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RESPONSE OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD ATTRIBUTES AND ECONOMICS OF PEARL MILLET (*PENNISETUM GLAUCUM* L.) IN BUNDELKHAND REGION OF INDIA

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ABSTRACT

A field experiment was conducted during Kharif, 2023 at Agronomy crop research farm, Department of Agronomy, University of Agriculture and Technology, Banda (U.P.). The experimental site is situated between latitude 25°31'00" and 28°7'00" North and longitudes 80°20'00" and 41°9'00" East and having an altitude of 119 m above sea level. The experiment was carried out to evaluate the effect of integrated nutrient management on pearl millet in randomized block design with ten treatments (viz., T_1 -Control, T_2 - 100% RDF, T_3 - 75% RDF, T_4 -125% RDF, T_5 -75% RDF + 5t ha^{-1} FYM, T_6 -75% RDF + 2.5t ha^{-1} FYM, T_7 -75% RDF + 2.5t ha^{-1} Vermicompost, T_8 75% RDF + 1.25t ha^{-1} Vermicompost, T_9 -100% RDF + 2.5t ha^{-1} FYM, T_{10} - 100% RDF +1.25t ha^{-1} Vermicompost); replicated thrice. The soil in which research experiment conducted was silty clay. The results of the experiment on growth attributes showed that significantly and maximum number of tillers per plant (5.28), number of leaves per plant (21.03), plant height (230.12 cm), plant dry weight per plant (48.15 g), crop growth rate (45.30 g m^2 day^{-1}), leaf area index (1.44) were recorded at harvest stage under treatment (T_9) and highest chlorophyll concentration (45.58 µmol) was recorded under treatment (T_4) with application of 125% RDF. Maximum net assimilation rate (1.76) was recorded under control at harvest stage. Yield and yield attributes viz., earhead length (29.71cm), girth of earheads (6.90 cm), weight of grains per ear heads (11.38 gm), test weight (9.95 gm), economic yield (24.10q ha^{-1}), biological yield (88.28 q ha^{-1}), stover yield (64.18 q ha^{-1}), and harvest index (27.34 %), maximum gross return (73086 INR ha^{-1}), Net return (37715 INR ha^{-1}) and B:C ratio (2.07) were observed in treatment T_9 with combined application of 100% RDF along with 2.5t ha^{-1} FYM. Among Integrated nutrient management practices, treatment (T_9) application of 100% RDF+ 2.5t ha^{-1} FYM was found significantly beneficial for productivity and economics of pearl millet in Bundelkhand region.

***Keywords*:** INM, Growth, Yield, FYM, Vermicompost and Economics.

Introduction

Millets are a highly varied group of small-seeded grasses, widely grown around the world as cereal crops or grains for fodder and human food. Millets are classified as two groups–A. Major millets: Pearl millet & Sorghum B. Minor millets: Finger millet, Proso millet, Foxtail millet, Barnyard millet and Kodo millet. Pearl millet (*Pennisetum glaucum* L.) is multipurpose cereal crop belong to the Poaceae family. It is commonly called as Bajra, Bajri, Kambu etc. In India pearl millet is the fifth most important cereal crop after rice, wheat, maize, and sorghum (Choudhary *et al.* 2014). It is native to Africa and mostly grown semi - arid to arid zones where soils predominantly have sandy textures, low organic matter, and nutrient levels; rainfall is limited and erratic; air and soil temperature are high, and the growing season length is short. Pearl millet is cultivated as multipurpose crop it provides food, fodder, and fuel and nutritionally superior to many cereals because it is a rich source of protein (11.6%), carbohydrates (67.5%), fats (5%), fiber (1.2%), minerals (2.3%), and has higher digestibility (Bijarnia *et al*, 2020). Pearl millet is gluten free, and it is one of the alternatives for the patients who have celiac diseases to consume a gluten free diet for normal and healthy lifestyle. It effectively helps in the maintaining the blood sugar levels constant in diabetes patient for long period of time (Dayakar Rao *et al.* 2017).

India is the largest producer of pearl millet in the world occupying 6.70 million hectares with annual production of 9.62 million tons and average productivity of 1436 kg ha^{-1} (Source: E&S Division, DA&FW, 2021-22). In India Uttar Pradesh occupying 0.90 million hectares with annual production of 1.95 million tons and average productivity of 2156 kg ha^{-1} (Source: E&S Division, DA&FW, 2021-22).

It realizes that, the productivity of Uttar Pradesh is considerably lower than the national average and the potential yield of various improved varieties. For various improved and hybrid varieties of pearl millet, the yield evidenced up to 25 quintal per ha. The causes responsible for the underside productivity in Uttar Pradesh, and particularly, in Bundelkhand region is drought prone which faces enormous problems of low rainfall, low agricultural productivity, water crisis, soil erosion, degradation of water resources, fodder crisis, high rate of cattle mortality, non-sustainable sources of livelihoods, and low content of organic matter and crust formation on the soil surface etc. In the recent years, increasing vulnerability to the frequent and unseasonal extreme weather conditions, like droughts, short-term rain and flooding in fields has been observed, adding to uncertainties in cultivation and increasing poverty, scarcity of water and inadequate and uneven distribution of rainfall, late onset and early cessation of monsoon rains, prolonged dry spells during the crop growing season and excessive evaporation are some paramount factors which affects millet productivity (Venugopal *et al*., 2015). Lack of balanced crop nutrition is one of them. Integrated nutrient management of soil fertility and plant nutrients supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner. Farmyard manure can be supplemented with NPK fertilizers. Although, it is costlier than chemical fertilizers on nutrient basis but other beneficial effects which it has on soil can compensate for the added cost and ultimately integrated nutrient management is economically viable in long period of time.

Available soil nutrient content increased significantly in treatments receiving organic manure (FYM) in combination with inorganic fertilizer. It is assumed that either nutrient was released from the reserves held in the clay inter layers. Further, the decomposition of added organic matter and its mineralization increased the availability of nutrient for the plants and fertility status and productivity of soil as reported by Thakur *et al.* (2012).

INM with vermicompost, FYM and their combination with inorganic fertilizers partially or alone significantly influenced the grain and stover yield of pearl millet. Under INM practices, the losses through leaching, runoff, volatilization, emissions, and immobilization are diminished, while high nutrient-use efficiency is attained (Zhang *et al.*, 2012). Therefore, the present investigation was carried to evaluate the response of Integrated Nutrient Management on growth and yield of pearl millet, response of Integrated Nutrient Management on soil fertility and to assess the economics of integrated nutrient management in pearl millet.

Material and Methods

A field experiment was conducted during Kharif, 2023 at Agronomy crop research farm, Department of Agronomy, Banda University of Agriculture and Technology, Banda (U.P.). The experiment was carried out in randomized block design with three replication and ten treatments viz., T_1 - rather than Control, T_2 - 100% RDF, T_3 - 75% RDF, T_4 -125% RDF, T_5 -75% RDF 5t ha^{-1} FYM, T_6 -75% RDF + 2.5t ha^{-1} FYM, T_7 - 75% RDF + 2.5t ha^{-1} Vermicompost, T_8 -75% RDF + 1.25t ha^{-1} Vermicompost, T_9 - 100% RDF + 2.5t ha^{-1} FYM, T_{10} - 100% RDF +1.25t ha^{-1} Vermicompost. The soil in which research experiment conducted was silty clay, pH value is (8.14), EC (0.22 dSm^{-1}), Organic carbon (0.37%) available nitrogen (224.92 kg ha^{-1}), available phosphorus (20.15 kg ha^{-1}), available potash (274.04 kg ha^{-1}) and soil dehydrogenase activity of soil (3.51 µg g^{-1} hr-24). The recommended dose of fertilizers (RDF) for NPK is 60:30:20 kg ha^{-1}. The total amount of phosphorous and potash (30 and 20 kg ha^{-1}), half quantity of nitrogen (30 kg ha^{-1}) as per treatment was applied at the time of sowing as basal dose and later half of nitrogen (30 kg ha^{-1}) was applied at the tillering stage of pearl millet at 30-35 DAS. The biometric observations were recorded on three randomly selected plants from net plot of each treatment.

The observations regarding various growth parameters, yield and harvest index were noted as:

Crop Growth Rate (CGR)

It is the gain in dry matter production on a unit of land in a unit of time. It is expressed in g $m^{-2}day^{-1}$.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where,

W_1 and W_2 are whole plant dry weight at time $t_1 - t_2$ respectively.

Leaf Area Index (LAR)

It is the ratio of leaf area to the area of ground cover. It is the leaf area divided by the land occupied by the plants. It is unit less figure.

$$LAR = \frac{\text{Leaf area per plant}}{\text{Plant dry weight}}$$

Net Assimilation Rate (NAR)

NAR is defined as dry matter increment per unit leaf area or per unit leaf dry weight per unit of time. The NAR is a measure of the average photosynthetic efficiency of leaves in a crop community. It is expressed in g $m^{-2}day^{-1}$.

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\log e\, L_2 - \log e\, L_1}{L_2 - L_1}$$

Where,

W_1 and W_2 is dry weight of whole plant at time t_1 and t_2 respectively.

L_1 and L_2 are leaf area at t_1 and t_2 respectively.

$t_1 - t_2$ are time interval in days.

Yield (q ha^{-1})

The dried ear heads of pearl millet from each plot were threshed to record grain yield per plot, which was converted to grain yield per hectare (q ha^{-1}). The pearl millet stover after separating the ear head at harvest was left in the plots for sun drying. After proper drying, it was weighed to record the stover yield per plot and converted into stover yield quintal per hectare (q ha^{-1}).

Harvest Index (HI)

Harvest index is the ratio of economic yield to the total biological yield and was calculated by using the following formula.

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Results and Discussion

Growth attributes

Number of Tillers per Plant

The number of tillers per plant is a critical growth attribute in pearl millet. As presented in Table 1, the application of 100% RDF + 2.5 t ha^{-1} FYM (T_9) resulted in the maximum number of tillers, particularly at 45 DAS. This was statistically on par with the application of 100% RDF + 1.25 t ha^{-1} Vermicompost (T10) and other nutrient-rich treatments such as 125% RDF (T4) and 75% RDF + 5 t ha^{-1} FYM (T_5). The significant effect of these treatments can be attributed to the combined benefits of organic and inorganic fertilizers, which enhance nutrient availability and soil health. Vermicompost, in particular, is known to provide secondary nutrients like Ca, Mg, and S, as well as micronutrients, which are essential for promoting tiller development (Thumar *et al.* 2016; Sinha *et al.* 2011; Chaudhary *et al.* 2015). These nutrients play a vital role in supporting vegetative growth, leading to an increased number of tillers.

Number of Leaves per Plant

The number of leaves per plant also showed a significant response to the different nutrient management practices. Treatment T9 (100% RDF + 2.5 t ha^{-1} FYM) consistently recorded the highest number of leaves at various growth stages (30, 45, 60 DAS, and at harvest). This increase in leaf number is likely due to the balanced nutrient supply provided by the combination of RDF and FYM, which ensures steady nutrient availability throughout the growing season. This treatment not only supports tiller formation but also enhances leaf development, likely due to improved soil physical conditions and the steady release of nutrients, promoting higher auxiliary bud activity (Sushil *et al.* 2015; Bana *et al.* 2012). In contrast, the control treatment (T_1) recorded the lowest number of leaves, highlighting the importance of integrated nutrient management for optimal crop growth.

Plant Height

Plant height, another vital growth parameter, was significantly influenced by the nutrient management practices. Treatment (T_9) (100% RDF + 2.5 t ha□¹ FYM) recorded the maximum plant height at all stages (76.82 cm at 30 DAS, 133.09 cm at 45 DAS, 178.33 cm at 60 DAS, and 230.12 cm at harvest). This treatment was statistically on par with T_{10} (100% RDF + 1.25 t ha^{-1} Vermicompost), T_4 (125% RDF), T_5 (75% RDF + 5 t ha^{-1} FYM), T7 (75% RDF + 2.5 t ha^{-1} Vermicompost), and T_8 (75% RDF + 1.25 t ha^{-1}

Vermicompost). The superior growth in plant height observed with these treatments can be attributed to the continuous nutrient supply, particularly nitrogen, which enhances chlorophyll formation, leading to increased photosynthetic activity and meristematic growth (Husain *et al*., 2017; Senthilkumar *et al.* 2018).

Dry Weight

The dry weight of plants, an indicator of total biomass production, was highest in treatment (T9) (100% RDF + 2.5 t ha^{-1} FYM) at all stages (7.90 g at 30 DAS, 26.57 g at 45 DAS, 35.06 g at 60 DAS, and 48.15 g at harvest). This was followed by T_{10} (100% RDF + 1.25 t ha^{-1} Vermicompost), T_4 (125% RDF), T_5 (75% RDF + 5 t ha^{-1} FYM), and T_7 (75% RDF + 2.5 t ha^{-1} Vermicompost). The superior dry weight observed in these treatments can be attributed to the slow and continuous release of nutrients from the organic amendments, which enrich the soil and provide the required nutrients for metabolic processes, thereby enhancing vegetative growth and biomass accumulation (Mekki *et al.* 1999). The combined application of FYM, vermicompost, and chemical fertilizers ensures nutrient availability over an extended period, positively impacting growth parameters and ultimately increasing the plant's dry matter production (Singh *et al.* 2015).

Chlorophyll content (μmol)

Chlorophyll is an important molecule associated with photosynthesis in plant leaves that directly involves in the growth and yield of pearl millet was recorded highest under treatment T_4 (125% RDF) at all stages (34.80 μmol at 30 DAS, 41.76 μmol at 45 DAS, 49.07 μmol at 60 DAS and 45.58 μmol at harvest). This was at par with T_2 (100% RDF), T_5 (75% RDF+ 5t ha^{-1} FYM), T_6 (75% RDF+ 2.5t ha^{-1} FYM), T_9 (100% RDF+ 2.5t ha^{-1} FYM) and T_{10} (100% RDF+ 1.25t ha^{-1} Vermicompost).

The higher concentration of chlorophyll is direct output of higher dose of nitrogen provided through inorganic fertilizers (125% RDF) to the soil in initial stage of pearl millet. This might be due to the fact that when higher nitrogen doses were applied nitrogen content in plant get increased which enhances chlorophyll formation, chlorophyll attributed to increased photosynthesis rate in pearl millet plants and enhanced meristematic activity in cells of plant.

Leaf Area Index

LAI is an important character depends on leaf orientation was recorded highest under treatment T9 (100% RDF+ 2.5t ha^{-1} FYM) at all growth stages (0.71 at 30 DAS, 1.39 at 45 DAS, 2.27 at 60 DAS and 1.44 at harvest). This was at par with T_{10} (100% RDF+ 1.25t ha^{-1} Vermicompost), T_4 (125%RDF), T_5 (75% RDF+ 5t ha^{-1}FYM), and T_7 (75% RDF+ 2.5t ha^{-1} vermicompost). The vertically oriented leaves had a higher photosynthesis rate than those with horizontal leaves. Whose plant highest plant height which provides better ventilated canopy and improved exchange of carbon di-oxide Noova and Loomis, (1981), Kumari *et al.* (2017).

Crop Growth Rate (g m^{-2} day^{-1})

Crop growth rate generally indicates the gain dry matter accumulation by the crop pre unit area and per unit time was recorded highest under treatment T_9 (100% RDF+ 2.5t ha^{-1} FYM) at different time intervals (26.04 g $m^2 day^{-1}$ at 0-30 days interval, 33.30 g $m^2 day^{-1}$ at 30-45 days interval and 45.30 g $m^2 day^{-1}$ at 45-60 days interval). This was at par with T_{10} (100% RDF +1.25t ha^{-1} Vermicompost), T_4 (125% RDF), T_5 (75% RDF + 5t ha^{-1} FYM) and T_7 (75% RDF + 2.5t ha^{-1} Vermicompost).

The reason of higher gain crop growth is due to better air circulation, light interception in wider row spacing and also more moisture and nutrient availability in bunds which supported side dressed nutrients absorption by roots which culminated to higher dry matter accumulation plant-1, which ultimately indicated as higher stover yield of pearl millet, similar result recorded by Jain and Poonia (2003), Rathore (2006).

Net Assimilation Rate (g m^{-2} day^{-1})

Net assimilation rate indicates the dry matter production per unit of area per day and significantly maximum value was recorded in treatment T_2 (100% RDF) at different time intervals (3.55 g $m^2 day^{-1}$ 0-30 days interval, 6.14 g $m^2 day^{-1}$ at 30-45 days interval under T_3 and 1.76 g $m^2 day^{-1}$ at 45-60 days interval under control). This was at par with T_3 (75% RDF). Net assimilation rate indicates the dry matter production per unit of area per day and net rate of photosynthesis. The combined application of 2.5t ha^{-1} FYM along with 75% RDF as per treatments in present investigation also improves biological activities for long duration which directly affected the photosynthesis rate in positively and Physicochemical properties and hydraulic conductivity of the soil and thereby availability of nutrients which increased plant growth, dry matter accumulation $plant^{-1}$, CGR, NAR and RGR (Jain and Poonia, 2003).

Table 1 : Effect of Integrated nutrient management on growth attributes of pearl millet

Treatments	No. of Tillers plant^{-1} (DAS)				No. of leaves plant^{-1} (DAS)				Plant height (cm) (DAS)				Dry weight (g) (DAS)			
	At 30	At 45	At 60	At harvest	At 30	At 45	At 60	At Harvest	At 30	At 45	At 60	At Harvest	At 30	At 45	At 60	At Harvest
Control (T1)	2.78	3.55	4.00	3.41	7.11	11.81	13.88	12.22	61	120.26	164.33	200.65	2.56	12.38	24.32	35.99
100% RDF (T2)	3.76	4.19	4.44	4.11	10.21	19.24	19.22	18.22	73.33	128.48	167.93	216.64	4.17	23.82	31.05	44.71
75% RDF (T3)	3.40	3.44	4.11	3.88	9.19	16	17.09	16.44	65.92	126.87	166.42	207.76	3.03	20.07	27.27	40.83
125% RDF (T4)	3.99	4.88	5.33	5.00	14.36	20.37	22.06	20.92	76.38	131.66	177.33	228.35	6.43	25.01	33.71	46.03
75% RDF + 5 tha^{-1} FYM (T5)	3.77	4.55	5.26	4.33	13.05	20.12	21.05	20.24	75.52	130.15	175.93	225.99	5.31	24.53	33.42	45.72
75% RDF + 2.5 tha^{-1} FYM (T6)	3.55	3.91	4.14	2.70	10.51	17.48	18.11	17.51	69.76	127.11	167.07	211.58	3.50	21.81	29.43	42.77
75% RDF + 2.5 tha^{-1} Vermicompost (T7)	3.77	4.28	4.92	3.56	12	19.60	20.16	19.29	73.64	129.28	170.42	224.67	5.17	24.19	32.11	45.43
75% RDF + 1.25 tha^{-1} Vermicompost (T8)	3.46	4.07	4.44	3.00	10.86	18	18.78	18.44	71.69	128.22	167.74	214.20	4.10	22.66	29.92	43.55
100% RDF + 2.5 tha^{-1} FYM (T9)	4.22	5.33	6.22	5.28	13.61	21.56	22.77	21.03	76.82	133.09	178.33	230.12	7.90	26.57	35.06	48.15
100% RDF + 1.25 tha^{-1} Vermicompost (T10)	4.13	5.26	5.88	5.19	13.33	20.54	22.72	20.92	76.59	132.47	178.03	229.27	7.41	26.40	34.37	46.29
SEm±	0.43	0.37	0.46	0.40	1.26	1.32	0.80	0.76	4.07	4.37	3.41	6.49	1.18	1.11	1.09	1.40
CD (P=0.05)	NS	1.12	1.3	1.20	NS	3.92	2.39	2.25	NS	NS	10.10	19.25	NS	3.29	3.24	4.15

Table 2 : Effect of Integrated nutrient management on growth attributes of pearl millet

Treatments	Chlorophyll concentration (µmol) (DAS)				Leaf Area Index (DAS)				Crop Growth Rate (g m^{-2} day^{-1}) (Days interval)			Net Assimilation Rate (g m^{-2} day^{-1}) (Days interval)		
	At 30	At 45	At 60	At Harvest	At30	At 45	At 60	At Harvest	0-30	30-45	45-60	0-30	30-45	45-60
Control (T1)	24.03	29.66	35.58	34.59	0.52	1.15	1.97	1.18	12.21	23.50	36.03	2.11	1.67	1.76
100% RDF (T2)	33.75	39.14	46.27	44.60	0.62	1.30	2.11	1.33	23.54	29.46	42.64	3.55	5.17	1.54
75% RDF (T3)	27.66	32.26	38.13	37.68	0.56	1.25	2.03	1.26	19.86	25.93	39.01	3.40	6.14	1.69
125% RDF (T4)	34.80	41.76	49.07	45.58	0.68	1.35	2.20	1.37	24.58	32.05	43.78	3.11	3.51	1.31
75% RDF + 5 t ha^{-1} FYM (T5)	32.09	37.29	44.02	42.16	0.65	1.33	2.17	1.37	24.18	31.78	43.49	3.28	3.17	1.32
75% RDF + 2.5 t ha^{-1} FYM (T6)	33.14	38.02	45.19	43.86	0.58	1.27	2.06	1.28	21.58	27.97	40.80	3.51	1.0	1.60
75% RDF + 2.5 t ha^{-1} Vermicompost (T7)	30.91	36.64	43.44	41.59	0.64	1.32	2.14	1.35	23.84	30.49	43.29	3.38	0.87	1.46
75% RDF + 1.25 t ha^{-1} Vermicompost (T8)	29.24	35.19	41.06	39.13	0.59	1.28	2.09	1.30	22.38	28.41	41.56	3.51	0.83	1.60
100% RDF + 2.5 t ha^{-1} FYM (T9)	34.28	39.90	47.16	45.34	0.71	1.39	2.27	1.44	26.04	33.30	45.30	2.99	0.75	1.24
100% RDF + 1.25 t ha^{-1} Vermicompost (T10)	34.69	40.04	47.69	45.50	0.70	1.37	2.26	1.40	25.91	32.61	44.00	3.11	0.67	1.23
SE m±	2.58	1.61	1.48	2.49	0.04	0.04	0.06	0.01	0.56	0.68	0.64	0.22	1.34	0.08
CD (P= 0.05)	N S	4.79	4.39	NS	NS	0.12	0.18	0.12	1.65	2.02	1.91	0.67	NS	0.26

Yield attributes

Ear head length (cm)

Significantly highest length of ear heads was recorded in T_9 (100% RDF + 2.5t ha^{-1} FYM) at harvest (29.71 cm). This was also found at par with treatment T_4 (125% RDF), T5 (75% RDF + 5 t ha^{-1} FYM), T7 (75% RDF + 2.5 t ha^{-1} Vermicompost) and T_{10} (100% RDF + 1.25 t ha^{-1} Vermicompost). Significantly lowest length was recorded under treatment T_1 (control) at harvest.

Better nutrition due to supply of chemical fertilizers along with vermicompost and FYM might have resulted into better root growth and development, enhanced nutrient availability, and translocation and thus increasing the ear head length Kugedera and Kokerai (2019), Guggari *et al.* (2007).

Girth of Ear head (cm)

As presented in Table 3, the application of 100% RDF + 2.5 t ha^{-1} FYM (T_9) resulted in the maximum girth of ear head (cm) at harvest time. This was followed by T_{10} (100% RDF + 1.25 t ha^{-1}

Vermicompost), T_5 (75% RDF + 5 t ha^{-1} FYM), T_7 (75% RDF + 2.5 t ha^{-1} Vermicompost) and T_8 (75% RDF + 1.25 t ha^{-1} Vermicompost). Significantly minimum girth was recorded in T_1 (control). Application of chemical fertilizers combined with vermicompost and FYM might have increased the nutrient availability for plants at the flower primordial initiation stage, which might have helped in enhance the girth of ear head (cm). These results collaborate with the results of Patel *et al.* (2016), Guggari *et al.* (2007).

Weight of grains ear head^{-1} (g)

Weight of grains per ear heads (gm) significantly highest recorded in treatment T_9 (100% RDF + 2.5t ha^{-11} FYM). This was at par with T_{10} (100% RDF + 1.25 t ha^{-1} Vermicompost), T_5 (75% RDF + 5 t ha^{-1} FYM), and T_7 (75% RDF + 2.5 t ha^{-1} Vermicompost). Integrated Nutrient Management practices significantly enhanced the grain weight earhead^{-1}. Increase in grain weight earhead^{-1} among integrated nutrient management might be attributed to better response of crop to vermicompost combined with FYM and chemical fertilizers due to increased nitrogen availability by fixing appreciable amount of molecular nitrogen and making available for plant growth and due to synthesis of growth promoting enzymes like IAA, gibberellins, vitamins altering the microbial balance in the rhizosphere and metabolites that stimulate plant development. Fully developed plant has more energy to correct the synthesized material into grains numbers and its weight. These results also substantiate the findings of Choudhary *et al.* (2014), Marngar and Dawson (2017), Gurrala *et al.* (2020).

Test weight (gm)

Test weight of pearl millet influenced by integrated nutrient management practices. The highest 1000 grain weight was recorded in T_9 (100% RDF + 2.5t ha^{-1} FYM). The probable reason for increase in test weight was mainly due to adequate application of nutrients from recommended doses of fertilizers combined with FYM and vermicompost throughout the grain formation and development period which might have resulted bold grains maximum test weight (Thumar *et al.* (2016).

Economic yield (q ha^{-1})

Conspicuous differences in economic yield of pearl millet were noticed due to INM practice. Treatment T_9 (100% RDF + 2.5t ha^{-1} FYM) resulted significantly maximum grain yield. It was superior to rest of all treatments except T_{10} (100% RDF + 1.25t ha^{-1} Vermicompost). The lowest grain yield was recorded with control. This could mainly be associated with the increased growth of the crop in terms of plant height, number of effective tillers per plant, chlorophyll content and dry matter accumulation recorded under these treatments due to greater availability of most of the macro and micro nutrients in adequate proportion that led to higher uptake of the plant nutrients Priyadarshini *et al.* (2012), Lakum *et al.* (2011), Patil and shete (2008), Chaudhary *et al.* (2015).

Biological yield (q ha^{-1})

It is the total biomass (Both grain and stover yield) of a crop. Treatment T_9 (100 % RDF + FYM @ 2.5t ha^{-1}) resulted significantly highest biological yield. It was found at par with T_{10} (100% RDF+1.25t ha^{-1} Vermicompost), T_5 (75% RDF + 5 t ha□¹ FYM) and T7 (75% RDF + 2.5t ha^{-1} Vermicompost). Significantly lowest biological yield was found under treatment T_1 (Control). This could be due to better nutrition, which accelerated the photosynthetic rate, which leads to higher plant growth and biomass production that reflected on grain and stover yield due to higher photosynthetic area. These results are in accordance with Debnath *et al.* (2015), Sakarvadia *et al.* (2012) and Reddy *et al.* (2016).

Stover yield (q ha^{-1})

Significantly highest stover yield was recorded under T9 (100% RDF+ 2.5t ha^{-1} FYM). This was found at par with T_5 (75% RDF + 5 t ha□¹ FYM), T_7 (75% RDF + 2.5t ha^{-1} Vermicompost) and T_{10} (100% RDF+1.25t ha^{-1} Vermicompost). While, lowest stover yield was noted under treatment (T_1) control. This might be due to synergistic effect of integration of organic and inorganic sources combined with vermicompost that resulted in better nutrition, which accelerated the photosynthetic rate, adequate biomass production and leaf area index that reflected on higher stover yield. The more plant height and highest number of tillers per plant and dry matter accumulation recorded in pearl millet in the present study may have contributed for its higher stover yield. These results are in accordance with Reddy *et al*. (2016), Thumar *et al.* (2016).

Harvest index (%)

Harvest index was significantly influenced by integrated nutrient management practices. However, the higher value of harvest index was recoded under T_9 (100% RDF + 2.5t ha^{-1} FYM). The lowest harvest index was recorded under T_1 (control).

Table 3 : Effect of Integrated nutrient management on yield attributes of pearl millet

Treatments	Ear head length (cm)	Girth of Ear head (cm)	Weight of grains ear head^{-1} (g)	Test weight (g)
Control (T1)	19.11	3.90	4.64	8.27
100% RDF (T2)	24.04	4.59	8.73	8.67
75% RDF (T3)	21.40	4.48	8.18	8.44
125% RDF (T4)	27.49	4.75	9.74	9.08
75% RDF + 5 t ha^{-1} FYM (T5)	28.44	5.60	10.44	9.32
75% RDF + 2.5 t ha^{-1} FYM (T6)	23.88	4.68	8.90	8.81
75% RDF + 2.5 t ha^{-1} Vermicompost (T7)	28.36	5.11	10.19	9.19
75% RDF + 1.25 t ha^{-1} Vermicompost (T8)	25.93	4.69	9.24	8.93
100% RDF + 2.5 t ha^{-1} FYM (T9)	29.71	6.90	11.38	9.95
100% RDF + 1.25 t ha^{-1} Vermicompost (T10)	29.21	5.83	11.14	9.62
SEm±	1.01	0.57	1.04	0.43
CD (P=0.05)	2.99	NS	3.10	NS

Table 4 : Effect of Integrated nutrient management on yield and harvest index of pearl millet

Treatments	Economic yield (q ha^{-1})	Biological yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
Control (T1)	9.36	64.33	54.97	14.55
100% RDF (T2)	15.40	73.66	58.26	20.91
75% RDF (T3)	14.45	71.17	56.72	20.31
125% RDF (T4)	16.30	77.56	61.26	21.02
75% RDF + 5 t ha^{-1} FYM (T5)	23.54	87.18	63.64	27.00
75% RDF + 2.5 t ha^{-1} FYM (T6)	20.42	80.56	60.14	25.36
75% RDF + 2.5 t ha^{-1} Vermicompost (T7)	23.47	86.98	63.51	26.98
75% RDF + 1.25 t ha^{-1} Vermicompost (T8)	21.43	81.95	60.52	26.15
100% RDF + 2.5 t ha^{-1} FYM (T9)	24.10	88.28	64.18	27.34
100% RDF + 1.25 t ha^{-1} Vermicompost (T10)	23.82	87.72	63.90	27.16
SEm±	0.09	0.86	0.89	0.31
CD (P=0.05)	0.28	2.55	2.64	0.93

Economics analysis

The data regarding to economics in terms of cost of cultivation, gross return, net return and B:C ratio of pearl millet which was recorded are described briefly below.

The highest cost of cultivation (Rs. ha^{-1} 59490 INR ha^{-1}) was recorded in treatment T_7 (75 % RDF + 2.5t ha^{-1} vermicompost) while, the lowest cost of cultivation (Rs. 25803 INR ha^{-1}) was recorded under T_1 (Control). Vermicompost is very costly which is increased total cost of treatments in comparison to without application of vermicompost.

Gross income revealed for different treatment combinations showed that the maximum gross income (73086 INR ha^{-1}) was recorded with T_9 (100% RDF + 2.5t ha^{-1} FYM). While, the minimum gross return (34386 INR ha^{-1}) was recorded in T_1 (Control).

The maximum net income of (37715 INR ha^{-1}) was recorded with T_9 (100% RDF + 2.5t ha^{-1} FYM) and lowest was recorded under the treatment T_1 (Control).

Among the different integrated nutrient management practices, the highest benefit: cost ratio (2.07) was noticed with T_9 (100% RDF + 2.5t ha^{-1} FYM). While the lowest value (1.20) was recorded under the treatment T_7 (75% RDF + 2.5 t ha^{-1} vermicompost).

The application of vermicompost is very costly in pearl millet due to its higher price and more cost of application with labors Meena and RC Gautam, (2005), Rajiv and Dabbas (2012), Divya *et al.* (2017), Togas *et al.* (2015).

Table 5 : Effect of Integrated nutrient management on economics of pearl millet

Treatments	Cost of Cultivation (INR ha^{-1})	Gross return (INR ha^{-1})	Net return (INR ha^{-1})	B:C ratio
Control (T1)	25803	34386	8582	1.33
100% RDF (T2)	29050	50144	21093	1.73
75% RDF (T3)	28240	47476	19236	1.68
125% RDF (T4)	29842	53002	23159	1.78
75% RDF + 5 t ha^{-1} FYM (T5)	40740	71570	30829	1.76
75% RDF + 2.5 t ha^{-1} FYM (T6)	34490	63085	28595	1.83
75% RDF + 2.5 t ha^{-1} Vermicompost (T7)	59490	71368	11878	1.20
75% RDF + 1.25 t ha^{-1} Vermicompost (T8)	43865	65671	21805	1.50
100% RDF + 2.5 t ha^{-1} FYM (T9)	35300	73086	37715	2.07
100% RDF + 1.25 t ha^{-1} Vermicompost (T10)	44675	72337	27662	1.62

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