The Pharma Innovation Journal 2023; 12(8): 1198-1202

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(8): 1198-1202

www.thepharmajournal.com
Received: 20-06-2023
Accepted: 23-07-2023

Shubham Yadav
Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

KC Meena
Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

MK Tripathi
Department of Physics and Meteorology, College of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

BK Kachouli
Department of Plant Breeding and Genetics, College of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

BK Patidar
Department of Plant Pathology, College of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Nitin Soni
Department of Fruit Sciences, College of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

DK Patida
Department of Fruit Sciences, College of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Corresponding Author:
KC Meena
Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Response of major nutrients and organic manure on growth, yield and economics of ajwain (*Trachyspermum ammi* L.)

Shubham Yadav, KC Meena, MK Tripathi, BK Kachouli, BK Patidar, Nitin Soni and DK Patida

Abstract
The primary goal of integrated nutrient management strategies is to substitute a portion of chemical fertilizers with a more sustainable and environmentally safe organic manure in order to mitigate soil degradation, improve crop production, and protect the environment. Nutrient management is closely associated with fertilizer type, application rate, application time, and application placement. Applying organic manure in combination with chemical fertilizers has become an effective approach towards nutrient management, this will maximize the agronomic value of organic manure and encourage recycling agricultural wastes into new valuable products for agricultural enhancement. Therefore, the present study was conducted to assess the impacts of different INM practices namely absolute control (T_1), 25 t/ha FYM (T_2), NPK – 40:20:20 Kg/ha + 5 t/ha FYM (T_3), NPK – 40:25:20 Kg/ha + 10 t/ha FYM (T_4), NPK – 40:30:20 Kg/ha + 15 t/ha FYM (T_5), NPK – 45:20:20 Kg/ha + 5 t/ha FYM (T_6), NPK – 45:25:20 Kg/ha + 10 t/ha FYM (T_7), NPK – 45:30:20 Kg/ha + 15 t/ha FYM (T_8), NPK – 50:20:20 Kg/ha + 5 t/ha FYM (T_9), NPK – 50:25:20 Kg/ha + 10 t/ha FYM (T_{10}) and NPK – 50:30:20 Kg/ha + 15 t/ha FYM (T_{11}) in RBD Design with three replications at Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, RVSKVV, Mandsaur, (M.P.) during the Rabi season of 2021-2022. The result indicated that treatment T_{11} showed early germination, flowering and maturity. The treatment T_{11} was recorded with superior values of plant height, number of branches plant^{-1}, fresh weight plant^{-1} and dry weight plant^{-1} at 45, 90 days after sowing and at harvest respectively. The treatment T_{11} was registered with highest value of number of umbels plant-^{1}, number of fruit umbel^{-1}, number of umbellates umbel^{-1}, number of fruit umbellate^{-1}, test weight, seed yield and highest net return while T_9 recorded best B: C ratio.

Keywords: Growth, nutrients, organic manures, phenology, *Trachyspermum ammi* and yield

1. Introduction
Ajwain (*Trachyspermum ammi* L.) is a plant of the Apiaceae family also known as Bishop's weed or Carom seed. It is grown in the Mediterranean region and South West Asian countries such as Iran, Iraq, Afghanistan, Egypt, and India. In India, it is primarily grown in the states of Rajasthan and Gujarat, with other growing states including Uttar Pradesh, Bihar, Madhya Pradesh, Punjab, Tamil Nadu, West Bengal, and Andhra Pradesh. The seeds of ajwain are the most lucrative and economical part of the plant and oil extracted from seeds used in the perfumery, essences, pharmaceutical and cosmetics. Ajwain seed gets its distinct odour and flavor from the presence of an essential oil (2-4%) that includes around 50% thymol, a powerful germicide, antispasmodic, and fungicidal agent and it is used as preservatives and flavorings in food (Thomas *et al*., 2020) [1]. Because of their aromatic scent and spicy flavour, their seeds (volatile oil) are extensively used as a spice in curry powder (Fathi *et al*., 2020) [2]. Plant nutrition is an important aspect in enhancing plant productivity (Chandravanshi *et al*., 2021 and Chundawat *et al*., 2023) [3, 4]. The integrated use of organic composts along with chemical fertilizer has been well-recognized as a vital agricultural practice to gain more benefits or at least comparable results with that of solely applying chemical fertilizers (Chouhan *et al*., 2023) [5]. The partial replacement of chemical fertilizer by manure has a significant positive impact on nutrient supply and crop yield (Lazcano *et al*, 2013) [6]. Importantly, the integrated use of organic compost and chemical fertilizers not only improves different soil properties and crop productivity, but also significantly minimizes the use of chemical fertilizer, which subsequently conserves energy, minimizing the risk of pollution, improving fertilizer use efficiency, reducing the cost for farmers especially in low-income

countries, and ensuring ecosystem sustainability against the degradation of soil and water resources.

2. Materials and Methods

The experiment was carried out with eleven treatments in simple Randomized Block Design and replicated three times at department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Mandsaur, (M.P.) during the winter season of 2021-2022. The treatments accompanied with Absolute control (T_1), 25 t/ha FYM (T_2), NPK – 40:20:20 Kg/ha + 5 t/ha FYM (T_3), NPK – 40:25:20 Kg/ha + 10 t/ha FYM (T_4), NPK – 40:30:20 Kg/ha + 15 t/ha FYM (T_5), NPK – 45:20:20 Kg/ha + 5 t/ha FYM (T_6), NPK – 45:25:20 Kg/ha + 10 t/ha FYM (T_7), NPK – 45:30:20 Kg/ha + 15 t/ha FYM (T_8), NPK – 50:20:20 Kg/ha + 5 t/ha FYM (T_9), NPK – 50:25:20 Kg/ha + 10 t/ha FYM (T_{10}) and NPK – 50:30:20 Kg/ha + 15 t/ha FYM (T_{11}). Full doses of all organic and inorganic fertilizers were applied at the time of sowing except, nitrogen which was applied in two split doses. All the parameters were noted at 45, 90 days after sowing and at harvest. The statistical analysis of variance for the applied design (RBD) was analyzed using Genstat software (14th Edition). The F-test was measured at the $P<0.05$ level of significance.

3. Results

3.1 Phenological parameters

Data pertaining to phenology are diagrammatically illustrated in Figure 1. The data showed non-significant relation at days to 50% germination to different level of NPK and FYM. However, at days to 50% flowering, showed significant variation on application of different level of NPK and FYM. Treatment T_{11} recorded early flowering (95.00 DAS) followed by T_8 (95.67 DAS) and at par with T_5 (96.00 DAS), T_{10} (96.33 DAS), T_2 (97.33 DAS) and T_7 (98.67 DAS), but significantly early then rest of the treatments. Late flowering was recorded under control T_1 (101.00 DAS). The results revealed that days taken to maturity of ajwain shown statistically non-significant variation due to different levels of NPK and FYM.

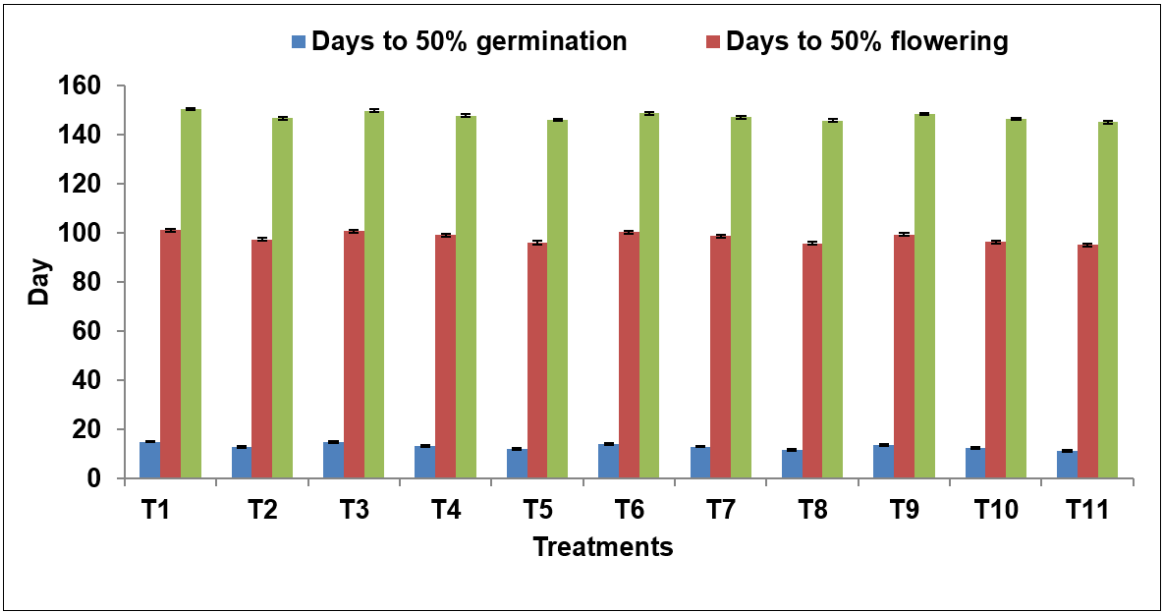

Fig 1: Effect of different levels of major nutrients and organic manure on phenological parameters of ajwain

3.2 Morphological parameters

The data on morphological parameters are presented in Table 1 and Table 2. The varied amounts of NPK and FYM had perceived significant changes in plant height during the different intervals of plant growth. The significantly highest plant height (9.19 cm) was recorded under the treatment T_{11} which was at par with treatment T_8 (9.00) but significantly superior to rest of the treatments at 45 DAS. The treatment T_{11} recorded significantly highest plant height (75.76 cm) over treatments T_6 (65.70 cm), T_3 (64.12 cm) and T_1 (63.07 cm) at 90 DAS. The treatment of varied levels of NPK and FYM had significant influence on the number of primary branches per plant during the various growth stages. At 45 days after sowing, the maximum number of primary branches per plant was found in treatment T_{11} (5.39) followed by treatment T_8 (5.36) and they were at par with treatment T_5 (5.34), T_{10} (5.31), T_2 (5.12) and T_7 (5.02) and with each other but appreciably superior to remaining treatments. At 90 DAS, the data indicated that the treatment T_{11} had the more number of primary branches per plant (14.60) and were at par with treatments T_8 (14.51), T_5 (14.34), T_{10} (14.06), T_2 (13.55) and T_7 (13.44) but significantly superior over all the remaining treatments. At harvest, the significantly higher primary branches was recorded under treatment T_{11} (15.26) than treatments T_9 (12.49), T_6 (11.04), T_3 (10.60) and T_1 (10.42). The fresh and dry weight were recorded significantly highest (220.59 g plant^{-1} and 46.68 g plant^{-1}) under the treatment T_{11} at harvest.

Table 1: Effect of different levels of major nutrients and organic manure on plant height and number of primary branches of ajwain

Treatments		Plant height (cm)			Number of primary branches		
		45 DAS	90 DAS	At harvest	45 DAS	90 DAS	At harvest
T_1	Absolute control	7.20	63.07	103.72	4.12	10.03	10.42
T_2	25t/ha FYM	7.67	69.84	123.68	5.12	13.55	14.06
T_3	40:20:20 kg/ha NPK+5 t/ha FYM	7.37	64.12	105.82	4.13	10.29	10.60
T_4	40:25:20 kg/ha NPK+10 t/ha FYM	7.61	68.46	113.39	4.97	12.62	13.04
T_5	40:30:20 kg/ha NPK+15 t/ha FYM	7.94	71.33	130.02	5.34	14.34	14.57
T_6	45:20:20 kg/ha NPK+5 t/ha FYM	7.40	65.70	107.80	4.79	10.83	11.04
T_7	45:25:20 kg/ha NPK+10 t/ha FYM	7.63	69.56	119.17	5.02	13.44	13.89
T_8	45:30:20 kg/ha NPK+15 t/ha FYM	9.00	74.41	132.99	5.36	14.51	14.70
T_9	50:20:20 kg/ha NPK+5 t/ha FYM	7.54	68.16	110.14	4.83	11.68	12.49
T_{10}	50:25:20 kg/ha NPK+10 t/ha FYM	7.77	70.47	128.91	5.31	14.06	14.22
T_{11}	50:30:20 kg/ha NPK+15 t/ha FYM	9.19	75.76	133.81	5.39	14.60	15.26
S.Em. ±		0.105	2.525	5.023	0.130	0.612	0.849
C.D. at 5%		0.310	7.449	14.818	0.385	1.807	2.505

Table 2: Effect of different levels of major nutrients and organic manure on fresh and dry weight of ajwain

Treatments		Fresh weight (g plant^{-1})			Dry weight (g plant^{-1})		
		45 DAS	90 DAS	At harvest	45 DAS	90 DAS	At harvest
T_1	Absolute control	10.14	168.43	189.07	2.23	31.94	40.04
T_2	25t/ha FYM	10.95	189.12	203.98	2.33	35.81	43.17
T_3	40:20:20 kg/ha NPK+5 t/ha FYM	10.22	171.48	192.70	2.25	32.52	40.47
T_4	40:25:20 kg/ha NPK+10 t/ha FYM	10.81	179.98	197.15	2.31	34.45	42.27
T_5	40:30:20 kg/ha NPK+15 t/ha FYM	11.15	194.61	215.77	2.40	36.87	45.59
T_6	45:20:20 kg/ha NPK+5 t/ha FYM	10.65	174.55	195.02	2.30	33.10	41.30
T_7	45:25:20 kg/ha NPK+10 t/ha FYM	10.89	185.75	200.64	2.32	35.16	42.53
T_8	45:30:20 kg/ha NPK+15 t/ha FYM	11.23	197.07	217.42	2.42	37.23	46.05
T_9	50:20:20 kg/ha NPK+5 t/ha FYM	10.81	182.40	199.54	2.30	34.11	41.90
T_{10}	50:25:20 kg/ha NPK+10 t/ha FYM	11.10	192.36	212.84	2.38	36.37	45.10
T_{11}	50:30:20 kg/ha NPK+15 t/ha FYM	11.27	199.57	220.59	2.44	37.56	46.68
S.Em. ±		0.260	4.462	4.100	0.033	0.816	1.032
C.D. at 5%		NS	13.163	12.096	0.098	2.407	3.044

3.3 Yield and their components

The significant differences were indicated among the yield and yield attributing traits and data is represented in Table 3. The result revealed that, treatment T_{11} had significantly highest number of umbels plant^{-1} (260.09), number of fruits umbel^{-1} (437.83), number of umbellates umbel^{-1} (19.52), number of fruits umbellates^{-1} (22.42), test weight (1.14g) and seed yield (14.32 q ha^{-1}). The lowest number of umbels plant^{-1}, number of fruits umbel^{-1}, number of umbellates umbel^{-1}, number of fruits umbellates^{-1}, test weight and seed yield were recorded in treatment T_1.

Table 3: Effect of different levels of major nutrients and organic manure on yield and yield attributes of ajwain

Treatments		Number of umbels (plant^{-1})	Number of fruits (umbel^{-1})	Number of umbellates (umbel^{-1})	Number of fruits (umbellate^{-1})	Test weight (g)	Harvest index (%)	Seed yield (q ha^{-1})
T_1	Absolute control	232.06	228.17	13.73	16.51	0.73	34.04	9.35
T_2	25 t/ha FYM	246.42	358.03	18.28	19.54	0.91	38.00	12.20
T_3	40:20:20 kg/ha NPK+5 t/ha FYM	235.79	261.32	14.88	17.60	0.76	36.50	10.16
T_4	40:25:20 kg/ha NPK+10 t/ha FYM	244.71	335.17	17.34	19.33	0.86	39.77	11.80
T_5	40:30:20 kg/ha NPK+15 t/ha FYM	252.15	396.25	19.01	20.91	1.02	41.82	13.63
T_6	45:20:20 kg/ha NPK+5 t/ha FYM	237.48	295.16	15.52	18.91	0.77	38.14	10.64
T_7	45:25:20 kg/ha NPK+10 t/ha FYM	245.94	353.56	18.19	19.40	0.88	39.48	11.99
T_8	45:30:20 kg/ha NPK+15 t/ha FYM	258.44	423.56	19.30	21.96	1.07	41.77	14.01
T_9	50:20:20 kg/ha NPK+5 t/ha FYM	240.94	309.03	15.87	19.30	0.80	40.93	11.59
T_{10}	50:25:20 kg/ha NPK+10 t/ha FYM	250.26	386.70	18.86	20.53	0.93	38.97	12.50
T_{11}	50:30:20 kg/ha NPK+15 t/ha FYM	260.09	437.83	19.52	22.42	1.14	42.44	14.32
S.Em. ±		4.348	17.940	0.348	0.980	0.056	3.233	0.743
C.D. at 5%		12.826	52.924	1.026	2.891	0.164	NS	2.193

3.4 Economics of the treatments

The result revealed from Table 4 that, treatment T_2 had maximum cost of cultivation (₹ 48210 ha^{-1}) followed by T_{11} (₹ 41127 ha^{-1}). While the minimum cost of cultivation (₹ 23210 ha^{-1}) was recorded under treatment T_1. However, the maximum gross income was calculated in the treatment T_{11} (₹ 143233.33 ha^{-1}) followed by T_8 (₹ 140134.57 ha^{-1}). Similarly, the maximum net profit was obtained in T_{11} (₹ 102106.33 ha^{-1}) followed by T_8 (₹ 99079.57 ha^{-1}). The maximum cost: benefit ratio (2.80) was noted under the treatment T_9 followed by T_{10} (2.49) and T_6 - (2.49).

Table 4: Effect of different levels of major nutrients and organic manure on economics of ajwain

Treatments		Total cost	Gross return	Net profit	B:C ratio
T_1	Absolute control	23210	65435.31	42225.31	1.82:1
T_2	25 t/ha FYM	48210	122034.16	73824.16	1.53:1
T_3	40:20:20 kg/ha NPK+5 t/ha FYM	30372	101609.88	71237.88	2.35:1
T_4	40:25:20 kg/ha NPK+10 t/ha FYM	35710	118044.03	82334.03	2.31:1
T_5	40:30:20 kg/ha NPK+15 t/ha FYM	40984	136287.65	95303.65	2.33:1
T_6	45:20:20 kg/ha NPK+5 t/ha FYM	30444	106376.54	75932.54	2.49:1
T_7	45:25:20 kg/ha NPK+10 t/ha FYM	35779	119869.14	84090.14	2.35:1
T_8	45:30:20 kg/ha NPK+15 t/ha FYM	41055	140134.57	99079.57	2.41:1
T_9	50:20:20 kg/ha NPK+5 t/ha FYM	30516	115939.09	85423.09	2.80:1
T_{10}	50:25:20 kg/ha NPK+10 t/ha FYM	35854	125004.94	89150.94	2.49:1
T_{11}	50:30:20 kg/ha NPK+15 t/ha FYM	41127	143233.33	102106.33	2.48:1

4. Discussion

Result revealed that treatment T_{11} showed early germination, flowering and maturity while, late under treatment T_1. The assumption seems to be justify that nitrogen, phosphorus and potassium application from organic and inorganic manure enhances the fertility, better aeration and porosity of the soil leads to early germination, increased NPK content in the plants from early stage of crop growth results in faster growth of plants and better availability of metabolites and nutrients, which synchronized to the demand of ajwain plant resulted in early flowering and maturity (Naruka *et al*., 2012) [7]. Result determined that treatment T_{11} attributed the highest plant height while, lowest under treatment T_1 at all growth stages. This could be due to addition of organic and inorganic fertilizer, particularly in deep soils, increased porosity, improved soil structure and aeration, and increased soil water availability. These substances promote root development and expansion, nutrient absorption, and the synthesis of growth hormones. Plant growth and development were enhanced, eventually led to increased plant height. The reason could be related to the addition of increased nitrogen doses, which stimulates plant growth and development by metabolic processes (Ali *et al*., 2015 and Malhotra *et al*., 2006) [8, 9]. The treatment T_{11} had more number of primary branches while, less in treatment T_1 during all the growth stages. The significant increase in growth parameters observed under greater fertilizer rates may be attributed to increased nutrient uptake by the plants, and it may have produced more branches, nodes, and plant dry matter production when compared to the recommended fertilizer level (Meena *et al*., 2020 and Waskela *et al*., 2017) [10, 11]. The maximum fresh and dry weight was accumulated in T_{11} while, minimum in T_1 during all the growth stages. The higher dry matter production might be linked to greater vegetative development, as measured by plant height, number of primary and secondary branches, and number of leaves, among other factors that contribute to the creation of more fresh weight (Thanuja *et al*., 2020) [12]. The experimental data exhibited the yield and yield attributing parameters *viz*, number of umbels, number of umbellates, number of fruit, test weight and seed yield were significantly highest in treatment T_{11}. Inorganic and organic fertilizers were probably responsible for the synthesis of essential enzymes, proteins, energy, chlorophyll and other components for photosynthetic translocation and increased the number of umbels. Positive nitrogen and phosphorus responses increased phosphorus availability in soil, which is a major structural element of the cell and aids in cell elongation, greater availability of photosynthesis, metabolites, nutrients to develop reproductive structures and translocation of photosynthates from source to sink which attributed to higher yield attributes (Sathyanarayana et al., 2015 and Shakywa *et al*., 2022) [13, 14]. The increased yield could be due to a better nutritional status of the soil, which could have stimulated the rate of various plant physiological processes, leading to increased yield attributing characteristics and their cumulative effect resulted in enhanced seed yield (Desai et al., 2020) [15]. Increased yields may also be linked with fertilizer's effect in enhancing nutrient absorption by the root system, increased chlorophyll content, photosynthetic activity, and protein content in cultivated plants (Rana, 2012 and Sathyanarayana *et al*., 2017) [16, 17]. The present research manifested significant variation in economics. The maximum cost of cultivation was observed in treatment T_2 while highest gross return and net return was obtained in T_{11}. The maximum benefit: cost ratio was calculated in treatment T_9. The intensification in the net return may be attributed to supply of optimal level of nutrients by using organic manures and chemical fertilizer's to meet the crop mandate at proper time which in turn lead to higher yield.

5. Conclusions

On the basis of research and the results reported, it could be concluded that, the different levels of major nutrients and organic manure significantly influenced the growth and yield attributes of ajwain. Hence, out of eleven treatments, T_{11} NPK – 50:30:20 Kg/ha + 15 t/ha FYM was best comprises for enhanced growth and yield of ajwain while T_9 NPK – 50:20:20 Kg/ha + 5 t/ha FYM recorded best B: C ratio among the treatments.

6. Acknowledgement

Authors would like to show their gratitude to the Dean and Director Instructions, RVS University of Agriculture, Gwalior (M.P.) for providing necessary facilities during the period of this investigation.

7. Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

8. References

1. Thomas M, Tripathi N, Meena KC, Sastry JLN, Kimothi GP, Sharma S, *et al*. Effects of containers and duration of storage on the guggulsterone and volatile oils content of guggul. The Pharma Innovation Journal. 2020;9(1):25-30.
2. Fathi S, Najafian S. Effect of organic and chemical

fertilizers on morphophysiological and biochemical properties of ajwain (*Trachyspermum ammi* L.). Iranian Journal of Plant Physiology. 2020;11(1):3405-3415.
3. Chandravanshi OK, Meena KC, Khan KA, Soni N, Patidar DK. Responses of organic manures and inorganic fertilizers on growth, yield and economics of turmeric (*Curcuma longa* Linn.). Journal of Medicinal Plants Studies. 2021;9(3):243-247.
4. Chundawat RS, Meena KC, Patidar DK, Patidar BK, Kachouli BK. Responses of different levels of potassium and zinc on growth and yield of isabgol (*Plantago ovate* Forsk.) under malwa plateau of Madhya Pradesh. The Pharma Innovation Journal. 2023;12(3):5671-5673.
5. Chouhan S, Meena KC, Soni N, Patidar DK, Kachouli BK, Patidar BK, *et al*. Response of recommended dose of fertilizers with organic manures on growth, yield and economics of kalmegh (*Andrographis paniculata* Nees.): A way to reduced use of chemical Fertilizers. The Pharma Innovation Journal. 2023;12(3):119-124.
6. Lazcano C, Gomez-Brandon M, Revilla P, Dominguez J. Short-term effects of organic and inorganic fertilizers on soil microbial community structure and function. Biology and Fertility of Soils. 2013;49:723-733.
7. Naruka IS, Singh PP, Barde M, Rathore SS. Effect of spacing and nitrogen levels on growth, yield and quality of ajwain (*Trachyspermum ammi* L. Sprague). International Journal of Seed Spices. 2012;2(1):12-17.
8. Ali MMK, Hasan MA, Islam MR. Influence of fertilizer levels on the growth and yield of black cumin (*Nigella sativa* L.). The Agriculturist. 2015;13(2):97-04.
9. Malhotra SK, Vashishtha BB, Apparao VV. Influence of nitrogen, *Azospirillum sp* and farmyard manure on growth, yield and incidence of stem gall disease in coriander (*Coriandrum sativum* L.). Journal of Spices and Aromatic Crops. 2006;15:115-117.
10. Meena SS, Lal G, Sharma YK, Meena MD, Lal S. Effect of spacing and fertilizer levels on growth, yield and yield attributes of different ajwain (*Trachyspermum ammi* L.) genotypes. International Journal Seed Spices. 2020;10(1):47-51.
11. Waskela P, Naruka IS, Shaktawat RPS. Effect of Row Spacing and Level of NPK on growth and yield of Fennel (*Foeniculum vulgare*). Journal Krishi Vigyan. 2017;6(1):78-82.
12. Thanuja GS, Sreenivasulu B, Yuvaraj KM, Giridhar K, Umakrishna U, Lath P. Effect of organic manures, plant growth promoting rhizobacteria and micronutrients on growth, grain yield and quality of Ajwain (*Trachyspermum ammi* L.). Journal of Pharmacognosy and Phytochemistry. 2020;9(5):1864-1870.
13. Sathyanarayana E, Hadole SS, Laharia GS, Ghawade SM. Effect of nutrient levels on fertility status of soil and quality of ajwain. International Journal of Therapeutic Applications. 2015;33(4):3727-3729.
14. Shakywa SK, Meena KC, Soni N, Patidar DK, Patidar BK. Response to Organic Manures and Plant Geometry in Kalmegh (*Andrographis Paniculata* Nees.): Way to Reduce Exploitation of Forest. Ann for Res. 2022;65(1):7633-7641.
15. Desai SS, Chaudhary MG, Patel RS, Joshi JR. Effect of integrated nutrient management on growth, yield and economics of cumin (*Cuminum cyminum* L.). International Journal of Current Microbiology and Applied Sciences. 2020;9(11):3712-3719.
16. Rana S, Singh PP, Naruka IS, Rathore SS. Effect of nitrogen and phosphorus on growth, yield and quality of black cumin (*Nigella sativa* L.). International Journal of Seed Spices. 2012;2(2):5-8.
17. Sathyanarayana E, Hadole SS, Ghawade SM. Effect of nutrient levels on nutrient uptake by ajwain crop (*Trachyspermum ammi* L. Sprague). International Journal of Chemical Studies. 2017;5(4):1987-1990.