

Comparative Performance of Groundnut-Cumin and Clusterbean-Cumin Cropping Systems under Foliar Application of Panchgavya in Western Rajasthan

R.N. Kumawat[§], R.S. Mertia and S.S. Mahajan^{§§}

Regional Research Station, Central Arid Zone Research Institute, Jaisalmer 345 001, India

Abstract: The field trials on groundnut-cumin and clusterbean-cumin systems were conducted during three seasons (2006, 2007 and 2008) at the Regional Research Station, CAZRI, Jaisalmer, to determine productivity and profitability of two cropping systems under foliar application of panchgavya and 1:1 solution of panchgavya plus leaf extracts of neem (*Azadirachta indica*), datura (*Datura metel*) and tumba (*Citrullus colocynthis*). The results showed that foliar application of neem plus panchgavya at branching and flowering increased yield of crops in both the cropping systems. The increase in yield in clusterbean and cumin was 64 and 199%, respectively, under clusterbean-cumin system over application of water (control) at flowering. While groundnut and cumin yield was 118 and 156% higher, respectively, under groundnut-cumin system. In comparison to clusterbean-cumin system, higher cumin equivalent yield was recorded under groundnut-cumin system with neem + panchgavya (1259 kg ha⁻¹) followed by tumba + panchgavya (1068 kg ha⁻¹). In monetary terms, however, clusterbean-cumin system recorded 10% higher net return than groundnut-cumin system (Rs. 62,628 ha⁻¹) with neem plus panchgavya. Clusterbean-cumin system recorded 34% higher net returns than groundnut-cumin system (Rs. 52,666 ha⁻¹) with dual application of the foliar sources both at branching and flowering. The clusterbean-cumin system also recorded higher benefit: cost (2.41) compared to groundnut-cumin system (1.61) with neem + panchgavya.

Key words: Groundnut, cumin, clusterbean, cropping systems, panchgavya.

The agriculture of seventies in Jaisalmer was chiefly the subsistence farming involving rearing of livestock in association with rainfed cultivation of guar, moth and pearl millet. Before 1985, pasture lands dominated among different land use systems and provided main support to the huge livestock population of the region. Cultivation of arable crops was not at all beneficial ecologically or economically in the region. With the advent of IGNP and tubewell, farmers of the region began cultivating groundnut, gram, wheat, rapeseed-mustard, cumin and isabgol. Groundnut is the most common crop utilized as base crop for different sequential cropping systems in the region. Farmers adopted groundnut-based cropping system on their marginal lands very fast, but the soils of the desert regions have inherent problems of salinity, low water and nutrient availability and poor soil biological activity which lead to low crop productivity (Kumar *et al.*, 2009). Groundnut takes more than five months for maturity (July to December) leaving very short growth period for subsequent rabi crops which lead to low productivity of the system. Moreover

groundnut requires 9 to 15 irrigations and heavy investments on labor and use of pesticides because of which the groundnut-based systems got threaten these days. The excessive irrigation in arid regions over the years has adverse effect on soil conditions favouring rise in soil salinity and sodicity because of poor physico-chemical properties of desert soils and high evaporative rates (Ahmad, 2002). The factor productivity of the groundnut-based system is getting declined and the yield either reached plateau or started declining in spite of using higher inputs. There is a need to evolve a cropping system other than groundnut, which is not only highly productive and profitable, but also stable over time and maintain soil fertility. Clusterbean-based cropping system might be a good option to replace groundnut in kharif due to its short growth period and low irrigation requirement.

Responses of crops and cropping systems to different nutrient management practices differ in terms of productivity and profitability (Kumar *et al.*, 2004). Organic farming in recent years is gaining impetus due to realization of inherent advantages it confers in sustaining crop production and also in maintaining dynamic soil nutrient status and safe environment (Lokanath and Paramesh-

[§]Present address: Zonal Project Directorate, Zone VI, Jodhpur 342 003.

^{§§}Central Arid Zone Research Institute, Jodhpur 342 003.

*E-mail: rnkumawat@rediffmail.com

warappa, 2006). The use of fermented, liquid organic fertilizers has been introduced to the modern agriculture in recent years to produce food with good quality and safety (Galindo *et al.*, 2007). Of late use of fermented cow dung, urine, milk fat, curd and milk with the name of panchgavya is getting adaptive popularity in Indian agriculture largely through the efforts of small groups of farmers. There are reports that efficacy of panchgavya solution enhanced manifold with the mixing of endemic plant leaves. In waste lands of Indian Thar Desert, plants of tumba (*Citrullus colocynthis*) and datura (*Datura metel*) grow profusely which could form mixing materials of panchgavya to increase its efficiency in supplying plant nutrients. However, hitherto information on using panchgavya as a liquid fertilizer in foliar application and its effect on yield of different cropping systems is scanty. Therefore, the present investigation was undertaken to compare the productivity and profitability of groundnut-cumin and clusterbean-cumin cropping systems under foliar application of panchgavya in arid regions of western Rajasthan.

Materials and Methods

The field trials on groundnut-cumin and clusterbean-cumin systems were conducted during kharif season of 2006 for two consecutive years up to rabi 2007-08 at the CAZRI Regional Research Station, Jaisalmer. The experiments were conducted on the same site in both the years. During the crop growth period, 369 and 190 mm rainfall was received in 2006 and 2007, respectively. The soil of the experimental field was sandy and shallow in depth (50 cm) having 0.08% organic carbon, 72.80 kg ha⁻¹ available N, 6.45 kg ha⁻¹ available P, 252.78 kg ha⁻¹ available K, 6.92 kg ha⁻¹ available S, and 7.55% free CaCO₃ with pH 9.2. The experiment for each crop was laid out in factorial randomized block design with three replications. The 15 treatments comprised foliar applications of water (control), panchgavya, neem + panchgavya, datura + panchgavya and tumba + panchgavya either at branching or flowering and both at branching plus flowering stages. Panchgavya solution was prepared by mixing 1 kg cow dung with 1 kg ghee + 10 litre urine

Table 1. Effect of foliar sources and their stage of application on yield (kg ha⁻¹) of different crops under clusterbean-cumin and groundnut-cumin cropping systems

Treatment	Clusterbean-cumin system						Groundnut-cumin system					
	Clusterbean grain yield			Cumin grain yield			Groundnut pod yield			Cumin grain yield		
	Kharif 2006	Kharif 2007	Mean	Rabi 2006-07	Rabi 2007-08	Mean	Kharif 2006	Kharif 2007	Mean	Rabi 2006-07	Rabi 2007-08	Mean
Sources of foliar application												
Control	1662	1495	1578	397	383	390	2178	1721	1949	277	104	190
Panchgavya	1819	1789	1804	415	442	428	2372	1800	2086	331	149	240
Neem + panchgavya	2029	2190	2109	620	611	615	3673	2329	3001	563	224	394
Datura + panchgavya	2074	2055	2064	495	524	510	3053	2145	2599	375	169	272
Tumba + panchgavya	2088	2010	2049	509	518	513	3157	2169	2663	434	180	307
SEm±	71	51	44	12	13	9	149	55	80	10	4	5
CD (P=0.05)	205	149	124	36	37	25	432	159	225	28	13	15
Stages of foliar application												
Branching	1945	1824	1885	475	483	479	2827	1998	2412	394	164	279
Flowering	1650	1777	1713	367	374	370	2363	1825	2094	356	148	252
Branching + flowering	2208	2122	2165	619	630	625	3470	2275	2873	438	183	311
SEm±	55	40	34	10	10	7	116	43	62	7	3	4
CD (P=0.05)	159	115	96	28	28	19	335	123	175	21	10	12

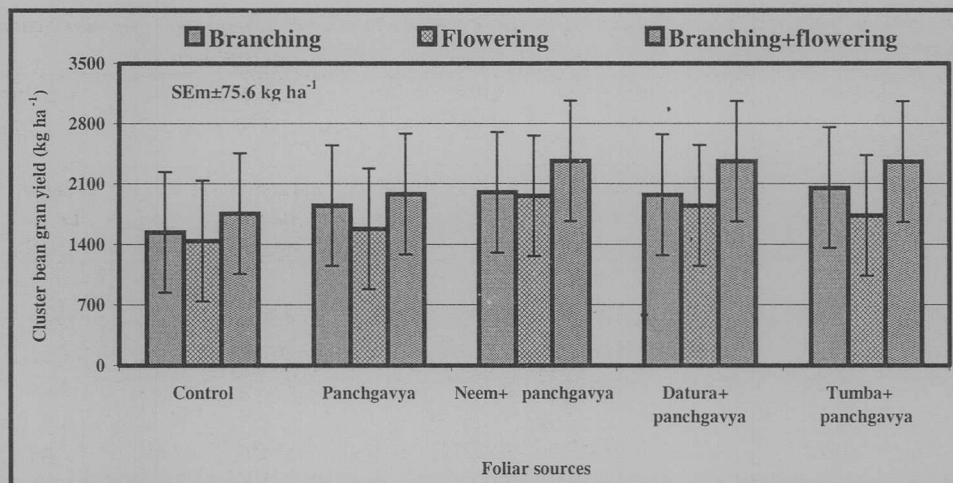
Table 2. Cumin equivalent yield, net returns and benefit: cost ratio of clusterbean-cumin and groundnut-cumin systems under different foliar sources and their stages of application (average of two years)

Treatment	Cumin equivalent yield (kg ha ⁻¹)		Cultivation cost (Rs. ha ⁻¹)		Gross return (Rs. ha ⁻¹)		Net return (Rs. ha ⁻¹)		Net benefit:cost ratio	
	Cluster-bean-cumin	Ground-nut-cumin	Cluster-bean-cumin	Ground-nut-cumin	Cluster-bean-cumin	Ground-nut-cumin	Cluster-bean-cumin	Ground-nut-cumin	Cluster-bean-cumin	Ground-nut-cumin
Sources of foliar application										
Control	671	769	27110	37597	66873	61008	39763	23411	1.46	0.62
Panchgavya	749	845	28080	38617	74216	68750	46136	30133	1.64	0.78
Neem + panchgavya	990	1259	28380	38917	97009	101545	68629	62628	2.41	1.61
Datura + panchgavya	877	1022	28330	38917	86694	81879	58414	42962	2.05	1.10
Tumba + panchgavya	877	1068	28380	38917	86236	86557	57856	47641	2.03	1.22
SEm±	13	19			1219	1636	1219	1636	0.04	0.04
CD (P=0.05)	38	53			3454	4635	3454	4635	0.12	0.12
Stages of foliar application										
Branching	814	975	27866	38426	80495	78647	52629	40221	1.88	1.04
Flowering	675	830	27866	38426	67291	69605	39425	31178	1.41	0.81
Branching+ flowering	1010	1173	28466	38926	98831	91592	70365	52666	2.46	1.35
SEm±	10	15			944	1267	944	1267	0.03	0.03
CD (P=0.05)	29	41			2676	3590	2676	3590	0.10	0.09

+ 3 litre milk + 2 litre curd (Kumawat *et al.*, 2009) as suggested by Selvaraj (2006). The undiluted panchgavya and leaf extracts of neem, datura and tumba solution consisted pH 4.35, 4.39, 4.00 and 5.42; electrical conductivity (dS m⁻¹) 19.36, 33.70, 34.20 and 34.90; organic carbon (%) 1.50, 1.90, 1.67 and 1.60; nitrogen (%) 0.58, 1.05, 0.86 and 0.83 and phosphorus (%) 0.09, 0.78, 0.76 and 0.39, respectively. The leaf extracts of plants were prepared by mixing fresh ground leaves with cow urine in 1:1 ratio followed by fermentation. The solutions of leaf extracts and panchgavya were filtered through a muslin cloth and mixed in 1:1 ratio for respective leaf extracts. A recommended dose of FYM (0.77% N, 0.14% P and 0.42% K) @ 11 t ha⁻¹ was applied uniformly in both the kharif crops (clusterbean and groundnut) while succeeding cumin was raised on the residuals of kharif crops. After a pre-sowing irrigation, groundnut cultivar MA-10 and clusterbean cultivar RGC-936 were sown on 17th July and 21st July in kharif 2006 and 21st and 22nd July in kharif 2007, respectively. The succeeding cumin cultivar RZ-19 was sown on 25th November, 2007 and 20th November, 2007 in clusterbean-cumin system

and on 26th November, 2006 and 22nd November, 2007 in groundnut-cumin system in rabi seasons. The seeds were treated with *Trichoderma viridae* (6 g kg⁻¹ seed) as prophylactic measure against seed borne diseases. During both the years groundnut was given nine irrigations, clusterbean three and cumin was given six irrigations. The solutions of panchgavya and plant leaf extracts were diluted with water by 30 times and applied on the crop foliage as per treatment either at branching (35 DAS in clusterbean and groundnut and 45 DAS in cumin), flowering (55 DAS in clusterbean and groundnut and 65 DAS in cumin) or both at branching plus flowering. Total chlorophyll content and nitrate reductase (NR) activity in fresh leaves was estimated from upper leaves most fully expanded-leaves following methods of Arnon (1949) and Jaworski (1971), respectively. Biological and economic yields (grain yield/pod) were computed from the plants of net plot in each treatment. The economics and cumin-equivalent yield (CEY) were computed at prevailing market rates of different commodities during 2006-08. The data were analyzed using Statistical Package for Social Sciences (SPSS) version 13.0

a



b

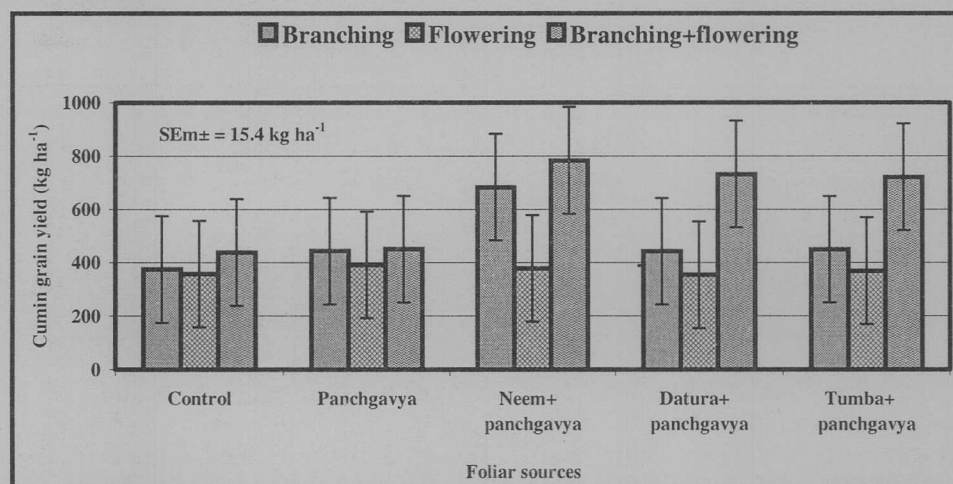


Fig. 1. Interaction effect of foliar sources and their stage of application on (a) grain yield of clusterbean and (b) grain yield of cumin in clusterbean-cumin system.

software in order to test the significance of variance due to treatments of foliar application and their stages of application. The data were analyzed separately for two years and individual year's data were subjected for pool analysis to obtain a trend among results over the years.

Results and Discussion

Yield of crops

In both the cropping systems, economic yields (grain/pod) were significantly influenced due to different sources and stages of application. Foliar application of neem + panchgavya recorded significantly higher yield among the sources of foliar application in all the 4 crops of both the cropping systems (Table 1). However, in

clusterbean, grain yield was recorded at par with foliar application of neem + panchgavya, datura + panchgavya and tumba + panchgavya. Application of neem + panchgavya recorded 34 and 58% higher grain yield of clusterbean and cumin under clusterbean-cumin system and 54 and 107% higher pod yield of groundnut and grain yield of cumin, respectively, under groundnut-cumin system over control. Dual application of these plant sources at branching + flowering recorded significantly higher grain/pod yield than single spray either at branching or flowering. The grain yields of clusterbean and cumin under clusterbean-cumin cropping system increased by 26 and 69%, respectively, while pod yield of groundnut and grain yield of cumin under groundnut-cumin cropping system was 37 and

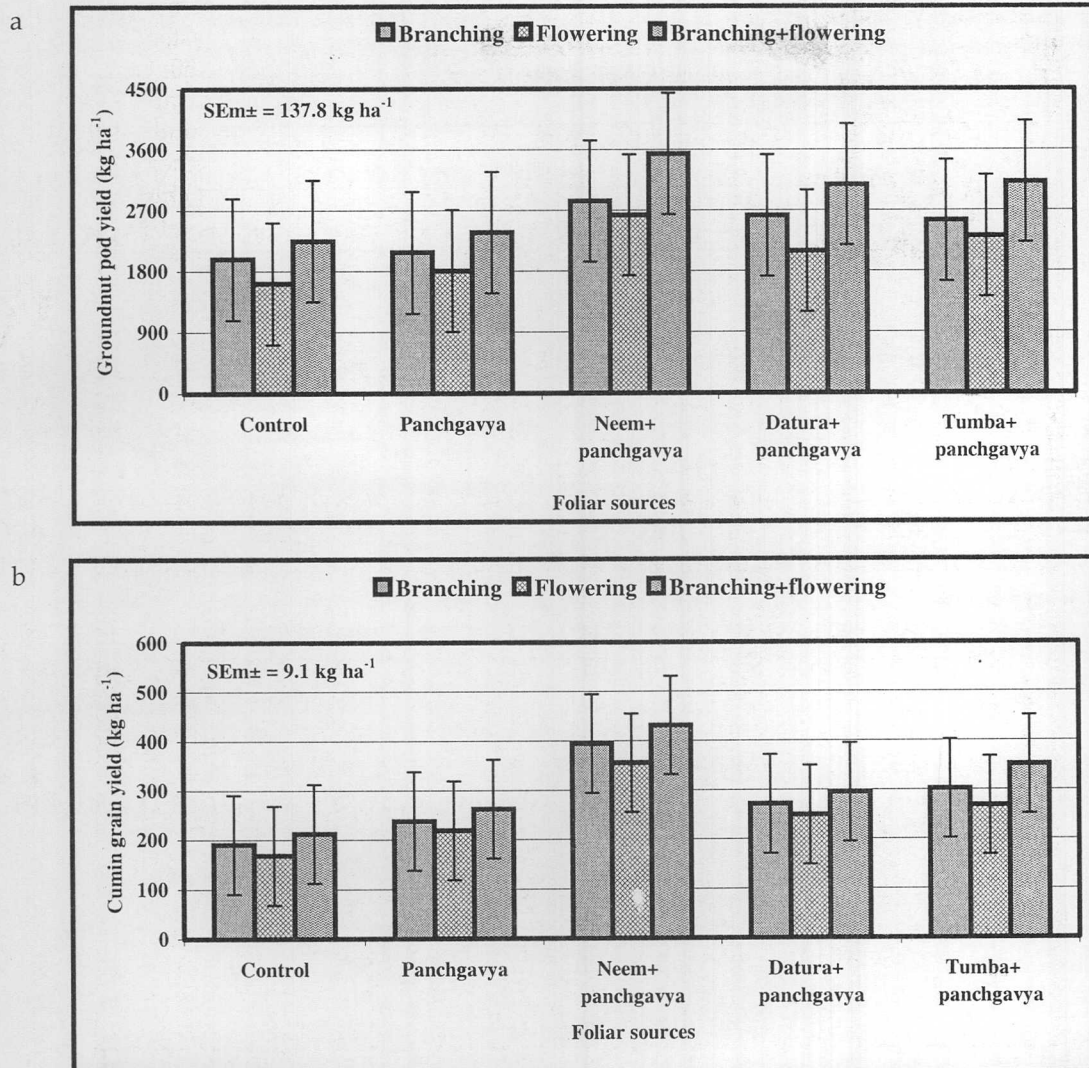


Fig. 2. Interaction effect of foliar sources and their stage of application on (a) pod yield of groundnut and (b) grain yield of cumin in groundnut-cumin system.

23% higher with dual application of sources both at branching and flowering compared to spray at flowering only. Interaction revealed that dual application of neem + panchgavya, both at branching and flowering significantly increased grain/pod yields of crops in both the cropping systems (Fig. 1 and 2). Dual application of neem + panchgavya at branching and flowering increased grain yield of clusterbean and cumin under clusterbean-cumin cropping system by 64 and 119%, respectively, over application of water (control) at flowering only. Similarly, pod yield of groundnut and grain yield of cumin increased to the tune of 118 and 156%, respectively, with this treatment under groundnut-cumin cropping system. The significant improvement in yield of

crops with all the foliar sources was ascribed to increased dry matter accumulation of plant due to concomitant increase in chlorophyll content, NR activity and supply of plant nutrients. In the present study foliar application of neem + panchgavya increased total chlorophyll content of clusterbean leaf at 45 DAS and 65 DAS from 1.65 to 1.82 and 3.45 to 4.52 mg g^{-1} fresh weight of leaf over control. In groundnut total chlorophyll increased from 1.32 to 1.69 and 3.45 to 4.13 mg g^{-1} fresh weight of leaf with neem + panchgavya at 45 and 70 DAS, respectively. Similarly, NR activity in green leaves increased by 25 and 26% in clusterbean and 49 and 59% in groundnut at these stages with neem + panchgavya over control. In clusterbean-cumin system, foliar application of

Table 3. Effect of foliar sources and their stages of application on dry matter (DM) accumulation, chlorophyll content (mg g^{-1} fresh weight of leaf) and nitrate reductase (NR) activity ($\mu\text{mol NO}_2 \text{ h}^{-1} \text{ g}^{-1}$ fresh weight of leaf) of crops under clusterbean-cumin and groundnut-cumin cropping systems at various crop growth stages (average of two years)

Treatment	DM (g plant ⁻¹)		Chlorophyll content		NR activity		DM (mg plant ⁻¹)		Chlorophyll content		NR activity	
	45	65	45	65	45	65	50	75	50	75	50	75
	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS
Clusterbean-cumin system												
	Clusterbean						Cumin					
Sources of foliar application												
Control	9.2	28.2	1.65	3.45	261	191	60	366	2.86	1.82	240	90
Panchgavya	11.2	36.4	1.74	3.91	294	218	73	473	3.02	1.96	251	93
Neem+panchgavya	14.0	47.5	1.82	4.52	327	241	78	564	3.24	2.31	265	108
Datura+panchgavya	12.6	41.3	1.77	4.20	302	236	75	525	3.17	2.08	254	98
Tumba+panchgavya	13.1	43.8	1.78	4.20	311	235	75	528	3.21	2.21	255	102
SEm±	0.2	0.5	0.02	0.08	7	4	1	11	0.06	0.03	2	2
CD (P=0.05)	0.7	1.5	0.05	0.21	20	10	3	30	0.18	0.09	7	5
Stages of foliar application												
Branching	13.3	39.1	1.83	3.92	308	225	79	489	3.32	2.00	257	98
Flowering	9.6	35.5	1.59	3.62	281	211	61	459	2.69	1.82	245	93
Branching+flowering	13.1	43.7	1.83	4.65	309	237	76	526	3.29	2.40	257	104
SEm±	0.2	0.4	0.01	0.06	5	3	1	8	0.05	0.02	2	1
CD (P=0.05)	0.5	1.2	0.04	0.17	15	8	3	23	0.14	0.07	5	4
Correlation (r) with yield	0.81	0.90	0.75	0.92	0.83	0.91	0.63	0.72	0.76	0.85	0.78	0.85
Groundnut-cumin system												
	Groundnut						Cumin					
Sources of foliar application												
Control	3.9	37.2*	1.32	3.45*	181	27*	43	583	2.07	1.31	57	21
Panchgavya	4.2	43.1*	1.51	3.54*	222	33*	49	710	2.19	1.39	64	23
Neem+panchgavya	5.3	62.7*	1.69	4.13*	270	43*	61	923	2.56	1.73	71	37
Datura+panchgavya	4.8	54.9*	1.60	3.76*	265	36*	55	834	2.46	1.48	68	34
Tumba+panchgavya	4.7	56.8*	1.59	3.94*	250	37*	57	880	2.49	1.55	70	35
SEm±	0.1	0.6*	0.03	0.08*	9	1*	1	12	0.04	0.03	1	1
CD (P=0.05)	0.3	1.8*	0.09	0.23*	24	3*	3	35	0.12	0.07	4	3
Stages of foliar application												
Branching	5.0	50.5*	1.58	3.73*	251	33*	59	784	2.54	1.49	70	30
Flowering	3.7	45.8*	1.42	3.51*	206	33*	41	760	1.99	1.43	56	26
Branching+flowering	5.0	56.5*	1.61	4.06*	257	40*	59	814	2.52	1.55	73	33
SEm±	0.1	0.5*	0.03	0.06*	7	1*	1	10	0.03	0.02	1	0.3
CD (P=0.05)	0.2	1.4*	0.07	0.18*	19	2*	2	27	0.09	0.06	3	0.9
Correlation (r) with yield	0.81	0.95*	0.88	0.93*	0.85	0.88*	0.72	0.94	0.70	0.96	0.66	0.88

*70 DAS in groundnut-cumin crop.

neem + panchgavya at 50 DAS and 75 DAS increased total chlorophyll content of cumin by 13 and 27% while NR activity by 10 and 20% at these stages over control, respectively. Similarly, total chlorophyll was increased from 2.07 to 2.56 and 1.31 to 1.73 mg g^{-1} fresh weight of leaf and NR activity from 57 to 71 and 21 to 37 μmol

$\text{NO}_2 \text{ h}^{-1} \text{ g}^{-1}$ fresh weight of leaf in green leaves of cumin in groundnut-cumin system with neem + panchgavya over control at 50 DAS and 75 DAS, respectively. The dual application at branching and flowering was found significantly superior over single application either at branching or flowering in increasing total chlorophyll and

NR activity in all the 4 crops under both the cropping systems. Further, in the study grain/pod yield per hectare was positively correlated with all these factors ($r=0.63$ to 0.95) (Table 3). Kumawat *et al.* (2009) reported increased pod yield of groundnut with neem + panchgavya in the light textured soils of Jaisalmer. Similarly, Natarajan (2002) reported that panchgavya application increased the yields by enhancing the biological efficiency of crop plants. Fermented panchgavya and panchgavya plus leaf extracts contain proven biofertilizers, viz., *Azospirillum*, *Azotobacter*, *Phosphobacter*, *Pseudomonas* and their metabolites along with plant growth promoters such as IAA and GA₃ that play important role in stimulation of plant growth and in suppression of pest load on crop plants (Mahalingam and Sheela, 2003). In the present study no disease and pest infestation was observed in all the 4 crops except aphid attack on clusterbean and cumin during both the years. The application of these sources either at branching or flowering may not supply sufficient nutrients required for full development of the plants. Hence, higher plant dry matter and grain yields per plant are observed in the experiment with dual application of these leaf extracts both at branching + flowering.

Cumin-equivalent yield and economic returns

The cropping system productivity measured as cumin equivalent yield (CEY) and net returns were influenced significantly with different foliar sources and their stages of application (Table 2). The CEY of different cropping systems showed that the maximum productivity (1259 kg ha^{-1}) was obtained from neem + panchgavya followed by tumba + panchgavya (1068 kg ha^{-1}) under groundnut-cumin system. Similarly, dual application of foliar sources both at branching and flowering also recorded highest CEY (1173 kg ha^{-1}) under groundnut-cumin system. The higher CEY in this cropping system was due to higher yield and higher price of produce. In general, clusterbean-cumin system recorded higher net returns and benefit: cost ratio than groundnut-cumin system with all the sources and their stages of foliar applications. In both the cropping systems foliar application of neem + panchgavya recorded significantly higher net return among sources of foliar application. Comparatively, higher net return (Rs. 62,628 ha^{-1}) was recorded under clusterbean-cumin cropping system with neem + panchgavya which showed 10% increase over groundnut-cumin system. The clusterbean-cumin system also

recorded higher benefit: cost (2.41) ratio compared to groundnut-cumin system (1.61) with neem + panchgavya. Dual application of sources both at branching and flowering gave significantly higher net returns and benefit: cost ratio in both the cropping systems. Clusterbean-cumin system recorded 34% higher net returns than groundnut-cumin system (Rs. 52,666 ha^{-1}) with foliar applications at branching and flowering. Similar results were also obtained in benefit: cost ratio. The higher net returns and benefit: cost ratio under clusterbean-cumin system than groundnut-cumin system was due to lower cost of cultivation of clusterbean and short growth cycle of the crop requiring lesser irrigations compared to groundnut, which requires more irrigations and heavy investments on labor.

It was concluded that foliar application of neem + panchgavya both at branching and flowering resulted in higher yield of all the crops in both the cropping systems. Clusterbean-cumin system was more remunerative in the light textured soils of western Rajasthan and gave higher net returns and benefit: cost ratio than groundnut-cumin system with all the foliar sources and their stages of application.

References

- Ahmad, S. 2002. Effectiveness of biological, chemical and bio-cum-chemical amelioration strategies for calcareous saline-sodic soils. *Ph.D. Thesis*. Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan.
- Arnon, D.I. 1949. Copper enzymes in isolated chloroplast: Polyphenol oxidase in *Beta vulgaris*. *Plant Physiology* 24: 1-15.
- Galindo, A., Jeronimo, C., Spaans, E. and Weil, M. 2007. los abonos liquidos fermentados y su efectividad en plantulas de papaya (*Carica papaya* L.). *Tierra Tropical* 3(1): 91-96.
- Jaworski, E.G. 1971. Nitrate reductase assay in intact plant tissue. *Biochemical and Biophysical Research Communications* 43: 1274-1279.
- Kumar, P., Tarafdar, J.C., Painuli, D.K., Raina, P., Singh, M.P., Beniwal, R.K., Soni, M.L., Kumar, M., Santra, P. and Shamsuddin, M. 2009. Variability in arid soil characteristics. In *Trends in Arid Zone Research in India* (Eds. Amal Kar, B.K. Garg, M.P. Singh and S. Kathju), pp. 78-112. CAZRI, Jodhpur.
- Kumar, S., Singh, R.K. and Solanki, N.S. 2004. Economics and productivity of two crop rotations and their integrated nutrient management of irrigated areas in south-western Rajasthan. *Indian Journal of Agronomy* 49(4): 237-240.
- Kumawat, R.N., Mahajan, S.S. and Mertia, R.S. 2009. Growth and development of groundnut (*Arachis*

- hypogaea*) under foliar application of panchgavya and leaf extracts of endemic plants. *Indian Journal of Agronomy* 54(3): 324-331.
- Lokanath, H.M. and Parameshwarappa, K.G. 2006. Effect of organics on the productivity of Spanish bunch groundnut under rainfed farming situations. In *Proceedings of 18th World Congress of Soil Science*, July 9-15, 2006, pp. 62-63. Philadelphia, Pennsylvania, USA.
- Mahalingam, P.U. and Sheela, S. 2003. Production of plant growth regulators by *Pseudomonas aeruginosa*. In *Abstract of the UGC Sponsored State Level Seminar on Indigenization of Indian Farming: Problems and Prospects*, pp. 61 held at Gandhigram Rural Institute, Deemed University Gandhigram. Tamil Nadu on 7 and 8 March 2003.
- Natarajan, K. 2002. *Panchgavya-A Manual*, pp.13-27. Other India Press, Mapusa, Goa, India.
- Selvaraj, N. 2006. Dasagavya: Organic growth promoter for plants. In *The Hindu Daily News Paper*, pp. 18, (November 13, 2006). New Delhi, India.