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Comparative Effect of Subhash Palekar's Natural Farming, Organic and Inorganic Systems of Nutrition on Performance of Fodder Sorghum and Pearl Millet Hybrids

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate different nutrient management practices in fodder sorghum and pearl millet hybrids.
Study Design: Randomized block design.
Place and Duration of Study: A field experiment was conducted at the research farm of Fodder Section, CSK HPKV, Palampur during *Kharif* seasons of 2018 and 2019
Methodology: Ten nutrient management practices *i.e.* absolute control (T_1), 5% *Jeevamrit* (T_2), 10% *Jeevamrit* (T_3), seed treatment with *Beejamrit* + 5% *Jeevamrit* (T_4), seed treatment with *Beejamrit* + 10% *Jeevamrit* (T_5), 10 t/ha FYM + 5% *Jeevamrit* (T_6), 10 t/ha FYM + 10% *Jeevamrit* (T_7), 50% recommended N + 10 t/ha FYM + 5% *Jeevamrit* (T_8), 50% recommended N + 10 t/ha

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FYM + 10% *Jeevamrit* (T_9) and recommended NPK through inorganic sources (T_{10}) were tested in randomized block design with three replications.

Results: The results indicated that integrated nutrient management *i.e.* 50 per cent recommended N + 10 t/ha FYM + 10% *Jeevamrit* and 50 per cent recommended N + 10 t/ha FYM + 5% *Jeevamrit* and recommended NPK through inorganic sources remaining at par resulted in better crop growth (plant height, shoot number, leaf stem ratio, percent proportion), higher fodder yield (green and dry fodder yields), NPK uptake and crude protein yield than rest of the organic (10 t/ha FYM + 10% *Jeevamrit* and 10 t/ha FYM + 5% *Jeevamrit*) and natural farming (*Beejamrit* + 5% *Jeevamrit* and *Beejamrit* + 10% *Jeevamrit*) nutrient management treatments. Application of recommended NPK resulted in highest net returns (79049 INR/ha) and net returns per rupee invested (2.09).

Conclusion: Integrated and inorganic nutrient management practices in fodder sorghum and pearl millet hybrids appeared best practices for realising higher yield than organic and natural farming nutrient management practices.

Keywords: Fodder yield; integrated nutrient management; natural farming; organic farming.

1. INTRODUCTION

Livestock, a key source of supplementary income and livelihood especially for small and marginal farmers, plays an important role in the rural economy of the country. India ranks first in livestock population (535.78 million) as well as in milk production in the world [1], but milk production per animal is very low [2]. Deficiency in quantity and quality of fodder is one of the major causes of this low animal productivity. India has only 4 per cent of gross cropped area (9.13 m ha) as cultivated fodder crops and 10.26 million ha of pastures and grasslands [3]. The country at present faces a net deficit of 23.40 per cent in dry fodder and 11.24 per cent in green fodder [4]. In Himachal Pradesh, also 9,451 ha cultivated fodder crops and 1508 thousand ha pastures and grasslands [5] are able to meet the partial requirement of large livestock population of 4.41 million [1]. In the state, there are shortages of about 26.57 and 66.95 per cent, respectively of green and dry fodder [6].

Under the situation, high yielding crops/varieties of forage with appropriate agronomic techniques can help to mitigate the fodder deficit in the state. In recent years, fodder sorghum and pearl millet hybrids are becoming popular with the farmers. Fodder sorghum [*Sorghum bicolor* (L.) Moench] occupies an area of 5.65 million ha in India [7], whereas, in Himachal Pradesh this crop has an area of 20,000 ha [8]. Fodder pearl millet [*Pennisetum glaucum* (L.) R. Br.] locally known as bajra, occupies an area of about 6.98 million ha in India [7] with an acreage of about 6,250 ha in Himachal Pradesh [8]. These crops are fast growing, adaptive to different environmental conditions, palatable, nutritious, drought tolerant and have high production potential.

These fodder crops are highly nutrient demanding and mainly grown under inorganic nutrition conditions. But the low income of small and marginal farmers restricts the use of costly chemical fertilizers on one hand and on the other, concern about soil exhaustion; environmental deterioration and nutritional imbalance arising from continuous use of inorganic fertilizers necessitate the use of other sources of nutrition. Under this situation the use of organic manures has been found to be promising in arresting the decline in productivity through correction of deficiency of secondary and micro nutrients, and improving the physical and biological health of the soil as well. Although, organics are eco-friendly and sustain productivity but their limited availability and lower nutrient status are the major constraints. These constraints can be overcome by the judicious use of manures and fertilizers in an integrated manner for maintaining the economic crop production and soil fertility status on a long term basis.

In recent years, a new cost effective concept of Subhash Palekar’s Natural Farming (SPNF) is claimed to sustain the production and maintain the ecological balance. The principle methods of SPNF include mulching, whapasa, intercropping and use of several preparations like *Beejamrit*, *Jeevamrit* and *Ghan-Jeevamrit*. *Beejamrit* help in the improvement of seed germination, seedling length and seed vigour index of crops [9]. *Jeevamrit* enhances microbial activity in soil and helps in improvement of soil fertility [10]. *Jeevamrit* is claimed to be a panacea for natural farming. But this needs experimental testing on a long term basis. Therefore, an attempt has been made to do the comparisons of different nutrient management practices in terms of growth characteristics, green and dry fodder yields, profitability, nutrient content and uptake (N, P and K) and crude protein content yield in fodder sorghum and pearl millet hybrids.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

A field experiment was conducted during *Kharif* seasons of 2018 and 2019 at Research Farm of Fodder Section, CSK HPKV, Palampur. The area represents the mid hills sub-humid zone of Himachal Pradesh. The experimental farm was situated at 32°10' N latitude and 76°55' E longitude with an elevation of about 1227 meters above mean sea level in North-Western Himalayas. Total rainfall received during *Kharif* 2018 and *Kharif* 2019 was 2046 mm and 1227 mm, respectively. The mean relative humidity during *Kharif* 2018 and *Kharif* 2019 ranged between 52.93 to 94.93 and 43.36 to 91.36 per cent, respectively. The mean maximum temperature ranged from 24.39°C to 30.64°C during *Kharif* 2018 and 25.29°C to 33.00°C during *Kharif* 2019. Soil of the experimental field was acidic in reaction (pH 5.47), medium in organic carbon (0.70 %), low in available nitrogen (230 kg/ha), medium in available phosphorus (17 kg/ha) and medium in available potassium (168 kg/ha).

2.2 Experimental Design and Treatments

The experiment was laid out in randomized block design with three replications, consisting of ten nutrient management treatments *i.e.* absolute control (T_1), 5% *Jeevamrit* (T_2), 10% *Jeevamrit* (T_3), seed treatment with *Beejamrit* + 5% *Jeevamrit* (T_4), seed treatment with *Beejamrit* + 10% *Jeevamrit* (T_5), 10 t/ha FYM + 5% *Jeevamrit* (T_6), 10 t/ha FYM + 10% *Jeevamrit* (T_7), 50% recommended N + 10 t/ha FYM + 5% *Jeevamrit* (T_8), 50% recommended N + 10 t/ha FYM + 10% *Jeevamrit* (T_9) and recommended dose of NPK through inorganic sources (T_{10}).

2.3 Procedure

'PHS-111' of sorghum and 'PG-3545' of pearl millet varieties were grown. The seeds of sorghum and pearl millet hybrids were mixed using 50 per cent recommended seed rate of sorghum (22.5 kg/ha) + 50 per cent recommended seed rate of pearl millet (7.5 kg/ha) and this seed mixture was sown in lines 30 cm apart. Prior to sowing, full dose of FYM on a dry weight basis was incorporated in the soil in all the treatments comprised of FYM application. Inorganic fertilizers were applied to crop as per treatments. Half dose of N as per treatments and whole of P and K was applied at the time of sowing. The remaining 1/4th dose of N was top dressed after 30 days of sowing of crop and remaining 1/4th was applied after first cut. *Beejamrit* was prepared on farm using local cow dung (5 kg), local cow urine (5 litres), lime (50 g), soil (0.1 g) and water (20 litres) for treating seeds (100 kg) as per treatments. *Jeevamrit* (2 litres) was also prepared on the farm itself using local cow dung (100 g), local cow urine (100 ml), jaggery (20 g), pulse flour (20 g), soil (0.1 g) and water (2 litres). Both the inputs of natural farming were prepared as per the procedure proposed by Subhash Palekar [11]. After 48 hours of *Jeevamrit* fermentation, two dilutions of 5 and 10 per cent were prepared from the concentrated *Jeevamrit* and used @500 l/ha as basal and at 4 weeks interval after sowing of crop in the respective treatments.

2.4 Data Collection

The observations on growth characteristics and yields of the crops were recorded through standard procedures. Plant samples were collected at harvest of each crop for chemical analysis *viz*. nitrogen, phosphorus and potassium content (%) following standard methods of modified Kjeldahl's method [12], vanado-molybdate phosphoric method [13] and flame photometer technique [13], respectively. The nutrient uptake by crops was computed with the help of following relationship:

Nutrient uptake (kg/ha) = Nutrient content (%) × dry fodder yield/straw yield/grain yield (kg/ha) /100

The per cent crude protein content was assessed by multiplying per cent nitrogen with a constant factor of 6.25. The crude protein yield (q/ha) was calculated by the following formula:

$$\text{Crude protein yield (q/ha)} = \frac{\text{Crude protein content (\%) x dry fodder yield (q/ha)}}{100}$$

For economic analysis, cost of production, net returns (INR/ha) and net returns per rupee invested was calculated on the basis of prevailing market prices, costs of inputs and outputs. The net returns (INR/ha) were computed treatment wise by subtracting the cost of cultivation from the gross returns of the respective treatment. Net returns per rupee invested was worked out by using the following equation:

$$\text{Net returns per rupee invested} = \frac{\text{Net returns (INR/ha)}}{\text{Cost of cultivation (INR/ha)}}$$

2.5 Data Analysis

The data pertaining to growth characteristics, green and dry fodder yields, profitability, nutrient content and uptake, crude protein content and yield were subjected to statistical analysis as per the procedures suggested by Gomez and Gomez [14]. Wherever present the effect of significance at 5 percent level of probability and the critical difference (CD) was calculated.

3. RESULTS AND DISCUSSION

3.1 Effect of Nutrient Management Treatments on Growth Characteristics

3.1.1 Plant height

Plant height of sorghum and pearl millet at both the cuts was significantly influenced by different treatments (Table 1). In sorghum, at first cut, application of recommended NPK through inorganic sources resulted in significantly taller plants, which remained statistically at par with the application of 50 per cent recommended N + 10 t/ha FYM + 10 per cent *Jeevamrit* and 50 per cent recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit.*

In pearl millet, at first cut, application of 50 per cent recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit* resulted in significantly more height of plants, which remained statistically at par with the application of 50 per cent recommended N + 10 t/ha FYM + 10 per cent *Jeevamrit* and recommended NPK through inorganic sources.

In both the crops, next to inorganic and integrated systems of nutrition; organic nutrient management treatments of 10 t/ha FYM + 5 per cent *Jeevamrit* and 10 t/ha FYM + 10 per cent *Jeevamrit* being at par with each other were significantly better over remaining treatments. Natural farming nutrient management treatments *i.e. Beejamrit* + 5 per cent *Jeevamrit* and *Beejamrit* + 10 per cent *Jeevamrit* remaining at par with 5 per cent *Jeevamrit,* 10 per cent *Jeevamrit* and absolute control failed to exhibit any significant improvement in plant height of sorghum and pearl millet at their first cut.

At second cut, significantly taller plants of sorghum and pearl millet were produced in integrated nutrient management treatments *i.e.* 50 per cent recommended N + 10 t/ha FYM + 10 per cent *Jeevamrit* and 50 per cent recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit* which remained at par with recommended NPK through inorganic sources. Plant height of sorghum and pearl millet recorded with integrated nutrient management practice of 50 per cent recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit* and recommended NPK also remained statistically at par with organically managed treatment of 10 t/ha FYM + 10 per cent *Jeevamrit*.

Maximum vegetative growth of crops under inorganic and integrated nutrient management, at the first cut and slow regeneration at the second cut might have caused no significant differences among the respective treatments. Minimum plant height of sorghum and pearl millet was recorded under absolute control which was at par with 5 per cent *Jeevamrit,* 10 per cent *Jeevamrit,* natural farming nutrient management treatments of *Beejamrit* + 5 per cent *Jeevamrit* and *Beejamrit* + 10 per cent *Jeevamrit*.

Improvement in plant height owing to integrated use of inorganic fertilizers and farm yard manure could be attributed to better availability of essential major and minor nutrients required in various metabolic processes which ultimately resulted in better mobilization of synthesized carbohydrates into amino acids and proteins that in turn stimulated rapid cell-division and cell elongation and facilitated the faster vegetative growth and ultimately increased the plant height [15].

3.1.2 Shoot number

A perusal of the data in table 1 indicated that shoot number of sorghum and pearl millet at both the cuts was significantly influenced by different nutrient management treatments. In sorghum, at first cut, significantly more number of shoots were obtained with the application of recommended NPK through inorganic sources, which was statistically at par with the integrated nutrient management treatments comprised of 50 per cent recommended N + 10 t/ha FYM + *Jeevamrit.* In pearl millet, at first cut, integrated nutrient management treatments i.e. 50 per cent recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit* and 50 per cent recommended N + 10 t/ha FYM + 10 per cent *Jeevamrit* resulted in significantly more number of shoots, which remained statistically at par with recommended NPK through inorganic sources.

An observation of data indicated that natural farming nutrient management (*Beejamrit* + 5% *Jeevamrit* and *Beejamrit* + 10% *Jeevamrit*) treatments resulted in statistically similar number of shoots per square meter of sorghum and pearl millet as of inorganic and integrated nutrient management practices. This might be due to the fact that lack of nutrition under natural farming resulted in short and thin shoots which behaved similar in number to that of tall, thick, and well-expanded shoots under inorganic and integrated systems of nutrition. Similarly, shoot number of sorghum and pearl millet obtained with natural farming nutrient management and *Jeevamrit* treatments as well as absolute control was at par with organic nutrient management treatments comprised of 10 t/ha FYM + *Jeevamrit*. At second cut, recommended NPK through inorganic sources in sorghum and integrated nutrient management treatments i.e. 50 per cent recommended N + 10 t/ha FYM + 10 per cent *Jeevamrit* and 50 per cent of recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit* in pearl millet remaining at par with each other resulted in significantly more number of shoots.

The data further indicated that integrated nutrient management practices in sorghum and inorganic nutrient management practice in pearl millet remained statistically at par with organic and natural farming nutrient management practices which further behaved similar to *Jeevamrit* (5 or 10%) treatments.

The positive effect of integrated nutrient management and recommended NPK due to availability of sufficient amount of nutrients might have resulted in significant improvement in growth and development of the crops [16].

3.1.3 Leaf stem ratio

An appraisal of data in Table 1 indicated that leaf stem ratio of sorghum and pearl millet was significantly influenced by different nutrient management treatments at both the cuts. A glance of data indicated better leaf stem ratio of sorghum than pearl millet. This might be due to better leaf area and prominent mid rib in sorghum, thus giving higher fresh weight of leaves in sorghum as compared to pearl millet.

At both the cuts of sorghum and pearl millet, significantly higher leaf stem ratio was observed under absolute control, which was statistically at par with *Jeevamrit* (5 or 10%) and natural farming nutrient management (*Beejamrit* + 5% *Jeevamrit* and *Beejamrit* + 10% *Jeevamrit)* treatments. Treatments having no or low supply of nutrients from external sources shortened the plant height (Table 1), reduced stem girth which reduced the stem weight and resulted in more leaf stem ratio. Recommended NPK through inorganic sources in sorghum and integrated nutrient management (50 per cent recommended N + 10 t/ha FYM + *Jeevamrit*) in pearl millet remaining at par with each other resulted in significantly lowest value of leaf stem ratio at both the cuts of sorghum and pearl millet.

3.1.4 Percent proportion of crops

The data on percent proportion of sorghum and pearl millet on fresh weight basis was significantly influenced by different nutrient management treatments (Table 1). The perusal of data indicated higher proportion of pearl millet at both the cuts as compared to sorghum. Better plant height (Table 1) and shoot number (Table 1) helped to increase the dry matter accumulation of pearl millet which in turn was reflected on higher proportion of this crop. Perusal of data at first cut indicated the highest proportion of sorghum with the application of recommended NPK through inorganic sources while the lowest under absolute control, which consequently resulted in significantly higher proportion of pearl millet under absolute control as compared to other treatments. The better proportion of sorghum can be ascribed to improved growth attributes *viz.* plant height (Table 1), shoot number (Table 1) and leaf stem ratio (Table 1) under the respective (inorganic) treatment.

The data further indicated that percent proportion of sorghum at first cut under recommended NPK was statistically at par with integrated nutrient management practices *i.e.* 50 per cent recommended N + 10 t/ha FYM + 10 per cent *Jeevamrit* and 50 per cent recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit.* Absolute control was found at par with *Jeevamrit* (5 or 10%), natural farming (*Beejamrit* + *Jeevamrit*) and organic nutrient management (10 t/ha FYM + *Jeevamrit*) practices. At second cut, no significant effect on percent proportion of sorghum and pearl millet was observed. The significant effect of nutrient management treatments on proportion of crops at first cut can be well ascribed to plant growth in terms of plant height (Table 1).

Table 1. Effect of nutrient management treatments on growth characteristics of sorghum and pearl millet (mean of two years)

Treatments	Plant height (cm)				Shoot number (per m^2)				Leaf stem ratio				Per cent proportion			
	Sorghum		Pearl millet		Sorghum		Pearl millet		Sorghum		Pearl millet		Sorghum		Pearl millet	
	Cut I	Cut II	Cut I	Cut II	Cut I	Cut II	Cut I	Cut II	Cut I	Cut II	Cut I	Cut II	Cut I	Cut II	Cut I	Cut II
Absolute control	83.7	56.9	98.7	68.0	55	30	65	40	1.36	1.52	1.24	1.44	36.2	40.3	63.8	59.7
5% *Jeevamrit*	86.8	62.5	101.3	71.8	59	37	67	43	1.30	1.44	1.18	1.39	37.5	43.0	62.5	57.0
10% *Jeevamrit*	88.1	61.3	104.4	72.8	62	35	70	45	1.27	1.47	1.12	1.39	36.9	41.7	63.1	58.3
Beejamrit + 5% *Jeevamrit*	93.6	64.0	110.9	76.2	64	37	73	48	1.19	1.35	1.08	1.28	37.5	42.5	62.5	57.5
Beejamrit + 10% *Jeevamrit*	93.4	64.5	110.9	75.6	64	39	73	47	1.20	1.34	1.08	1.30	37.1	43.5	62.9	56.5
10 t/ha FYM + 5% *Jeevamrit*	115.6	69.1	133.0	85.5	57	40	68	47	0.88	1.07	0.73	0.89	39.5	42.3	60.5	57.7
10 t/ha FYM + 10% *Jeevamrit*	111.9	71.6	129.2	87.0	54	42	65	47	0.94	1.05	0.77	0.89	39.0	43.3	61.0	56.7
50% recommended N + 10 t/ha FYM + 5% *Jeevamrit*	135.2	79.4	161.5	96.0	68	48	82	58	0.73	0.89	0.53	0.79	41.8	47.4	58.2	52.6
50% recommended N + 10 t/ha FYM + 10% *Jeevamrit*	139.4	79.9	159.1	97.2	72	48	80	60	0.70	0.93	0.53	0.76	44.1	45.5	55.9	54.5
Recommended NPK	139.7	78.4	153.9	94.7	73	50	77	53	0.69	0.90	0.59	0.81	45.2	47.2	54.8	52.8
SEm+	5.4	3.0	5.1	3.0	4.0	2.8	3.2	3.2	0.05	0.06	0.05	0.06	1.6	1.8	1.6	1.8
CD (P=0.05)	16.2	9.1	15.4	9.1	12.0	9.3	10.2	9.5	0.17	0.18	0.16	0.16	4.65	NS	4.65	NS

3.2 Effect of Nutrient Management Treatments on Yield

3.2.1 Green fodder yield

Total green fodder yield was significantly influenced by different treatments at first cut, second cut and total of two cuts (Table 2). At both the cuts and total of two cuts, significantly higher total green fodder yield was recorded with the application of 50 per cent recommended N + 10 t/ha FYM + 10 per cent *Jeevamrit* which was statistically at par with the application of 50 per cent recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit* and recommended NPK through inorganic sources. Following to integrated and inorganic nutrient management, organically managed treatments *i.e.* 10 t/ha FYM + 5 per cent *Jeevamrit* and 10 t/ha FYM + 10 per cent *Jeevamrit* being at par with each other were significantly better over rest of the treatments with natural farming nutrition (*Beejamrit* + *Jeevamrit*), *Jeevamrit* (5 or 10%) and absolute control at both the cuts and total of two cuts. Integrated nutrient management at total of two cuts resulted in 58.36, 54.28, 49.92, 30.66 and 1.28 per cent more yield over absolute control, *Jeevamrit*, natural farming, organic and inorganic nutrient management treatments, respectively. Similar results regarding superior yield under integrated and inorganic nutrient management practices over organic were reported by Ravankar et al. [17], Kumar et al. [18], Katkar et al. [19] in sorghum crop and Singh et al. [20], Togas et al. [21], Samruthi et al. [22] in pearl millet crop. Similarly, Aulakh et al. [23] in maize, Kasbe et al. [24] in rice, Sharma et al. [25] in soybean crops observed better results with inorganic and integrated nutrient management over organic as well as natural farming systems of nutrition. Integrated and inorganic nutrient management owing to better nutrient availability might have improved the vegetative growth in terms of plant height, leaf stem ratio and shoot number per m^2 (Table 1) which ultimately resulted in better fodder yield of crops. Combined application of FYM along with inorganic fertilizers have been reported to increase the status of major and micro nutrients along with enhancement of organic carbon and other physical properties of soils [26]. The integrated use of FYM along with inorganic fertilizers checks the loss of N and conserves it by forming organic-mineral complexes, thus leading to continuous N supply resulting in higher yields [27]. The contribution of *Jeevamrit* in integrated nutrient management practices can be attributed to higher microbial load and growth hormones which might have enhanced the soil biomass, thereby sustaining the availability and uptake of applied as well as inherent soil nutrients which ultimately resulted in better growth and yield of crops [11,28,29]. The nutrient content of the *Beejamrit* and *Jeevamrit* irrespective of the source is very low to meet the nutritional requirement of fodder crops and their only addition to the soil lead to starvation of plants for nutrients.

3.2.2 Dry fodder yield

Total dry fodder yield (t/ha) at first cut, second cut and total of two cuts was significantly influenced by the different treatments (Table 2). An examination of the data revealed that the total dry fodder yield at first cut, second cut and total of two cuts obtained under different treatments was in accordance with green fodder yield obtained in respective treatments. Total dry fodder yield of both the cuts was also significantly highest with the integrated nutrient management treatments, which was 64.16, 59.44, 54.38, 35.62 and 2.47 per cent higher over absolute control, *Jeevamrit*, natural farming, organic and inorganic nutrient management treatments, respectively. Better availability of nitrogen under integrated and inorganic nutrient management leads to more synthesis of carbohydrates and their translocation. Involvement of nitrogen in increasing protoplasmic constituents and accelerating the process of cell elongation might have resulted in better growth and yield of the crops [30].

3.3 Economics

Significantly higher net returns of 79049 INR/ha were obtained with the application of recommended NPK through inorganic sources which was followed by 50 per cent recommended N + 10 t/ha FYM + 10 per cent *Jeevamrit* (55496 INR/ha) and 50 per cent recommended N + 10 t/ha FYM + 5 per cent *Jeevamrit* (55371 INR/ha). Natural farming nutrient management practices *i.e. Beejamrit* + 5 per cent *Jeevamrit* and *Beejamrit* + 10 per cent *Jeevamrit* were next in place, however remained statistically at par with organic nutrient management practices of 10 t/ha FYM + 5 per cent *Jeevamrit* and 10 t/ha FYM + 10 per cent *Jeevamrit* as well as with the application of *Jeevamrit* (5 or 10%). Application of recommended NPK through inorganic sources also resulted in significantly highest net returns per rupee invested (2.09). This was followed by integrated nutrient management (50 per cent recommended N + 10 t/ha FYM + *Jeevamrit*) and natural farming nutrient management (*Beejamrit* + *Jeevamrit*) practices. Lowest net returns per rupee invested were obtained with organic nutrient management treatments comprised of 10 t/ha FYM + *Jeevamrit* which remained statistically at par with absolute control and *Jeevamrit* (5 or 10%) treatments. The enhanced yield under recommended NPK resulted in highest net returns and net returns per rupee invested. The difference with respect to green fodder yield between integrated nutrient management and recommended NPK was less but increased cost of cultivation in the integrated nutrient management because of higher cost of FYM application, made integrated nutrient management less profitable in terms of net returns and net returns per rupee invested. The fodder yield in natural farming nutrient management was lower but on farm preparation of its inputs *Beejamrit* and *Jeevamrit* reduced the cost of cultivation and made it comparable with organic nutrient management in terms of net returns and net returns per rupee invested. Significantly higher net returns per rupee invested with the sole *Jeevamrit* application as compared to 7.5 t/ha FYM + *Jeevamrit* was also reported by Manjunatha et al. [31].

3.4 NPK Content and Uptake

An observation of data in Table 3 inferred that the nutrient content was significantly influenced by the different treatments. Integrated nutrient management practices and recommended NPK remaining at par with each other resulted in higher N, P and K content in the herbage compared to other treatments with organic and natural farming systems of nutrition. Togas et al. [21] and Patel et al. [32] also observed better NPK content with integrated nutrient management practices in pearl millet and sorghum, respectively. Better availability of nutrients with integrated nutrient management and recommended NPK in the soil and improved root system accompanied with higher absorbing capacity might have helped to accumulate more NPK content in the plants.

The data in the Table 3 showed significant effect of different treatments on the uptake of NPK. Integrated nutrient management practices comprised of 50 per cent recommended N + 10 t/ha FYM + *Jeevamrit* and recommended NPK remaining at par with each other resulted in significantly higher uptake of N, P and K than organic nutrient management (10 t/ha FYM + *Jeevamrit*), natural farming nutrient management (*Beejamrit* + *Jeevamrit*) and *Jeevamrit* (5 or 10%) treatments as well as absolute control. Since nutrient uptake is a function of dry fodder yield and content of respective nutrients, the dry fodder yield (Table 2) obtained under different treatments in the present study support the nutrient uptake behaviour of the crops in respective treatments. The increased dry matter in the above ground plant parts favours the translocation of carbohydrates towards developing roots. This in turn enhances the root volume and increases the uptake of plant nutrients [33]. Ghodpage and Datke [34] in sorghum and Thumar et al. [35] in pearl millet reported higher uptake with integrated nutrient management, whereas, Gupta et al. [36] in sorghum and Singh et al. [37] in pearl millet had higher NPK uptake with the application of recommended dose of inorganic fertilizers.

3.5 Crude Protein Content and Yield

The data pertaining to the effect of different nutrient management practices on crude protein content in forage and crude protein yield have been given in the Table 3. A critical observation of data revealed that different treatments exhibited significant influence on the crude protein content (%) at the first and the second cut. At both the cuts, integrated nutrient management practices and recommended NPK remaining at par with each other resulted in higher crude protein content in the herbage compared to all other treatments having 10 t/ha FYM + *Jeevamrit, Beejamrit* + *Jeevamrit, Jeevamrit* and no fertilizers or manure application. Increased shoot dry weights and shoot N concentrations as a result of fertilizer-N applications might have helped to increase the crude protein content with integrated and inorganic nutrient management [38].

A perusal of data in Table 3 indicated that crude protein yield was significantly influenced by different nutrient management treatments. At both the cuts and total of two cuts, integrated nutrient management comprised of 50 per cent recommended N + 10 t/ha FYM + *Jeevamrit* and recommended NPK remaining at par with each other resulted in significantly maximum crude protein yield than all other treatments involving organic nutrition *i.e.* 10 t/ha FYM + *Jeevamrit*, natural farming nutrition *i.e. Beejamrit* + *Jeevamrit*, 5 or 10 per cent *Jeevamrit* and absolute control. Integrated nutrient management

Table 2. Effect of nutrient management treatments on yield and economics of sorghum + pearl millet hybrids (mean of two years)

Treatments	Green fodder yield (t/ha)			Dry fodder yield (t/ha)			Economics	
	Cut I	Cut II	Total	Cut I	Cut II	Total	Net returns (Rs./ha)	Net returns per rupee invested
Absolute control	12.02	7.61	19.63	1.81	1.38	3.19	19004	0.62
5% *Jeevamrit*	12.88	8.41	21.29	1.99	1.57	3.56	21229	0.64
10% *Jeevamrit*	13.40	8.42	21.82	2.09	1.57	3.66	21954	0.64
Beejamrit + 5% *Jeevamrit*	14.64	8.88	23.52	2.34	1.70	4.04	26622	0.81
Beejamrit + 10% *Jeevamrit*	14.66	9.04	23.70	2.35	1.73	4.07	26472	0.77
10 t/ha FYM + 5% *Jeevamrit*	20.93	12.05	32.98	3.43	2.36	5.78	26311	0.50
10 t/ha FYM + 10% *Jeevamrit*	19.69	12.71	32.40	3.17	2.51	5.68	24286	0.47
50% recommended N + 10 t/ha FYM + 5% *Jeevamrit*	31.22	15.78	47.00	5.62	3.24	8.85	55371	0.86
50% recommended N + 10 t/ha FYM + 10% *Jeevamrit*	31.45	15.84	47.29	5.70	3.26	8.95	55496	0.84
Recommended NPK	30.90	15.64	46.54	5.49	3.19	8.68	79049	2.09
SEm+	0.80	0.40	0.95	0.14	0.10	0.19	2363	0.06
CD (P=0.05)	2.39	1.19	2.84	0.42	0.31	0.56	7089	0.18

Table 3. Effect of nutrient management treatments on nutrient content (%), nutrient uptake (kg/ha), crude protein content (%) and crude protein yield (q/ha) of sorghum + pearl millet hybrids (mean of two years)

Treatments	Nutrient content (%)			Nutrient uptake (kg/ha)			Crude protein content (%)		Crude protein yield (q/ha)		
	N	P	K	N	P	K	I Cut	II Cut	I Cut	II Cut	Total
Absolute control	0.99	0.18	0.91	32.14	5.83	29.11	7.11	5.22	1.29	0.73	2.01
5% *Jeevamrit*	1.00	0.19	0.93	36.37	6.86	33.14	7.18	5.33	1.43	0.84	2.27
10% *Jeevamrit*	1.03	0.19	0.94	38.22	6.96	34.34	7.26	5.51	1.52	0.87	2.39
Beejamrit + 5% *Jeevamrit*	1.07	0.21	0.96	43.86	8.20	38.73	7.33	6.04	1.72	1.02	2.74
Beejamrit + 10% *Jeevamrit*	1.04	0.21	0.95	42.90	8.29	39.17	7.16	5.75	1.69	1.00	2.69
10 t/ha FYM + 5% *Jeevamrit*	1.17	0.24	1.06	68.42	14.02	61.70	7.89	6.68	2.70	1.58	4.28
10 t/ha FYM + 10% *Jeevamrit*	1.17	0.25	1.07	66.76	13.85	60.59	7.82	6.77	2.48	1.70	4.18
50% recommended N + 10 t/ha FYM + 5% *Jeevamrit*	1.28	0.29	1.21	114.89	25.05	108.12	8.55	7.41	4.78	2.41	7.19
50% recommended N + 10 t/ha FYM + 10% *Jeevamrit*	1.28	0.28	1.20	116.83	24.49	108.08	8.58	7.44	4.87	2.42	7.28
Recommended NPK	1.26	0.27	1.16	110.66	22.75	101.12	8.37	7.40	4.57	2.37	6.94
SEm+	0.04	0.01	0.03	3.69	0.91	2.82	0.33	0.27	0.20	0.12	0.24
CD (P=0.05)	0.11	0.02	0.09	11.06	2.74	8.45	0.99	0.81	0.58	0.36	0.71

resulted in 72.24, 67.82, 62.43, 41.57 and 4.14 per cent more total crude protein yield over absolute control, *Jeevamrit*, natural farming, organic and inorganic nutrient management, respectively. The difference in crude protein yield in all treatments can be mainly attributed to the variations in crude protein content but more pronouncedly due to the dry fodder yield (Table 2) under respective treatments. Integrated use of FYM and inorganic fertilizers in sorghum resulted in higher crude protein yield [39]. Yadav et al. [30] obtained higher crude protein yield with the application of 100 kg N/ha through urea which was closely followed by the application of 50 kg N through urea + 50 kg N/ha through FYM in pearl millet crop.

4. CONCLUSION

It can be concluded that in fodder sorghum and pearl millet hybrids, application of 50 per cent recommended N + 10 t/ha FYM + 10 or 5 % *Jeevamrit* and recommended NPK through inorganic sources are found to be most promising nutrient management practices for obtaining highest fodder yield and profit. Therefore it can be suggested to farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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