	0.476	0.576	0.583	0.580
T_5	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	2.139	2.139	2.139	0.464	0.470	0.467	0.574	0.571	0.573
T_6	Conventional Management Practices	2.129	2.130	2.130	0.464	0.461	0.463	0.577	0.571	0.574
	SEm ±	0.008	0.021	0.011	0.007	0.032	0.016	0.007	0.019	0.010
	CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 9: Effect of different management practices on N, P and K content in mustard stover

S. No.	Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
		2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled	2022- 23	2023-24	Pooled
T_1	Control (Excluding all inputs except labour for weeding)	0.269	0.274	0.272	0.207	0.206	0.206	0.829	0.828	0.828
T_2	Complete Natural Farming Practices	0.279	0.264	0.272	0.199	0.198	0.199	0.828	0.812	0.820

T_3	Organic Management Practices	0.272	0.269	0.271	0.196	0.196	0.196	0.818	0.815	0.816
T_4	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	0.264	0.267	0.266	0.189	0.190	0.190	0.814	0.809	0.812
T_5	ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	0.252	0.256	0.254	0.183	0.184	0.183	0.815	0.797	0.806
T_6	Conventional Management Practices	0.258	0.259	0.258	0.181	0.188	0.184	0.800	0.802	0.801
	SEm ±	0.028	0.029	0.020	0.026	0.025	0.018	0.028	0.028	0.020
	CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 10: Nutrient balance sheet for nitrogen as influence by different treatment during *rabi* 2022-23

Treatment	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil D = (A+B) - C	Actual soil fertility status (E)	Apparent gain (+) or loss (-) F= E -D	Net gain (+) or loss (-) G= E-A
Control (Excluding all inputs except labour for weeding)	281.43	0	27.11	254.32	269.95	15.63	-11.48
Complete Natural Farming Practices	281.43	18.05	32.87	266.61	297.75	31.14	16.32
Organic Management Practices	281.43	111.17	51.99	340.61	300.65	-39.96	19.22
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	281.43	120	59.83	341.6	296.98	-44.62	15.55
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	281.43	120	78.67	322.76	296.85	-25.91	15.42
Conventional Management Practices	281.43	120	81.76	319.67	294.75	-24.92	13.32

Table 11: Nutrient balance sheet for nitrogen as influence by different treatment during *rabi* 2023-24

Treatment	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil D = (A+B) - C	Actual soil fertility status (E)	Apparent gain (+) or loss (-) F= E-D	Net gain (+) or loss (-) G=E-A
Control (Excluding all inputs except labour for weeding)	281.43	0	30.28	251.15	267.13	15.98	-14.3
Complete Natural Farming Practices	281.43	18.05	39.16	260.32	296.23	35.91	14.8
Organic Management Practices	281.43	111.17	50.77	341.83	299.85	-41.98	18.42
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	281.43	120	62.28	339.15	296.48	-42.67	15.05
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	281.43	120	78.71	322.72	296.53	-26.19	15.1
Conventional Management Practices	281.43	120	81.15	320.28	293.6	-26.68	12.17

Table 12: Nutrient balance sheet for phosphorus as influence by different treatment during *rabi* 2022-23

Treatment	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil D = (A+B)- C	Actual soil fertility status (E)	Apparent gain (+) or loss (-) F= E-D	Net gain (+) or loss (-) G= E-A
Control (Excluding all inputs except labour for weeding)	20.35	0	11.72	8.63	16.05	7.42	-4.3
Complete Natural Farming Practices	20.35	7.15	14.01	13.49	19.33	5.84	-1.02
Organic Management Practices	20.35	27.68	21.96	26.07	21.15	-4.92	0.8
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	20.35	60	25.34	55.01	20.08	-34.93	-0.27
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	20.35	60	32.61	47.74	19.9	-27.84	-0.45
Conventional Management Practices	20.35	60	33.68	46.67	19.45	-27.22	-0.9

Table 13: Nutrient balance sheet for phosphorus as influence by different treatment during *rabi* 2023-24

Treatment	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil D = (A+B) - C	Actual soil fertility status (E)	Apparent gain (+) or loss (-) F= E-D	Net gain (+) or loss (-) G= E-A
Control (Excluding all inputs except labour for weeding)	20.35	0	9.81	10.54	16.25	5.71	-4.1
Complete Natural Farming Practices	20.35	7.15	12.84	14.66	19.63	4.97	-0.72
Organic Management Practices	20.35	27.68	16.67	31.36	21.19	-10.17	0.84
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	20.35	60	19.95	60.4	20.83	-39.57	0.48
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	20.35	60	24.37	55.98	20.05	-35.93	-0.3
Conventional Management Practices	20.35	60	25.35	55	19.65	-35.35	-0.7

Table 14: Nutrient balance sheet for potassium as influence by different treatment during *rabi* 2022-23

Treatment	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil D = (A+B)-C	Actual soil fertility status (E)	Apparent gain (+) or loss (-) F= E-D	Net gain (+) or loss (-) G= E-A
Control (Excluding all inputs except labour for weeding)	272.12	0	26.28	245.84	287.5	41.66	15.38
Complete Natural Farming Practices	272.12	14.52	31.92	254.72	305.4	50.68	33.28
Organic Management Practices	272.12	48.7	50.5	270.32	319.15	48.83	47.03
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	272.12	40	58.28	253.84	313.88	60.04	41.76
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	272.12	40	76.37	235.75	314.43	78.68	42.31
Conventional Management Practices	272.12	40	80.18	231.94	312.5	80.56	40.38

Table 15: Nutrient balance sheet for potassium as influence by different treatment during *rabi* 2023-24

Treatment	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil D = (A+B) - C	Actual soil fertility status (E)	Apparent gain (+) or loss (-) F= E-D	Net gain (+) or loss (-) G= E-A
Control (Excluding all inputs except labour for weeding)	272.12	0	31.01	241.11	286.6	45.49	14.48
Complete Natural Farming Practices	272.12	14.52	40.54	246.1	303.83	57.73	31.71
Organic Management Practices	272.12	48.7	49.28	271.54	318.08	46.54	45.96
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + natural pesticides)	272.12	40	57.51	254.61	310.68	56.07	38.56
ICM (50 % nutrient through organic and 50 % nutrient through inorganic sources + need based pesticides)	272.12	40	73.19	238.93	313.43	74.5	41.31
Conventional Management Practices	272.12	40	76.65	235.47	310.63	75.16	38.51

Net gain (+) or loss (-)

The data showed that net gain (+) or loss (-) of NPK nutrient was recorded as Organic Management Practices N values (19.22 and18.42), P (0.8 and 0.84) and K (47.03 and 45.96) during both the year respectively. Whereas, the lowest values of that net gain (+) or loss (-) of NPK nutrient was recorded under Control (Excluding all inputs except labour for weeding treatment).

Conclusion

The result of this study, concluded that nutrient content of both the crops wheat (grain and straw) and mustard (seed and straw) does not significantly influence by the different management practices. Whereas, apparent gain (+) or loss (-) of N nutrient was recorded as Complete natural farming Practices and P

nutrient was recorded as Control (Excluding all inputs except labour for weeding) Apparent gain (+) or loss (-) of K nutrient was recorded as Conventional management practices gave higher K positive value of apparent K.

Net gain (+) or loss (-) of NPK nutrient was recorded as Organic Management Practices during both the year. Whereas, the lowest values of that net gain (+) or loss (-) of NPK nutrient was recorded under Control (Excluding all inputs except labour for weeding treatment).

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