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Green agriculture cultivation of groundnut (*Arachis hypogaea*) with foliar applied plant leaf extract and soil applied *panchgavya**

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The soils of arid western Rajasthan are wind transformed ancient alluvial plains covered either by stabilized sand or wind blown new moving sand. Pasturelands dominated among different land use systems and provided main support to the huge livestock population of the region up to 1985 (Kar 2009). With the advent of IGNP and tube well technologies, farmers of the region however began cultivation of the groundnut, gram, wheat, rapeseed-mustard, cumin and isabgol. But prevailing climatic and edaphic constraints limits sustainable crop production in the region. In arid and semi-arid regions, efficiencies of inorganic fertilizers have often been less than expected. The availability of micronutrients to crop plants also restricted due to coarse texture, high *pH* and calcareousness nature of soils (Sakal 2001). Therefore, sustainability of soil health depends heavily on the maintenance of soil organic carbon. But higher oxidation coupled with lower mineralization rate of applied organic inputs in the form of farmyard manure, compost, etc. did not give desired results and hence deficiency of organic carbon remained steadily in the soils (Kar 2009).

The problem of poor mineralization associated with low microbial mass and low soil organic carbon of these soils might be solved with addition of microbial fermented *panchgavya* solution in the soil. Role of *panchgavya* in production of many arable crops has been well documented in our country. There are reports indicated that efficacy of *panchgavya* solution enhanced manifold with the mixing of endemic plant leaves (Shelvaraj 2006). However, information on use of *panchgavya* in combination with leaf extracts of endemic plants on groundnut is very meager. Therefore, an experiment was conducted with leaf extracts of endemic desert plants in association with *panchgavya* to explore role of these plants on green agriculture cultivation of groundnut (*Arachis hypogaea* L.).

The experiment was conducted at CAZRI, RRS, Jaisalmer, Rajasthan during rainy (*kharif*) season of 2006 and 2007 under irrigated condition. The sandy soils of the experimental field was shallow in depth (30 cm) having 0.08% organic carbon, 72.80 kg/ha available N, 6.45 kg/ha available P, 215.78 kg/ha available K, 6.92 kg/ha available S, and 7.55% free $CaCO_3$ with *pH* 9.2. The experiment was laid out in split-plot-design with four levels of soil applied *panchgavya* (0, 1.0, 2.0 and 3.0 l/m^2) in main plots and four levels of foliar applied sources (control, neem, datura and tumba) in sub plots with three replications. Solutions of panchgavya and plant leaf extracts of neem (*Azadirachta indica)*, datura (*Datura metal*) and tumba (*Citrullus colocynthis*) were prepared following method adopted by Kumawat *et al*. (2011) in cluster bean. After a pre-sowing irrigation, groundnut cultivar MA 10 was sown in rows spaced at 45 cm apart using a seed rate of 80 kg/ha. The seeds were treated with *Trichoderma viridae* (6 g/kg seed) as prophylactic measure against seed borne diseases. Thinning was done at 10 days after sowing (DAS) to maintain plant to plant distance 25 cm. The 15% water diluted solution of *panchgavya* was applied near the plants in rows at 25 DAS before second irrigation. The filtered leaf extracts of the plants were mixed with the filtered *panchgavya* solution in 1:1 ratio and diluted 30 times with water for foliar application and applied twice on the groundnut foliage at 35 and 55 DAS as per treatments. Five plants per treatment were uprooted manually at each sampling for growth analysis and yield attributes. Biological yield and pod yield was computed from the plants harvested from net plots in each treatment.

*Short note

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Oil content in kernels was estimated through Soxhlet apparatus using petroleum ether as organic solvent (40–60°C). Chrolophyll content and nitrate reductase activity from the fresh leaves were determined following methods of Arnon (1949) and Jaworski (1971), respectively.

The results revealed that synthesis of chlorophyll 'a' in the leaves increased linearly with successive increase in soil applied *panchgavya* up to 2.0 l/m^2 whereas chlorophyll 'b' and total chlorophyll increased linearly up to 3.0 l/m^2 at all the phenophases (Table 1). Similar to total chlorophyll content, activity of nitrate reductase was also increased linearly with soil applied *panchgavya* from 0 to 3 l/m^2. In the study soil application of *panchgavya* at 3.0 l/m^2 at 45 DAS and 2.0 l/m^2 at 70 DAS had favourable effect on the weight of root nodules/plant. The increased content of the chlorophyll in the present study attributed to increased availability of nutrients to crop plants directly with soil applied *panchgavya* and indirectly due to moderation of soil *p*H with the addition of acidic *panchgavya* which in turn increased the availability of Fe, N, P and S nutrients, essential for the synthesis of chlorophyll (Marschner 1995). The nutrient rich *panchgavya* solution used in the study was low in *p*H due to production of many organic acids by the fermentative microbes, *Lactobacillus* (Natarajan 2002) which in turn reduced the *pH* of the rhizosphere from 9.0 to 8.33 within 24 hours after application of 3.0 liter *panchgavya*/m^2. The analogous results were also observed by Kumawat *et al*. (2011) in cluster bean. Among sources, foliar application of neem + *panchgavya* in 1:1 ratio recorded significantly higher content of total chlorophyll and as well as its components than rest of the foliar sources (Table 1). The nitrate reductase activity in green leaves and weight of root nodules were also recorded considerably higher with neem + *panchgavya*. The higher chlorophyll content, nitrate reductase activity and root nodule weight with neem leaf extract in the study might be attributed to higher N (1.05%) and P (0.78%) content of the stock solution compared to rest of the foliar applied sources.

Dry matter accumulation in leaf, stem, pods as well as plant increased linearly with successive increase in soil applied *panchgavya* from 0 to 3.0 l/m^2 at all the phenophases, with level 3.0 l/m^2 recording significantly the highest (Table 2). Successive increase in dry matter accumulation with increased levels of *panchgavya* in the study might have related to improved soil health due to improvement in the availability of micronutrients, soil microbiology and reduction in soil *pH* and EC with the addition of nutrient rich *panchgavya* (Sharma 2002). The increased nutrient supply coupled with higher chlorophyll synthesis and nitrated reductase activity might have increased the photosynthesis rate of the plants which was reflected by increased dry matter accumulation and its distribution in crop plants. The reduction in soil *p*H with application of *panchgavya* increased the solubility of the Ca (Kumawat *et al*. 2006) in root rhizosphere, essentially required for the formation and development of the shell of the pods. Thus, increased dry matter of pods/plant with increased levels of *panchgavya* would be expected in the study. Among

Table 1 Effect of soil applied *panchgavya* and foliar applied sources on the chlorophyll content of ground nut leaves at different growth stages, mean of *kharif* 2006 and 2007 seasons

Treatment	45 DAS			70 DAS		
	Chl 'a'	Chl 'b'	Total Chl	Chl 'a'	Chl 'b'	Total Chl
Soil application of panchgavya (l/m^2)						
S_0	1.134	0.379	1.512	2.280	0.721	3.001
$S_{1.0}$	1.233	0.403	1.635	2.506	0.827	3.333
$S_{2.0}$	1.309	0.446	1.753	2.622	0.945	3.567
$S_{3.0}$	1.386	0.467	1.851	2.714	1.014	3.728
SEm±	0.014	0.006	0.024	0.026	0.007	0.038
CD at 5%	0.043	0.018	0.074	0.080	0.023	0.119
Foliar sources						
Control	1.133	0.383	1.515	2.284	0.736	3.020
Neem*	1.371	0.448	1.818	2.666	0.955	3.621
Datura*	1.311	0.438	1.748	2.599	0.917	3.517
Tumba*	1.247	0.425	1.671	2.572	0.899	3.471
SEm±	0.016	0.005	0.021	0.025	0.007	0.037
CD at 5%	0.045	0.015	0.061	0.072	0.020	0.106

*Applied as filtered extract of *panchgavya* + neem/datura/tumba in 1:1 ratio (v/v) after diluting 30 times, where Chl , Cholorophyll; S_0 , no soil application of *panchgavya*; $S_{1.0}$, soil application of *panchgavya* @ 1.0 l/m^2; $S_{2.0}$, soil application of *panchgavya* @ 2.0 l/m^2; $S_{3.0}$, soil application of *panchgavya* @ 3.0 l/m^2

Table 2 Effect of soil applied *panchgavya* and foliar applied sources on dry matter accumulation, yield and yield attributes of ground nut, mean of *kharif* 2006 and 2007 seasons

Treatment	Plant dry matter at 45 DAS (g/plant)			Plant dry matter at 70 DAS (g/plant)				Plant dry matter at harvest (g/plant)			Yield attributes				Yield (kg/ha)			
	Stem	Leaf	Plant	Stem	Leaf	Pod	Plant	Stem	Leaf	Pod	Plant	Pods/ Plant	Pod index	Kernel inded	Shelling (%)	Oil content	Haulm	Pods	Bio logical
Soil application of panchgavya (l/m²)																			
S_0	1.99	2.82	4.81	4.40	5.99	4.44	14.82	7.30	10.76	14.92	32.98	15.31	102.66	47.29	53.76	48.58	1532	1266	2798
$S_{1.0}$	2.43	3.32	5.75	5.90	7.37	5.22	18.50	10.90	16.44	17.26	44.60	16.44	117.67	55.40	56.07	48.94	2320	1721	4041
$S_{2.0}$	2.92	3.76	6.68	7.09	9.34	8.02	24.45	12.67	20.49	26.40	59.56	19.45	135.18	63.45	62.52	48.60	2814	2149	4962
$S_{3.0}$	3.39	4.25	7.65	8.26	10.01	8.27	26.54	13.17	21.72	27.82	62.71	20.51	143.73	66.29	68.37	48.62	2960	2347	5307
SEm±	0.05	0.08	0.09	0.11	0.16	0.11	0.46	0.13	0.30	0.30	0.73	0.30	1.58	0.61	0.73	0.51	37	42	79
CD at 5%	0.16	0.24	0.29	0.35	0.49	0.33	1.41	0.41	0.92	0.91	2.24	0.93	4.87	1.87	2.26	1.57	113	130	242
Foliar sources																			
Control	2.45	3.04	5.49	5.83	6.68	5.11	17.63	9.14	14.98	17.09	41.21	16.28	120.41	53.32	53.08	47.97	2047	1676	3722
Neem*	2.99	3.86	6.84	7.01	9.11	7.25	23.37	12.44	19.43	22.84	54.71	18.57	124.81	60.26	61.79	48.82	2704	1917	4621
Datura*	2.68	3.68	6.36	6.52	8.61	6.92	22.05	11.38	17.72	25.03	54.13	19.41	130.91	62.42	68.04	48.46	2469	2050	4519
Tumba*	2.62	3.58	6.20	6.28	8.32	6.67	21.26	11.09	17.27	21.43	49.79	17.45	123.10	56.43	57.80	49.49	2406	1840	4247
SEm±	0.05	0.06	0.09	0.10	0.15	0.10	0.44	0.13	0.28	0.28	0.69	0.31	1.53	0.61	0.71	0.50	35	41	76
CD at 5%	0.14	0.18	0.24	0.29	0.43	0.29	1.24	0.37	0.81	0.80	1.97	0.87	4.34	1.72	2.01	1.43	100	116	215

*Applied as filtered extract of *panchgavya* + neem/datura/tumba in 1:1 ratio (v/v) after diluting 30 times where, S_0 = No soil application of *panchgavya*, $S_{1.0}$ = Soil application of *panchgavya* @ 1.0 l/m², $S_{2.0}$ = Soil application of *panchgavya* @ 2.0 l/m², $S_{3.0}$ = Soil application of *panchgavya* @ 3.0 l/m²

Table 3 Correlation coefficient and regression line showing relationship between independent variable (X) and dependent variable (Y)

Dependent variable (X)	Independent variable (Y)	Correlation coefficient (r)	Regression line
Pod yield (kg/ha)	Pods/plant	0.93	Y = –1030.35 + 161.81 X
Pod yield (kg/ha)	Pod Index	0.98	Y = –1413.17 + 26.31 X
Pod yield (kg/ha)	Kernel index	0.98	Y = –1187.81 + 52.64 X
Pod yield (kg/ha)	NR 45 DAS	0.81	Y = –1963.68 + 34.09 X
Pod yield (kg/ha)	NR 70 DAS	0.85	Y = –1865.59 + 73.47 X
Pod yield (kg/ha)	Total chl 45 DAS	0.87	Y = –1828.57 + 2191.80 X
Pod yield (kg/ha)	Total chl 70 DAS	0.88	Y = –1768.21 + 1068.00 X
Pod yield (kg/ha)	Nodule weight/plant at 45 DAS	0.96	Y = 467.03 + 49.65 X
Pod yield (kg/ha)	Nodule weight/plant at 70 DAS	0.96	Y = – 830.19 + 17.55 X

foliar sources, signficantly higher dry matter accumulation at all stages of crop growth was recorded with neem + *panchgavya* application (Table 2). The higher dry matter accumulation in leaf and stem with neem + *panchgavya* in the study attributed to higher chlorophyll content, nitrate reductase activity, root nodule weight and plant nutrients which in turn increased photosynthetic capacity of the plants. Besides, sources of foliar application (neem, datura and tumba) have many beneficial microorganism that maintained the opening of stomata for longer period both in optimum and adverse conditions during the crop growth which led to increased leaf area index providing stronger source for sink (Natarajan 2002).

The number of pods/plant at harvest varied from 15.3 to 20.5 within soil applied *panchgavya*, with level 3.0 l/m^2 having significantly the highest (Table 2). Similarly, pod index, kernel index and shelling% increased linearly with successive increase in *panchgavya* levels. The oil content in kernels did not influenced statistically with increased levels of *panchgavya* from 0 to 3.0 l/m^2. The biological, haulm and pod yields/ha also responded positively to the increased levels of *panchgavya*. Soil application of *panchgavya* at 3.0 l/m^2 recorded 85, 93 and 90% higher pod, haulm and biological yield compared to control. The significant improvement in yield attributes with successive increase in *panchgavya* levels might be associated with increased crop growth and biochemical properties of the plant. Further, in the study pod yield/ha is positively correlated with the yield attributes, nitrate reductase activity, total chlorophyll and root nodule weight (Table 3). The increased dry matter and yield attributes thus contributed for higher pod and biological yield with *panchgavya* levels compared to control. Selvaraj (2003) also observed 36% increased yield of french bean with application of vermicompost + *panchgavya* due to restoration of soil fertility with these sources.

In the study, yield attributes were recorded higher with datura + *panchgavya* than other sources of foliar application (Table 2). Though foliar application of neem + *panchgavya* recorded statistically higher haulm yield, pod yield/ha was observed significantly higher with datura + *panchgavya*. Foliar application of datura + *panchgavya* recorded 22 and 21% higher pod and biological yields compared to control. The significant improvement in yield attributes and haulm, pod and biological yield with all the foliar sources might be associated with increased dry matter accumulation within plants due to concomitant increase in chlorophyll content, nitrate reductase activity and supply of all the plant nutrients. Increased pod intensity/plant with application of neem + *panchgavya* has also been reported by Kumawat *et al*. (2011) in cluster bean.

SUMMARY

The effect of soil applied *panchgavya* and foliar applied plant leaf extracts on the biochemical properties, yield and yield attributes of groundnut (*Arachis hypogaea* L.) was examined in a field trial at CAZRI, Regional Research Station, Jaisalmer during *kharif* 2006 and 2007 under irrigated conditions. Successive increase in *panchgavya* levels from 0 to 3.0 l/m^2 led to significant increase in dry matter, chlorophyll content, nitrate reductase activity, yield and yield attributes of groundnut. Soil application of *panchgavya* at 3.0 l/m^2 recorded 85, 93 and 90% higher pod, haulm and biological yield compared to control. Foliar application of neem (*Azadirachta indica*), datura (*Datura metel*) and tumba (*Citrullus colocynthis*) plant leaf extracts in combination with *Panchgavya* in 1: 1 ratio at 35 and 55 days after sowing recorded significantly higher content of chlorophyll, plant dry matter, yield attributes and pod yields compared to water sprayed control. Foliar application of datura + *panchgavya* recorded 22 and 21% higher pod and biological yields compared to water sprayed control

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