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Arun S Shelke

Assistant Professor, Department of
Agronomy, College of Agriculture,
Khandala, Vaijapur, Chh.
Sambhajnagar, Maharashtra,
India

Dr. NK Patke

Head and Associate Professor,
AICRP on Medicinal & Aromatic
Plants and Betelvine Nagarjun
medicinal Plants Garden, Dr.
PDKV, Akola, Maharashtra, India

Dattatraya F Shinde

Assistant Professor, Department of
Agro-meteorology, College of
Agriculture, Khandala, Vaijapur,
Chh. Sambhajnagar, Maharashtra,
India

Effect of integrated nutrient management on growth & yield contributing characters of Kalmegh (*Andrographis paniculata*)

Arun S Shelke, NK Patke and Dattatraya F Shinde

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Abstract

Kalmegh (*Andrographis paniculata*), a significant medicinal plant, is widely recognized for its therapeutic properties, including, immune-stimulatory, anti-inflammatory, and antiviral effects. This study investigated the impact of organic manures and inorganic fertilizers on the growth and yield of Kalmegh. The experiment was conducted in a factorial randomized block design with three levels of organic manures control (M1), FYM @ 5 t/ha (M2), and vermicompost @ 2.5 t/ha (M3) and four inorganic fertilizer levels control (F1), 50% RDF (F2), 75% RDF (F3), and 100% RDF (F4). Results indicated that vermicompost @ 2.5 t/ha (M3) and 100% RDF (80:40:50 kg NPK/ha) each demonstrated significantly higher growth and yield parameters, including plant height, number of branches, dry weight, and fresh and dry foliage yield. Vermicompost (M3) provided readily available nutrients and beneficial microorganisms, enhancing soil structure and nutrient uptake, while 100% RDF (F4) delivered optimal nutrient supply for vigorous growth. Interaction effects were non-significant for most parameters, but both treatments independently enhanced seed yield, highlighting their effectiveness in improving vegetative growth and productivity. The findings underscore the importance of integrating organic and inorganic fertilizers for sustainable cultivation of Kalmegh, balancing high yield with ecological sustainability.

Keywords: Growth, yield, vermicompost, organic manures, inorganic fertilizers

Introduction

India is home to a diverse range of medicinal plants thriving in forests and uncultivated regions. In the current era of globalization and the World Trade Organization, the demand for these medicinal plants has grown exponentially. Kalmegh (*Andrographis paniculata*), an important medicinal plant from the Acanthaceae family, has been utilized in traditional Indian medicine for centuries. The entire plant holds medicinal value, with its fresh and dried leaves, as well as the extracted juice, recognized as effective treatments in the Indian system of medicine. Kalmegh (*Andrographis paniculata*) is known for its diverse medicinal properties, including antihepatotoxic, antibiotic, antimalarial, antihepatitic, antithrombogenic, and anti-inflammatory effects (Thiyagarajan *et al.*, 2011) ^[10]. It is also widely recognized for its role as an immune stimulant (Burgos *et al.*, 2009) ^[1]. Among medicinal plants, *Andrographis paniculata* is particularly valued for its anti-HIV properties. Pharmacological research highlights its anti-inflammatory (Shen *et al.*, 2002) ^[9], antipyretic, antiviral, immune-stimulatory, anticancer, anti-hyperglycemic, anti-snake venom, and antioxidant benefits (Zhang and Tan, 2000) ^[11].

The growth of Kalmegh is significantly influenced by environmental factors, which directly impact the plant's physiological processes. Fertilizers are essential for promoting plant growth and development, affecting both the quality and quantity of yield. However, the use of chemical fertilizers can sometimes lead to physiological imbalances in plants, negatively impacting their quality and productivity. While chemical fertilizers can enhance the production of medicinal plants by providing necessary nutrients, but, their prolonged and excessive use can degrade soil health and reduce the medicinal value of the crops. To improve crop quality, particularly in medicinal and aromatic plants (MAPs), organic manures are often preferred as a sustainable alternative to chemical fertilizers. However, complete replacement of inorganic fertilizers with organic manures is not practical due to their low nutrient content, which necessitates large quantities that may be challenging to source consistently.

Corresponding Author:

Arun S Shelke

Assistant Professor, Department of
Agronomy, College of Agriculture,
Khandala, Vaijapur, Chh.
Sambhajnagar, Maharashtra,
India

Therefore, a combination of organic manures and inorganic fertilizers is essential for enhancing crop yield while preserving soil health and supporting ecological sustainability over the long term. This study was designed to assess the impact of various types and application rates of organic manures and inorganic fertilizers on the growth and yield of Kalmegh.

Materials and Methods

The experimental site for investigation was Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The laboratory work was carried out in the Department of Agronomy, Post Graduate Institute, Akola. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Akola is situated in the sub-tropical zone at the latitude of 22°42' North longitude of 77°02' East. The altitude of the place is 307.41 meter above mean sea level.

The total rainfall received during Kalmegh crop growing period i.e. 24th MW to 52nd MW was 823.7 mm in 43 rainy days as against normal rainfall of 738.4 mm in 41.5 rainy days (1971-2010). The total rainfall received during crop growth period was 11% more than the normal and distribution was uniform during vegetative growth stages of Kalmegh crop. The experimental soil was deep black, having good drainage as well as a good water holding capacity and reasonably suitable for Kalmegh growth. The soil was low in available N and medium in available P₂O₅ as well as K₂O. Nursery was sown on raised beds of 15-20 cm height, 1.0 m width and of 10 m length. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three levels of organic manures viz. M 1-Control, M2-FYM @ 5 t/ha, M-3 Vermicompost @ 2.5 t/ha and four inorganic fertilizer levels viz. F1-Control, F 2-50% RDF (40:20:25 kg NPK/ha), F3 75% RDF (60:30:37.5 kg NPK/ha) and F-4 100% RDF (80:40:50 kg NPK/ha) with twelve treatment combinations replicated thrice. The seeds were sown in rows at 10 cm distance at shallow depth, 5.0 cm apart and lightly covered with finely sieved soil. The Kalmegh nursery was sown in 24th MW (Meteorological Week) and transplanted in 32nd MW i.e. 54 DAS. Transplanting delayed due to continuous and heavy rains in the month of July. The required quantities of vermicompost and FYM for gross plot area were computed as per their N contents and manually applied in respective plots as per the treatments. Half dose of nitrogen and full dose of phosphorus and potassium was applied as basal dose and remaining half dose of nitrogen was applied in two splits at 30 and 60 DAT. The nutrient content in vermicompost and FYM.

Results and Discussion

Growth contributing characters

The data pertaining to plant height and number of branches per plant recorded during harvest of Kalmegh is presented in Table 1.

Plant height (cm)

Effect of Organic manure

The plant height was significantly influenced by organic manure. Treatment M3 (Vermicompost @ 2.5 t/ha) resulted in significantly higher plant height as compared to treatment M1 (control) and was found at par with M2 (FYM @5 t/ha). The nutrient concentration of vermicompost is higher when compared to FYM and hence higher plant height was recorded M3 (Vermicompost @ 2.5 t/ha) at all growth stages followed by M2 (FYM @ 5 t/ha). The superior performance of M3 can be attributed to the higher nutrient concentration in vermicompost compared to FYM. Vermicompost provides readily available

nutrients, including nitrogen, phosphorus, and potassium, along with beneficial microorganisms that improve nutrient uptake and soil health. Additionally, it enhances soil structure, aeration, and water retention, creating an ideal environment for root development and plant growth. While FYM also improves soil fertility, its nutrient release is slower and less concentrated compared to vermicompost, which explains the slightly lower performance of M2 compared to M3. These results were in agreement with the findings of Parashar *et al.* (2011) [6], Ramesh *et al.* (2011) [7], Kamal and Yousuf (2012) [4] and Goel and Duhan *et al.* (2013) [2].

Effect of Inorganic fertilizer doses

The plant height was significantly influenced by the different doses of inorganic fertilizers. Among the treatments, F4 (100% RDF: 80:40:50 kg NPK/ha) resulted in the highest plant height, which was significantly greater than that of the control (F1). However, the plant height under F4 was statistically on par with F3 (75% RDF: 60:30:37.5 kg NPK/ha). This increase in plant height under F4 can be attributed to the balanced and adequate supply of essential nutrients (nitrogen, phosphorus, and potassium) at optimal levels, which play a vital role in cell division, elongation, and overall vegetative growth. Nitrogen likely contributed to enhanced foliage development, phosphorus supported root establishment and energy transfer, and potassium improved water and nutrient uptake efficiency. These synergistic effects of the nutrients explain the superior performance of F4 compared to other treatments. These results were in agreement with the findings of Sanjutha *et al.* (2008) [8].

Interaction effect

The interaction effect between organic manure and inorganic fertilizer doses was found non-significant.

Number of branches per plant

Effect of Organic manure

Treatment M3 (Vermicompost @ 2.5 t/ha) significantly superior over M1 (control) and was at par with M2 (FYM @ 5 t/ha). The possible reason for higher number of branches per plant might be due to better flow of various micro and macro-nutrients along with plant growth substances into the plant system, resulted for stimulation and production of auxiliary buds resulting in formation of a greater number of branches. These are in agreement with the findings of Ramesh *et al.* (2011) [7], studied interactive influence of organic and inorganic fertilizers on the growth and yield of Kalmegh.

Effect of Inorganic fertilizer doses

The no of branches was influenced significantly due to the inorganic fertilizer doses at all growth stages. Amongst different inorganic fertilizer doses, treatment F4 100% RDF (80:40:50 kg NPK/ha) was recorded significantly higher plant height as compared to treatment F1 (control) during all the growth stages and was found at par with treatment F3 75% RDF (60:30:37.5 kg NPK/ha) and treatment F2 50% RDF (40:20:25 kg NPK/ha). The growth parameters including plant height, number of leaves per plant and number of branches per plant were also significantly influenced by the application of inorganic fertilizers, under integrated nutrient management. Although, vermicompost alone and under integrated nutrient management, increased the growth parameters significantly compared to control but they were not significantly different from inorganic fertilizers. These effects collectively explain the higher branching observed in treatments with higher fertilizer doses. (Naik and Babu, 2007) [5].

Interaction effect

The interaction effect between organic manure and inorganic fertilizer doses was found non-significant.

Yield contributing characters

The data on fresh and dry foliage yield and seed yield per plant of Kalmegh at harvest as influenced by different organic manure and inorganic fertilizer doses is presented in Table 2.

Fresh Foliage Yield per Plant (g)

Effect of Organic manure

The effect of organic manure on mean fresh foliage yield per plant was found to be significant. Treatment M3 (Vermicompost @ 2.5 t/ha) was recorded significantly higher fresh foliage yield per plant (61.80 g) as compared to treatment M1 control (46.63 g) and was found at par with treatment M2-FYM @ 5 t/ha (60.47 g). Increased fresh foliage yield might be due to the increased plant growth parameters and improvement in soil physical properties due to application of vermicompost. (Sanjutha *et al.*, 2008) [18].

Effect of Inorganic fertilizer doses

The effect of inorganic fertilizer doses on mean fresh foliage yield per plant was found to be significant. Amongst different inorganic fertilizer doses, treatment F4 100% RDF (80:40:50 kg NPK/ha) was recorded significantly higher fresh foliage yield per plant i.e. 59.36 g as compared to treatment F1 (control) i.e. 52.16 g and F2 50% RDF (40:20:25 kg NPK/ha) i.e. 55.54 g and was found at par with treatment F3 75% RDF (60:30:37.5 kg NPK/ha) i.e. 58.14 g.

Interaction effect

Mean fresh foliage yield per plant (g) was non-significantly influenced by treatments interaction.

Dry Foliage Yield per Plant (g)

Effect of Organic manure

The effect of organic manure on mean dry foliage yield per plant was found to be significant. Treatment M3 (Vermicompost @ 2.5 t/ha) was recorded significantly higher dry foliage yield per plant i.e., 40.67 g as compared to treatment M1 (control) i.e. 30.88 g and was found at par with treatment M2 (FYM @ 5 t/ha) i.e. 39.52 g. The significantly higher dry foliage yield in Treatment M3 (Vermicompost @ 2.5 t/ha) compared to the control (M1) and its parity with M2 (FYM @ 5 t/ha) can be attributed to the nutrient-rich composition of vermicompost, which provides readily available macronutrients and micronutrients essential for plant growth. Additionally, vermicompost improves soil properties by enhancing structure, aeration, and water retention, fostering better root development. It also introduces beneficial microorganisms that promote nutrient cycling and efficient uptake. The presence of plant growth-promoting substances such as humic acids, auxins, and cytokinins further stimulates foliage development. Moreover, vermicompost ensures a sustained nutrient release, supporting continuous plant growth and biomass accumulation, leading to a significant increase in dry foliage yield.

Effect of Inorganic fertilizer doses

The effect of inorganic fertilizer doses on mean dry foliage yield per plant was found to be significant. Amongst different inorganic fertilizer doses, treatment F4 100% RDF (80:40:50 kg NPK/ha) was recorded significantly higher dry foliage yield per plant i.e. 39.00 g as compared to treatment F1 (control) i.e.

34.35 g and was found at par with treatment F2 50% RDF (40:20:25 kg NPK/ha) i.e. 36.56 g and treatment F3 75% RDF (60:30:37.5 kg NPK/ha) i.e. 38.19 g. The significantly higher dry foliage yield observed in Treatment F4 (100% RDF: 80:40:50 kg NPK/ha) can be attributed to the balanced and optimal supply of nitrogen, phosphorus, and potassium in adequate quantities. Nitrogen supports vigorous vegetative growth and foliage development, phosphorus enhances root establishment and energy transfer within the plant, and potassium improves water regulation and nutrient uptake. These nutrients collectively promote efficient photosynthesis, biomass accumulation, and overall plant health. The superior performance of F4 compared to the control (F1) and its parity with F3 (75% RDF) and F2 (50% RDF) highlights the role of nutrient sufficiency in achieving higher yields, as lower doses of fertilizers may have provided less optimal conditions for maximum growth and dry matter accumulation.

Interaction effect

Mean dry foliage yield per plant (g) was non-significantly influenced by organic and inorganic fertilizer interaction. This suggests that while both organic manures (e.g., vermicompost and FYM) and inorganic fertilizer doses individually affected the dry foliage yield, their combined application did not result in a statistically significant difference in yield. It indicates that the impact of organic and inorganic treatments on dry foliage yield might be independent, with each contributing to plant growth and productivity but not showing a synergistic effect when applied together. The results imply that optimizing either treatment alone could be sufficient for achieving desired growth outcomes and combining them may not necessarily enhance yield further under the conditions tested.

Seed Yield per Plant (mg)

Effect of Organic manure

The effect of organic manure on mean seed yield per plant was found to be significant. Treatment M3 (Vermicompost @ 2.5 t/ha) was recorded significantly higher mean seed yield per plant i.e. 2.86 mg as compared to treatment M1 (control) i.e. 2.04 mg and was found at par with treatment M2 (FYM @ 5 t/ha) i.e. 2.72 mg. The better vegetative growth due to vermicompost along with inorganic fertilizers might have reflected in increased production of flowers, more number of pods per plant subsequently higher seed yield per plant. More pods per plant due to vermicompost under integrated nutrient management could be attributed to the presence of B group vitamins, plant hormones (cytokinin and auxin) and chemicals exudates released during biological activity promoted by the vermicompost in the soil (Kale and Krishnamoorthi, 1981) [13].

Effect of Inorganic fertilizer doses

The effect of inorganic fertilizer doses on mean seed yield per plant was found to be significant. Amongst different inorganic fertilizer doses, treatment F4 100% RDF (80:40:50 kg NPK/ha) was recorded significantly higher seed yield per plant i.e. 2.81 mg as compared to treatment F1 (control) i.e. 2.22 mg, F2 50% RDF (40:20:25 kg NPK/ha) i.e. 2.51 mg and was found at par with treatment F3 75% RDF (60:30:37.5 kg NPK/ha) i.e. 2.62 mg.

Interaction effect

Mean seed yield per plant was non-significantly influenced by organic and inorganic fertilizer interaction.

Table 1: Effect of integrated nutrient management on growth characters like plant height (cm) and number of branches per plant of Kalmegh

Treatments	Plant Height (Cm)	Number of Branches Per Plant
Factor A (Organic Manure)		
M1-Control	60.82	37.80
M2-FYM @ 5 t/ha	67.45	42.07
M3-Vermicompost@ 2.5 t/ha	69.01	42.65
SE (m) +	1.28	0.85
CD (P=0.05)	3.74	2.49
Factor B (Inorganic fertilizer doses)		
F1-Control	61.07	38.33
F2-40:20:25 kg NPK/ha (50% RDF)	65.31	40.17
F3-60:30:37.5 kg NPK/ha (75% RDF)	68.06	42.38
F4-80:40:50 kg NPK/ha (100% RDF)	68.59	42.48
SE (m) +	1.48	0.99
CD (P=0.05)	4.32	2.88
Interaction (A X B)		
SE (m) +	2.56	1.71
CD (P=0.05)	NS	NS
GM	65.76	40.84

Table 2: Effect of integrated nutrient management on fresh and dry foliage yield (g per plant) & seed yield per plant (mg) of Kalmegh at harvest

Treatments	Fresh Foliage Yield (G Per Plant)	Dry Foliage Yield (G Per Plant)	Seed Yield Per Plant (Mg)
Factor A (Organic Manure)			
M1-Control	46.63	30.88	2.04
M2-FYM @ 5 t/ha	60.47	39.52	2.72
M3-Vermicompost@ 2.5 t/ha	61.80	40.67	2.86
SE (m) +	1.15	0.83	0.07
CD (P=0.05)	3.36	2.42	0.21
Factor B (Inorganic fertilizer doses)			
F1-Control	52.16	34.35	2.22
F2-40:20:25 kg NPK/ha (50% RDF)	55.54	36.56	2.51
F3-60:30:37.5 kg NPK/ha (75% RDF)	58.14	38.19	2.62
F4-80:40:50 kg NPK/ha (100% RDF)	59.36	39.00	2.81
SE (m) +	1.33	0.96	0.08
CD (P=0.05)	3.88	2.80	0.25
Interaction (A × B)			
SE (m) +	2.30	1.66	0.15
CD (P=0.05)	NS	NS	NS
GM	56.30	37.02	2.54

Conclusion

The study concludes that the application of Vermicompost @ 2.5 t/ha and 100% RDF (80:40:50 kg NPK/ha) individually resulted in significantly improved growth and yield parameters in Kalmegh. These treatments showed superior performance in terms of plant height, number of branches, dry weight per plant, fresh and dry foliage yield, and seed yield per plant, demonstrating their effectiveness in optimizing plant growth and productivity.

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