Journal of Spices and Aromatic Crops
Vol. 18 (2) : 92–99 (2009)

Indian Society for Spices

Response of cumin (*Cuminum cyminum* L.) to 'panchgavya' and plant leaf extracts in arid western Rajasthan

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Received 18 May 2009; Revised 7 September 2009; Accepted 10 September 2009

Abstract

A field experiment was conducted at Jaisalmer (Rajasthan) to study the effect of foliar applied neem (*Azadirachta indica*), datura (*Datura metel*) and tumba (*Citrullus colocynthis*) leaf extracts in 1:1 combination with 'panchgavya' on growth and yield of cumin (*Cuminum cyminum*). The results revealed that synthesis of chlorophyll and activity of nitrate reductase in fresh leaves increased significantly with application of neem + panchgavya compared to control at 55 and 80 days after sowing. Dry matter accumulation, branches plant^{-1}, umbels plant^{-1}, seeds umbel^{-1} and 100-seed weight also recorded significant increase with application of neem + 'panchgavya'. Compared to control, neem + 'panchgavya' increased grain, straw and biological yield by 58%, 72% and 65%, respectively. The content and uptake of N and P in seed and straw also recorded significant increase with application of neem + 'panchgavya'. Application of foliar sources both at branching and flowering stages recorded significantly higher accumulation of dry matter, yield and yield attributes, content and uptake of N and P in seed and straw compared to single application at branching or flowering.

Keywords: cumin, *Cuminum cyminum*, nutrient uptake, 'panchgavya', yield.

Introduction

Cumin (*Cuminum cyminum* L.) is grown extensively in Rajasthan, Gujarat and Haryana during *rabi* season. These arid regions contribute more than 80% of the total cumin production in India. The soils of arid regions are low in soil organic carbon and other available plant nutrients because of prevailing high annual soil temperature (> 22°C), lesser weathering of minerals and low microbial mass. Thus added organic inputs (farmyard manure and compost) remain in their original state for years without decomposition in the soils due to lower population of native microbes (Rao & Venkateswarlu 1983). In recent years, foliar application of fermented organic fertilizers has been introduced to modern agriculture to produce food with good quality and safety (Galindo *et al*. 2007). Use of fermented cow dung, urine, milk fat, curd and milk called 'panchgavya' is getting adaptive popularity in the agricultural sector in India. Role of

foliar applied 'panchgavya' in production of many plantation crops had been well documented in India. There are reports indicating that efficacy of 'panchgavya' solution is enhanced with the mixing of endemic plant leaves. In Rajasthan, plants of tumba (*Citrullus colocynthis* L.) and datura (*Datura metel* L.) grow naturally on waste lands producing a lot of biomass which could be utilized for supplying plant nutrients. Besides, these plant species are also being used in the preparation of many agro-pesticides by farmers of the region. However, there is insufficient information on the effect of 'panchgavya' on the growth and yield of cumin. Therefore, the present study was conducted to examine the effect of 'panchgavya' along with leaf extracts of neem, datura and tumba on growth, yield and nutrient uptake of cumin grown on light textured soils under irrigated conditions.

Materials and methods

The experiment was conducted at Central Arid Zone Research Institute, Regional Research Station, Jaisalmer (Rajasthan) during *rabi* 2006-07 and 2007-08 under irrigated condition. The sandy soils of the experimental field was shallow in depth (50 cm) having 0.08% organic carbon, available N, P, K and S was 72.80, 6.45, 252.78 and 6.92 kg ha^{-1}, respectively, and 7.55% free $CaCO_3$ with pH 9.2. The leaf-extract (in cow urine) of neem (*Azadirachta indica* L.) + 'panchgavya', datura + 'panchgavya', and tumba + 'panchgavya' along with 'panchgavya' and control (water spray) were used as sources of foliar application. These sources of foliar application were applied either at branching (45 days after sowing-DAS) or flowering (65 DAS) and both at branching and flowering stages. 'Panchgavya' was prepared by thorough mixing of fresh cow dung (7 kg), cow ghee (1 kg), fresh cow urine (10 l), cow milk (3 l) and cow milk curd (2 l). The leaf extracts of neem, datura and tumba were prepared by mixing fresh ground leaves with cow urine in 1:1 ratio followed by fermentation. The physicochemical properties of soil, 'panchagavya' and leaf extract is given in Table 1. The filtrates of leaf extracts were mixed with the filtered 'panchgavya' solution in 1:1 ratio for respective leaf extracts. The cumin variety RZ 19 was sown on 25 November 2007 and 20 November 2008 @ 12 kg seed ha^{-1} after applying pre-sowing irrigation. Foliar application of 'panchgavya' and plant leaf extracts was done as per treatments after diluting the solutions 30 times with water. Chlorophyll content and nitrate reductase (NR) in the fresh leaves were estimated at 55 DAS and 80 DAS following methods of Arnon (1949) and Jaworski (1971), respectively. The N and P contents in plant parts were determined using established methods of analysis.

Table 1. Physicochemical properties of soil, 'panchgavya' and plant leaf extracts

Physicochemical property	Soil of experimental site	'Panchgavya' solution	Neem leaf-extract	Datura leaf-extract	Tumba leaf-extract
pH	9.20	4.35	4.39	4.00	5.42
EC (dS/m)	-	19.36	33.70	34.20	34.90
OC content (%)	0.05	1.50	1.90	1.67	1.60
N content (ppm)	32.35	5800	10,500	8600	8300
P content (ppm)	2.86	900	7800	7600	3900
K content (ppm)	95.90	-	-	-	-
S content (ppm)	3.08	-	-	-	-
CaCO3 content (%)	7.55	-	-	-	-

EC=Electrical conductivity; OC=Organic carbon

Results and discussion

Chlorophyll content

Significantly higher content of total chlorophyll as well as chlorophyll 'a' and chlorophyll 'b' was recorded with all the sources of foliar application compared to control both at 55 and 80 DAS (Table 2). In general, chlorophyll 'a' and chlorophyll 'b' content at 55 DAS was on par among neem + 'panchgavya', datura + 'panchgavya' and tumba + 'panchgavya' treatments. The foliar application of neem + 'panchgavya' however recorded significantly higher content of total chlorophyll and its component chlorophylls at both the stages of observation. Single application of foliar sources at branching recorded significantly higher content of chlorophyll 'a', chlorophyll 'b' and total chlorophyll at 55 DAS while at 80 DAS, application of foliar sources both at branching and flowering recorded significantly higher chlorophyll content than application at branching or flowering. The observed increase in the content of chlorophyll with all the sources of foliar application in the study might be ascribed to supply of essential nutrients to the plants by different sources of nutrient supply (Table 1). The fermented solutions of 'panchgavya' and leaf extracts contain various salts rich in N, P, K, S and micronutrients in plant available form. Hence, availability of these nutrients to plants helps in the formation of chlorophyll in the leaves. Increased chlorophyll 'a', 'b' and carotenoid contents in green leaves with foliar application of organic solution has also been observed by Tejada & Gonzalez (2003) in rice. Besides, cow dung and urine contains calcium (0.4%) and silica (1.5%) that play an important role in the synthesis of chlorophyll by increasing protein formation and cell division in the leaves (Natarajan 2002).

Table 2. Effect of sources and their stage of application on chlorophyll content and nitrate reductase activity (NR) of cumin leaves (mean of 2 years)

Treatment	Chlorophyll content (mg g^{-1} FW leaf)						NR activity (µmolz NO_2 $g^{-1}h^{-1}$ FW leaf)	
	55 DAS			80 DAS				
	Chl 'a'	Chl 'b'	Total	Chl 'a'	Chl 'b'	Total	55 DAS	80 DAS
Sources of application								
Control	2.06	0.80	2.86	1.38	0.44	1.82	239.58	89.52
'Panchgavya'	2.19	0.83	3.02	1.48	0.48	1.96	251.01	92.75
Neem + 'Panchgavya'	2.35	0.90	3.24	1.75	0.56	2.31	265.18	107.63
Datura+ 'Panchgavya'	2.29	0.88	3.17	1.58	0.51	2.08	253.64	97.94
Tumba+ 'Panchgavya'	2.33	0.89	3.21	1.68	0.53	2.21	255.42	101.99
SEm±	0.06	0.02	0.06	0.02	0.01	0.03	2.37	1.67
CD (P=0.05)	0.17	0.06	0.18	0.07	0.02	0.09	6.71	4.74
Stages of foliar application								
Branching	2.41	0.91	3.32	1.52	0.48	2.00	257.07	97.66
Flowering	1.93	0.76	2.69	1.38	0.44	1.82	245.20	92.53
Branching+ Flowering	2.39	0.91	3.29	1.82	0.58	2.40	256.63	103.70
SEm±	0.05	0.02	0.05	0.02	0.01	0.02	1.83	1.30
CD (P=0.05)	0.13	0.04	0.14	0.05	0.02	0.07	5.20	3.67

DAS=Days after sowing

Nitrate reductase activity

The activity of nitrate reductase (NR) in leaves was higher at 55 DAS and decreased thereafter at 80 DAS in all the treatments (Table 2). NR activity in functional leaves was significantly higher with neem + 'panchgavya' among the

sources of foliar application at 55 and 80 DAS. Little difference was observed among 'panchgavya', datura + 'panchgavya' and tumba + 'panchgavya' treatments at 55 DAS. However, at 80 DAS tumba + 'panchgavya' and datura + 'panchgavya' were the next best treatments in increasing the NR activity in functional leaves after neem + 'panchgavya'. The frequency of foliar application had a significant effect on the activity of NR at both the stages of observation. Application of foliar sources at branching and flowering recorded significantly maximum activity of NR at 80 DAS than single application at branching or flowering. In green plants activity of the enzyme is very sensitive to the supply and availability of N to the crop plant (Hopkins 1995). Thus, increased supply of N with application of 'panchgavya' and 'panchgavya' + leaf extracts might have increased the activity of NR significantly compared to control at all observed stages in the study. The fermented solution of 'panchgavya' contains phytohormones such as cytokinin, auxin and GA-3 in appreciable amount affecting activity of NR positively (Kalarani & Jeyakumar 1998). Thus, supply of these hormones to the plants with the foliar sources might have increased the NR activity in functional leaves of the plants by increasing the synthesis of enzyme or protein by affecting the basic processes of translation/ transcription favourably (Huttly & Phillips 1995).

Dry matter accumulation

Foliar application of neem + 'panchgavya' recorded significantly higher plant dry matter among the sources of foliar application (Table 3). Application of neem leaf + 'panchgavya' recorded 30%, 54% and 80% higher plant dry matter than control at 55 DAS, 80 DAS and harvest, respectively. Similarly, seed weight plant^{-1} increased by 80% with application of neem leaf extract + 'panchgavya'. At harvest, application of these sources at branching and flowering recorded significantly higher plant dry matter compared to single spray either at branching or flowering. The significant improvement in the accumulation of dry matter in plant and its distribution in seed was attributed to increased supply of plant nutrients, specific weight of leaf, chlorophyll synthesis, nitrogen metabolism and phytohormones with the application of 'panchgavya' and 'panchgavya' + leaf extracts. The supply of N in plant is related to the specific area of leaf (projected leaf surface per unit leaf dry mass) and synthesis of chlorophyll (Khanzada *et al*. 2003). Improved nutrition (Table 1) with different sources of nutrients might enable greater leaf area production and greater interception of light thereby increasing dry matter productivity.

Yield attributes

Foliar application of 'panchgavya' and leaf extracts of neem, tumba and datura + 'panchgavya' increased all the yield attributes significantly compared to control (Table 3). Neem + 'panchgavya' application recorded 66%, 60%, 31% and 8% higher branches plant^{-1}, umbels plant^{-1}, seeds umbel^{-1} and 100-seed weight respectively than control. A non-significant difference however was observed among 'panchgavya', neem + 'panchgavya', datura + 'panchgavya' and tumba + 'panchgavya' for seeds umbel^{-1}. Stages of foliar application had significant effect on yield attributes of cumin with application at branching and flowering recording significantly higher yield attributes than spray at branching or flowering (Table 3). The dual application of sources recorded 15%, 52%, 74%, 27% and 14% higher plant height, branches plant^{-1}, umbels plant^{-1}, seeds umbel^{-1} and 100-seed weight than foliar application at flowering only. The significant improvement in yield attributes with sources of foliar application was ascribed to increased crop growth of the plant with these sources. Dry matter accumulation per plant showed consistent increase with these sources of application. The increased dry matter thus might have contributed for higher yield attributes compared to control. The overall higher yield attributes with neem + 'panchgavya' might be ascribed to higher nutrient content of the medium solution used

Table 3. Effect of foliar sources and their stage of application on dry matter accumulation and yield attributes of cumin (mean of 2 years)

Treatment	Dry matter (mg plant^{-1})			Plant height (cm)	Branches plant^{-1}	Yield attributes			
	55 DAS	80 DAS	Harvest			Umbels plant^{-1}	Seeds umbel^{-1}	100-seed weight (mg)	Seed weight plant^{-1} (g)
Sources of foliar application									
Control	60.12	366.09	1798.11	28.21	5.70	15.47	17.23	376.62	0.88
'Panchgavya'	72.74	472.90	2694.40	30.63	6.82	19.31	22.09	387.50	1.27
Neem+ 'Panchgavya'	78.02	563.55	3242.89	32.71	9.45	24.73	22.65	408.60	1.57
Datura+ 'Panchgavya'	75.08	524.63	2922.70	30.65	7.31	20.52	22.36	388.38	1.40
Tumba+ 'Panchgavya'	75.20	527.73	3083.88	33.31	8.24	22.57	22.56	396.62	1.40
SEm±	1.14	10.58	54.99	0.32	0.16	0.31	0.25	5.86	0.03
CD (P=0.05)	3.24	29.99	155.77	0.90	0.44	0.87	0.70	16.61	0.08
Stages of foliar application									
Branching	79.10	488.89	2467.14	31.32	7.40	20.17	21.63	384.92	1.22
Flowering	61.40	458.53	2231.85	28.77	6.00	16.57	18.72	368.84	1.08
Branching + Flowering	76.20	525.53	3546.21	33.21	9.10	24.82	23.79	420.88	1.61
SEm±	0.89	8.20	42.59	0.25	0.12	0.24	0.19	4.54	0.02
CD (P=0.05)	2.51	23.23	120.66	0.70	0.34	0.68	0.54	12.87	0.06

in the study compared to other sources (Table 1).

Yield

Grain, straw and biological yields increased significantly with foliar application of neem + 'panchgavya', datura + 'panchgavya' and tumba + 'panchgavya' treatments compared to control and application of 'panchgavya' alone (Table 4). However, neem + 'panchgavya' was significantly superior among sources of foliar application and recorded 58%, 72% and 65% higher grain, straw and biological yield respectively, compared to control. Application of these plant sources at branching and flowering recorded significantly higher biological and grain yield than single spray either at branching or flowering (Table 4). The interactive results of the study revealed that application of neem + 'panchgavya' at branching and flowering recorded significantly higher grain, straw and biological yields among the combinations of foliar sources and their stages of application. The significant improvement in grain and biological yield with all the foliar sources might be associated with increased yield attributes due to concomitant increase in dry matter accumulation, chlorophyll content, nitrate reductase activity and supply of all the plant nutrients. Natarajan (2002) reported that 'panchgavya' application increased the yield of crop plants by enhancing the biological efficiency of crop plants. The application of these sources either at branching or flowering may not supply nutrients in sufficient amount for full development of the plants. Hence, higher plant dry matter plant^{-1} and biological and grain yields were observed in the experiment with application of plant leaf extracts + 'panchgavya' both at branching and flowering.

Nutrient content and uptake

The content and uptake of N and P were significantly higher with foliar application of neem + 'panchgavya' among sources of application (Table 5). The N content in straw

Table 4. Interaction effect of sources and their stage of application on grain, straw and biological yield of cumin (mean of 2 years)

Stage	Control	'Panchgavya'	Neem + 'Panchgavya	'Datura + 'Panchgavya	'Tumba + 'Panchgavya'	Mean
			Grain yield (kg ha^{-1})			
Branching	374.9	443.2	683.4	442.9	449.5	478.8
Flowering	356.9	391.5	379.0	354.5	369.7	370.3
Branching+ flowering	438.1	450.3	783.0	731.7	720.4	624.7
Mean	390.0	428.3	615.2	509.7	513.2	491.3
	Sources of application		Stages of application		Interaction	
SEm±	8.9		6.9		15.4	
CD (P=0.05)	25.1		19.5		43.5	
			Straw yield (kg ha^{-1})			
Branching	512.1	571.2	964.8	629.0	628.3	661.0
Flowering	293.2	454.1	391.1	623.4	488.7	450.1
Branching + Flowering	570.5	640.9	1011.1	634.6	921.2	755.6
Mean	458.6	555.4	789.0	629.0	679.4	622.3
	Sources of application		Stages of application		Interaction	
SEm±	16.4		12.7		28.4	
CD (P=0.05)	46.4		35.9		80.3	
			Biological yield (kg ha^{-1})			
Branching	887.0	1014.4	1648.2	1071.9	1077.7	1139.8
Flowering	650.1	845.6	770.1	977.9	858.4	820.4
Branching + Flowering	1008.5	1091.1	1794.1	1366.3	1641.6	1380.3
Mean	848.6	983.7	1404.1	1138.7	1192.6	1113.5
	Sources of application		Stages of application		Interaction	
SEm±	16.8		13.0		29.1	
CD (P=0.05)	47.5		36.8		82.3	

increased from 0.61% to 0.78% and in seed from 1.88% to 2.85% with neem + 'panchgavya' treatment compared to water spray. Similarly, uptake of N in straw, seed and whole plant recorded 123%, 146% and 140% increase over control with neem + 'panchgavya'. A similar trend was also observed with content and uptake of P. Foliar application of neem + 'panchgavya' increased P content in straw and grain by 41% and 11% while uptake in straw, grain and whole plant by 152%, 81% and 97% respectively, compared to control. The content and uptake of N and P in different plant parts was also affected significantly with stages of foliar application. Application of sources both at branching and flowering recorded significantly higher content and uptake of N and P than spray at branching or flowering. Nutrient accumulation in plants is a function of nutrient concentration and dry matter accumulation. The increased supply of plant nutrients with sources of foliar application in plant available form might have increased the accumulation of dry matter concomitantly by affecting the ramification of roots

Table 5. Effect of sources and their stage of application on content and uptake of N and P in cumin (mean of 2 years)

Treatment	N content (%)		N uptake (kg ha^{-1})			P content (%)		P uptake (kg ha^{-1})		
	Straw	Grain	Straw	Grain	Total	Straw	Grain	Straw	Seed	Total
Sources of application										
Control	0.61	1.88	2.86	7.42	10.28	0.12	0.52	0.56	2.03	2.59
'Panchgavya'	0.63	2.12	3.54	9.15	12.69	0.13	0.53	0.75	2.27	3.02
Neem+ 'Panchgavya'	0.78	2.85	6.40	18.32	24.71	0.17	0.58	1.41	3.68	5.09
Datura+ 'Panchgavya'	0.66	2.20	4.15	11.57	15.72	0.14	0.56	0.90	2.92	3.81
Tumba+ 'Panchgavya'	0.69	2.65	4.77	14.33	19.11	0.15	0.57	1.04	2.96	4.00
SEm±	0.01	0.03	0.13	0.33	0.30	0.001	0.01	0.02	0.07	0.07
CD (P=0.05)	0.04	0.08	0.38	0.94	0.84	0.004	0.03	0.06	0.20	0.21
Stages of application										
Branching	0.65	2.41	4.32	11.85	16.17	0.14	0.56	0.93	2.70	3.63
Flowering	0.62	1.91	2.80	7.10	9.90	0.11	0.49	0.49	1.81	2.30
Branching + Flowering	0.76	2.71	5.92	17.52	23.43	0.18	0.60	1.37	3.81	5.18
SEm±	0.01	0.02	0.10	0.26	0.23	0.001	0.01	0.02	0.06	0.06
CD (P=0.05)	0.03	0.06	0.30	0.73	0.65	0.003	0.03	0.05	0.16	0.16

favourably. The increased dry matter in above ground parts favours translocation of more carbohydrate towards developing roots. Increased allocation of food material to roots in turn enhanced the root volume and thereby concomitantly increased uptake of more plant nutrients (Poorter & Nagel 2000).

It was concluded from the experiment that foliar application of 'panchgavya' + leaf extracts increased the dry matter accumulation in plants significantly compared to water spray by increasing the synthesis of chlorophyll and supplying plant nutrients and growth promoting substances to the plants. The increased biological efficiency of the plant with these sources in turn enhanced the grain, straw and biological yields in cumin.

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