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# Growth, yield and economics of fodder maize (*Zea mays*) as influenced by Jeevamrutha formulations under varying nutrient levels

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ABSTRACT

A split plot experiment was conducted at research farm of Agronomy Section, ICAR–National Dairy Research Institute, Karnal, Haryana during *kharif* 2018–19 to evaluate various jeevamrutha formulations under the varying nutrient levels in fodder maize (*Zea mays* L.). In main plot four nutrient levels [Control (0), 50, 75 and 100% RDF] and in sub-plot, five jeevamrutha formulations [Control (without jeevamrutha), water based jeevamrutha @1000 l/ha, water based jeevamrutha @1500 l/ha, whey based jeevamrutha @1000 l/ha and whey based jeevamrutha @1500 l/ha] were taken as treatments and replicated thrice. Better growth attributes, viz. plant height, number of leaves per plant, stem girth and leaf:stem ratio were observed with increased nutrient levels. Application of 50, 75 and 100% RDF resulted in 35.01, 61.21 and 74.19% higher green fodder yield (GFY) over control. Jeevamrutha (whey/water based) formulations significantly improved growth. Significantly higher dry matter yield (DMY) (11.65 t/ha) was obtained with 100% RDF. Whey based jeevamrutha formulation @1500 l/ha ((52.83 and 11.09 t/ha) closely followed by water based jeevamrutha formulation @1500 l/ha (51.38 and 10.79 t/ha) resulted in higher GFY and DMY, respectively. The highest gross returns and net returns were obtained in 100% RDF with whey based jeevamrutha @1500 l/ha (₹94.89 and 70.32 × $10^3$/ha, respectively). Maximum benefit:cost ratio (2.89) was recorded in 100% RDF and water based jeevamrutha formulation @1500 l/ha. Interaction effect between jeevamrutha formulation and nutrient levels suggested that application of jeevamrutha formulation @1500 l/ha in both forms (Whey and water) can save 25% nutrient dose.

**Keywords:** Dry matter yield, Fodder maize, Green fodder yield, Jeevamrutha formulations

Around 20.5 million people depend on livestock for their livelihood, contributing nearly 4.11% and 25.6% of the national GDP and agriculture GDP, respectively (Anonymous 2017). Dairying accounts for over 65% of the value of output in the cattle business (Anonymous 2018). The Indian dairy sector produces 18.5% of the world's milk (Anonymous 2012). Contrary to its size and milk production, India's cattle productivity is only about 1000 kg/lactation, or 40–60% of the worldwide average (Anonymous 2018). Lack of quality feed (Kumar *et al.* 2018) and green fodder contribute to our cattle's poor productivity (Anonymous 2016). Demand for green fodder and dry forage will climb to 1012 million tonnes (MT) and 631 MT by 2050, respectively, therefore supply of green fodder must increase by 1.69% annually (Anonymous 2018). Maize is the best fodder crop in *kharif* due to its high productivity and nutritional value (Kumar *et al.* 2017). Fodder maize has 9–11% crude protein, 60–64% neutral detergent fibre, 38–41% acid detergent fibre, 28–30% cellulose, and 23–25% hemicellulose (Das *et al.* 2015). Productivity and quality of fodder crops is affected by several agronomic practices (Kumar *et al.* 2018). Nutrient management practice is of utmost importance (Kumar *et al.* 2017). The rising inorganic fertilizer costs and declining soil health have pushed the use of organic sources. As shown by Manjunatha *et al.* (2009), Amareswari *et al.* (2014), organic liquid formulations like jeevamrutha may play a significant role in nutrient management. Vitamins, amino acids, and helpful bacteria are found in these (Palekar 2006). Whey is a by-product of the dairy industry, and its handling is problematic (Macwan *et al.* 2016). Environmentalists and technologists are concerned about using it as an effluent because it has a high biological oxygen demand and chemical oxygen demand (Siso *et al.* 1996). Whey waste represents a major loss of valuable nutrients (Macwan *et al.* 2016). Keeping above points in view, this research was undertaken to investigate the potential advantage of jeevamrutha formulations with varied nutritional levels in fodder maize crop.

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## MATERIALS AND METHODS

The study was carried out at research farm of Agronomy

Section, ICAR-National Dairy Research Institute, Karnal (Haryana) during *kharif* season, 2018–19. The climate of this zone is sub-tropical. This zone receives rainfall from both southwest and northeast monsoon. The soil of the experimental field was near neutral in reaction, medium in organic carbon and low in available nitrogen, medium in available phosphorus and potassium. The texture of the soil was sandy clay loam. As per Haryana state recommendation, recommended dose of fertilizer (100% RDF; 120:40:40 NPK kg/ha) was adopted. Sowing was done manually with J-1006 variety of maize. The experiment was laid out in split-plot design and replicated thrice. Four fertilizer levels (RDF) ($F_0$: control, $F_1$: 50% RDF, $F_2$: 75% RDF and $F_3$: 100% RDF) were assigned as mainplot treatments and in sub-plot, five jeevamrutha formulations ($J_0$: control, $J_1$: water based jeevamrutha @1000 l/ha, $J_2$: water based jeevamrutha @1500 l/ha, $J_3$: whey based jeevamrutha @1000 l/ha and $J_4$: whey based jeevamrutha @1500 l/ha) were taken. In main plots half dose of nitrogen, whole phosphorus and potassium was applied as basal, while remaining half N was top dressed at 25 DAS. In sub-plots jeevamrutha formulations were applied in two equal splits at 10 and 20 DAS as a soil application. Palekar (2006) method was followed for preparation of water based Jeevamrutha. Similarly, whey based jeevamrutha was prepared using whey and water in 50:50 ratio.

Biometric observations, viz. plant height, numbers of leaves and stem girth were recorded at 30 DAS and harvest stage. Crop was harvested at ~60 DAS when 50% flowering was observed in the field. At the time of harvesting a representative plant sample (1.0 kg fresh weight) was collected from each plot to estimate dry matter and nutrient contents. Nutrient uptake by the crop was calculated by multiplying dry matter yield and nutrient content. Statistical analysis was done using standard procedures of analysis of variance in split plot using OPSTAT software and statistical mean differences were found by Fisher's protected least significant difference test at $P<0.05$.

## RESULTS AND DISCUSSION

*Growth attributes*: Growth attributes were significantly influenced by jeevamrutha formulations under varying nutrient levels (Table 1). Among fertilizer levels, significantly taller plants (88.78 and 262.25 cm) were observed in $F_3$ treatment (100% RDF) whereas, shorter height (51.17 and 231.18 cm) was noticed with $F_0$ (control) at 30 DAS and harvest stage, respectively. Among the jeevamrutha formulations, significantly greater height was observed in $J_4$ (whey-based formulation @1500 l/ha) 81.96 and 258.21 cm at 30 DAS and harvest, respectively, and followed by $J_2$ (water based jeevamrutha formulation @1500 l/ha) (79.55 and 253.83 cm). Improvement in height at higher level of fertilizers, may be attributed to the fact that, with higher availability, uptake and utilization of nutrients protein and carbohydrate synthesis increased which might have helped in increased cell division, cell elongation and photosynthetic

Table 1 Growth attributes, yield [Green fodder yield (GFY) and dry matter yield (DMY)] and nutrient uptake as influenced by jeevamrutha formulations under varying nutrient levels

| Treatment | Growth attributes | | | | | | | Yield (t/ha) | | Nutrient uptake (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plant height (cm) | | No. of leaves | | Stem girth (cm) | | Leaf: stem ratio | | | | | |
| | 30 DAS | At harvest | 30 DAS | At harvest | 30 DAS | At harvest | At harvest | GFY | DMY | N | P | K |
| *Fertilizer level* | | | | | | | | | | | | |
| $F_0$: Control | 51.17 | 231.18 | 5.74 | 7.15 | 4.55 | 5.29 | 0.30 | 32.51 | 7.14 | 91.99 | 15.77 | 97.00 |
| $F_1$: 50% RDF | 69.98 | 240.95 | 7.67 | 11.27 | 5.30 | 6.43 | 0.33 | 43.89 | 9.57 | 135.82 | 22.58 | 142.06 |
| $F_2$: 75% RDF | 84.17 | 254.55 | 9.11 | 12.97 | 5.41 | 6.66 | 0.35 | 52.41 | 10.77 | 159.72 | 28.65 | 164.46 |
| $F_3$:100%RDF | 88.78 | 262.25 | 10.72 | 14.08 | 5.64 | 7.10 | 0.37 | 56.63 | 11.65 | 184.12 | 32.35 | 183.31 |
| SEm± | 1.25 | 1.74 | 0.08 | 0.22 | 0.06 | 0.11 | 0.01 | 0.83 | 0.25 | 4.45 | 1.69 | 3.22 |
| CD (P=0.05) | 3.97 | 5.54 | 0.26 | 0.70 | 0.20 | 0.34 | 0.04 | 2.64 | 0.81 | 14.17 | 5.38 | 10.25 |
| *Jeevamrutha formulation* | | | | | | | | | | | | |
| $J_0$:Control | 60.80 | 226.72 | 6.58 | 9.97 | 4.98 | 5.09 | 0.30 | 38.6 | 8.23 | 114.66 | 18.86 | 113.81 |
| $J_1$: Water based @1000 l/ha | 72.14 | 248.09 | 8.58 | 11.11 | 5.12 | 6.20 | 0.32 | 43.74 | 9.29 | 134.43 | 22.56 | 137.51 |
| $J_2$: Water based @1500 l/ha | 79.55 | 253.83 | 8.88 | 12.06 | 5.28 | 6.78 | 0.35 | 51.38 | 10.79 | 161.34 | 28.03 | 166.10 |
| $J_3$: Whey based @1000 l/ha | 73.18 | 249.31 | 8.59 | 11.48 | 5.14 | 6.59 | 0.33 | 45.23 | 9.51 | 137.93 | 24.44 | 142.11 |
| $J_4$: Whey based @1500 l/ha | 81.96 | 258.21 | 8.93 | 12.22 | 5.61 | 7.20 | 0.38 | 52.83 | 11.09 | 166.18 | 30.29 | 174.00 |
| SEm± | 1.85 | 2.69 | 0.12 | 0.26 | 0.14 | 0.16 | 0.01 | 0.99 | 0.26 | 4.24 | 0.61 | 3.64 |
| CD (P=0.05) | 5.14 | 7.48 | 0.32 | 0.72 | 0.39 | 0.45 | 0.04 | 2.76 | 0.71 | 11.78 | 1.70 | 10.10 |

activity. These results are in conformity with the findings of Jadav *et al.* (2018). Increased height in $J_4$ and $J_2$ could be due to balanced supply of essential nutrients through jeevamrutha formulations. Similar results were reported by Kumar *et al.* (2016).

Within fertilizer levels, significantly more number of leaves (10.72 and 14.08) were counted in 100% RDF compared to rest of the fertilizer levels at 30 DAS and at harvest, respectively (Table 1). Similar results were obtained by Onasanya *et al.* (2009), Jadav *et al.* (2018). Whey based jeevamrutha formulation $J_4$ noted markedly higher number of leaves (8.93 and 12.22) over other treatments of jeevamrutha formulation except $J_2$ (8.88 and 12.06) at 30 DAS and harvest, respectively. The beneficial effect with application of organic fertilizer such as FYM and jeevamrutha on number of leaves was also shown by Yogananda *et al.* (2020).

Application of 100% RDF recorded significantly higher stem girth (5.64 and 7.10 cm) at 30 DAS and harvest stage, respectively, over rest of nutrient levels. Considerably higher stem girth (5.61 and 7.20 cm at 30 DAS and at harvest stage, respectively) was recorded with $J_4$ as compared to other Jeevamrutha formulations except $J_2$ (5.28 and 6.78 cm). These results are in line with Boraiah *et al.* (2017), Ramesh *et al.* (2018), Safiullah *et al.* (2018).

The significantly higher leaf:stem ratio (0.37) was observed in $F_4$ (100% RDF) compared to $F_0$ (control) (Table 1). Higher leaf:stem ratio in $F_4$ may be due to more number of leaves per plant, higher leaf length and width. Among jeevamrutha formulations, whey based jeevamrutha @1500 l/ha (0.38) remained at par with water based jeevamrutha @1500 l/ha (0.35) and recorded markedly higher ratio.

*Yield:* Green fodder yield (GFY) as well as dry matter yield (DMY) was significantly influenced by nutrient levels and jeevamrutha formulations (Table 1). Highest GFY was achieved with $F_4$ treatment (100% RDF; 56.63 t/ha). Over control, the extent of enhancement in GFY through application of 50, 75 and 100% RDF was 35.01, 61.21 and 74.19%, respectively. Increase in the GFY at higher rate of RDF could be due to more availability of nutrients in the rhizosphere, easy transformation and more uptake of nutrients, resulting in vigorous plant growth ultimately yield.

Among the jeevamrutha formulations, $J_4$ recorded significantly maximum GFY compared to rest of the treatments. Magnitude of increase was 36.83% by imposition of $J_4$ treatment over $J_0$ (no jeevamrutha formulation). These results are in agreement with the findings of Siddappa *et al.* (2016). Interaction between jeevamrutha formulation and nutrient levels caused significant variations in GFY (Fig 1). Association of $F_3$ and $J_4$ being at par with $F_3 + J_2$ recorded considerably higher GFY. Hence, it is pertinent to mention that 25% of fertilizer dose can be saved through application of jeevamrutha formulation @1500 l/ha (either in whey or water).

$F_3$ resulted in highest DMY (11.65 t/ha) (Table 1). Magnitude of increments in DMY were 34.03, 50.84 and 63.17% through application of 50, 75 and 100% RDF, respectively, over control. Similar findings were also reported by Jadav *et al.* (2018). Water and whey based jeevamrutha formulation @1500 l/ha ($J_2$ and $J_4$) had at par DMY with respective value of 10.79 and 11.09 t/ha. Among different interaction effects (Fig 2), combinations of $F_3$ with $J_2$ (12.97 t/ha) and $F_3$ with $J_4$ (12.73 t/ha) resulted in higher DMY.

*Nutrient uptake:* Jeevamrutha formulations as well as nutrient levels brought significant variations in nutrient uptake (Table 1). The uptake of N, P and K significantly increased with successive increase in nutrient levels. Maximum uptake of N, P and K (184.1, 32.55 and 181.31 kg/ha, respectively) was observed in $F_3$ (100% RDF). Whereas amid jeevamrutha formulation, significantly higher uptake of N, P and K (166.18, 30.29 and 174 kg/ha, respectively) was recorded with application of whey based jeevamrutha formulation @1500 l/ha. Higher uptake might be due to increased growth attributes and yield. Similar results have been reported by Siddaram (2012).

*Economics:* Profitability/economics in terms of gross returns (GR), net returns (NR) and benefit:cost ratio (BCR) varied with different treatments (Table 2). 100% RDF with whey based jeevamrutha @1500 l/ha (₹94.89 and $70.32 \times 10^3$/ha) followed by 100% RDF with water based jeevamrutha @1500 l/ha (₹92.93 and $68.37 \times 10^3$/ha) showed higher GR and NR, respectively. Hoverer, the lowest GR and NR was obtained in control ($F_0J_0$). 1500 l/ha water based jeevamrutha with 100% RDF ($F_2J_4$) (2.89) followed by 100% RDF with whey based jeevamrutha @ 1500 l/ha ($F_3J_4$) (2.86) had higher BCR.

Our results suggested that $F_3$ treatment (100% RDF)

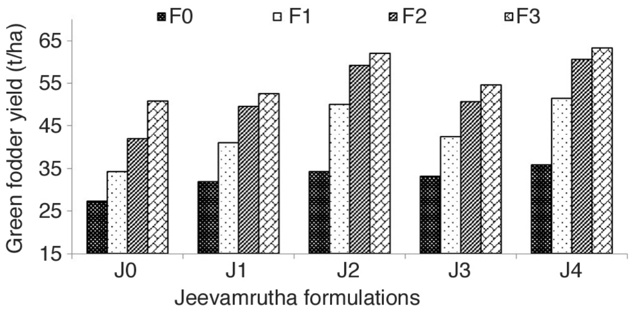


Fig 1 Interaction effect of jeevamrutha formulations under varying fertilizer levels on green fodder yield.

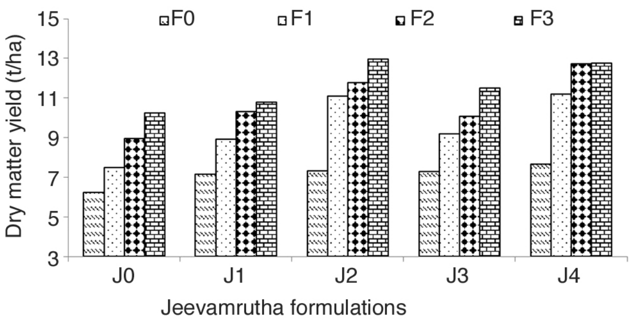


Fig 2 Interaction effect of jeevamrutha formulations under varying fertilizer levels on dry matter yield.

Table 2 Economics of jeevamrutha formulations under varying nutrient levels on fodder maize

| Treatment | Gross returns (₹ × $10^3$ ha) | Net returns (₹ × $10^3$ ha) | B:C ratio |
|---|---|---|---|
| $F_0J_0$ | 41.03 | 25.82 | 1.70 |
| $F_0J_1$ | 47.83 | 30.36 | 1.74 |
| $F_0J_2$ | 51.35 | 33.04 | 1.80 |
| $F_0J_3$ | 49.77 | 32.30 | 1.85 |
| $F_0J_4$ | 53.81 | 35.49 | 1.94 |
| $F_1J_0$ | 51.48 | 32.38 | 1.70 |
| $F_1J_1$ | 61.54 | 40.18 | 1.88 |
| $F_1J_2$ | 75.18 | 52.98 | 2.39 |
| $F_1J_3$ | 63.69 | 42.33 | 1.98 |
| $F_1J_4$ | 77.26 | 55.06 | 2.48 |
| $F_2J_0$ | 62.97 | 42.69 | 2.11 |
| $F_2J_1$ | 74.29 | 51.75 | 2.30 |
| $F_2J_2$ | 88.80 | 65.41 | 2.80 |
| $F_2J_3$ | 75.95 | 53.41 | 2.37 |
| $F_2J_4$ | 91.01 | 67.63 | 2.89 |
| $F_3J_0$ | 76.16 | 54.70 | 2.55 |
| $F_3J_1$ | 78.78 | 55.06 | 2.32 |
| $F_3J_2$ | 92.93 | 68.37 | 2.78 |
| $F_3J_3$ | 81.95 | 58.23 | 2.46 |
| $F_3J_4$ | 94.89 | 70.32 | 2.86 |

proved superior among tested RDF levels in terms of growth, yield, nutrient uptake as well as economic attributes. Among jeevamrutha formulations whey based formulation @1500 l/ha performed better with respect to aforesaid parameters. Water based formulation @1500 l/ha was at par with whey based formulation. The interaction effect suggested that 75% RDF with whey based formulation @1500 l/ha and 75% RDF with water based formulation @1500 l/ha could be used to reduce 25% nutrient dose.

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