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Growth and yield of clusterbean (*Cyamopsis tetragonoloba*) grown on light-textured soils with foliar application of fermented *panchgavya*

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ABSTRACT

A field study was carried out in rainy (*kharif*) season of 2006 and 2007 to examine the effect of foliar application of *panchgavya* plus leaf extracts of *neem* (*Azadirachta indica* A, Juss.), *datura* (*Datura metel* L.) and *tumba* (*Citrullus colocynthis* L.) in 1:1 ratio on dry matter accumulation, nutrient uptake, yield and yield attributes of clusterbean (*Cyamopsis tetragonoloba* L. Taub.) grown on light-textured soils under irrigated conditions. The results showed that the foliar application of *neem* plus *panchgavya* increased dry matter accumulation, nutrient uptake, yield and yield attributes significantly compared to control and sole application of *panchgavya*. Application of *neem* plus *panchgavya* recorded higher grain (34%), straw (21%) and biological yield (25%) compared to control. Application of the sources both at branching plus flowering recorded significantly higher dry matter as well as nutrient uptake, yield and yield attributes over the application either at branching or flowering. The grain, straw and biological yields recorded 26, 22 and 23% increase, respectively with dual application of sources both at branching and flowering compared to spray at flowering only.

Key words: Clusterbean, Dry matter, Nutrient uptake, *Panchgavya*, Yield, Yield attributes

Clusterbean (*Cyamopsis tetragonoloba* L. Taub.) is one of the important drought hardy legumes grown in Rajasthan, Gujarat and Haryana during rainy (*kharif*) season. It is highly adapted to poor soils and scanty rainfalls, low inputs and least after care. World demand for organically produced clusterbean has increased in recent years; however, lack of production technologies exclusive for organically produced clusterbean gum has restricted the scope for exports.

The use of fermented, liquid organic fertilizers, effective microorganisms and fermented plant extracts as foliar fertilizers have been introduced to modern agriculture in recent years to produce food with good quality and safety (Galindo *et al*. 2007). Microbial inoculants containing many kinds of naturally occurring beneficial microbes have been used widely in organic farming. Use of fermented curd rich in beneficial microorganisms are also practised elsewhere to augment the plant growth and suppress pest loads on crop plants (Lokanath and Parameshwarappa 2006). The benefits of effective microorganisms in increasing crop yields, improving crop quality and protecting plants from pests and diseases have been demonstrated for a wide range of crops and soil conditions (Munene 2005). Use of fermented cowdung, urine, milk fat, curd and milk together with the name of *panchgavya* is getting adaptive popularity in the agriculture sector in India, largely through the efforts of small groups of farmers. Role of foliar applied *panchgavya* in production of many plantation crops have been well documented in India (Selvaraj 2003). There are reports which indicated that the efficacy of *panchgavya* solution enhanced manifold with mixing of endemic plant leaves (Selvaraj 2006). Indian Thar Desert blessed with naturally grown native plants, like *tumba* (*Citrullus colocynthis*) and *datura* (*Datura metel* L.) on the waste lands, produce lot of biomass of less value. Thus, these vegetations could serve as resource for agriculture in supplying plant nutrients. These plant species are being used in the preparation of many agro-pesticides since time immemorial by the farmers of the region. However, most of the information published in journals have a low impact factor and were not scientifically (or seriously assessed) proven that could claim enormous benefits of the effective microorganisms (Anibal *et al*. 2007). Therefore, present experiment was hypothesized to examine the effect of *panchgavya* along with leaf extracts of different plants on the growth and yield of clusterbean.

MATERIALS AND METHODS

The experiment was conducted at RRS, CAZRI, Jaisalmer, Rajasthan during *kharif* season of 2006 and 2007 under

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irrigated condition. The soil was shallow in depth (50 cm) having 0.08% organic carbon, 72.80 kg/ha available N, 6.45 kg/ha available P, 252.78 kg/ha available K, 6.92 kg/ha available S, and 7.55% free $CaCO_3$ with *p*H 9.2. The experiment was laid out in factorial randomized block design with three replications. The 15 treatment combinations comprised five sources of foliar application and three stages of application. The leaf-extract of three commonly available arid plants, ie *neem* (*Azadirachta indica* A. Juss.), *datura* (*Datura metel* Linn.), and *tumba* (*Citrullus colocynthis* Linn.) along with *panchgavya* and control (water spray) were used as sources of foliar application. These sources of foliar application were applied either at branching (35 days after sowing) or flowering (55 days after sowing) and both at branching plus flowering. *Panchgavya* was prepared by thorough mixing of fresh cowdung (7.0 kg), cow ghee (1.0 kg), fresh cow urine (10.0 litre), cow milk (3.0 litre) and cow milk curd (2.0 litre). The leaf extracts of *neem*, *datura* and *tumba* were prepared by mixing grounded fresh leaves with cow urine in 1:1 ratio, followed by fermentation. The filtrates of leaf extracts were mixed with the filtered *panchgavya* solution in the ratio 1:1 for respective leaf extracts. Potential clusterbean 'RGC 936' was sown on 21 July 2006 and 10 July 2007 @ 15 kg seed/ha after applying presowing irrigation. Foliar application of *panchgavya* and plant leaf extracts were done at branching, flowering and both branching + flowering as per the treatments after diluting the solutions 30 times with water. Five plants altogether were taken from second row from each sides of every plot at 45 days after sowing (flowering), 65 days after sowing (podding) and maturity for per plant dry matter and yield attributes. Each sample was separated into its component plant parts – leaves, stems and pods and dry weights of plant parts were obtained after drying at 70°C for 72 hr to determine shoot dry matter and its distributions. Biological yield and grain yield was computed from the plants harvested from net plots in each treatment. The N and P content in plant parts were determined using the established methods of analysis.

RESULTS AND DISCUSSION

Dry matter accumulation

Foliar application of plant leaf extracts and *panchgavya* have considerable effect on the accumulation of dry matter in all the plant parts at various growth stages of clusterbean (Table 2). Foliar application of leaf extracts of neem, *datura* and *tumba* in combination with *panchgavya* however increased dry matter accumulation of plants and its distribution among leaf, stem, and pods significantly compared to alone application of *panchgavya* and control at 45 days after sowing, 65 days after sowing and maturity. Application of *neem* leaf plus *panchgavya* recorded 63, 44 and 52% higher dry matter in stem, leaf and plant than control at 45 days after sowing. Similarly, dry matter accumulation increased to the tune of 105, 94, 31 and 69% in stem, leaf, pods and plant at 65 days after sowing and 69, 62 and 64% at harvest in stem (stem + leaf), pod and plant respectively with application of *neem* leaf extract plus *panchgavya*. Foliar application of *tumba* plus *panchgavya* and *datura* plus *panchgavya* was found the next best treatment after *neem* plus *panchgavya* in increasing the dry matter accumulation in all parts of the plant. The dual application of these sources at branching + flowering recoded significantly higher plant dry matter compared to single spray either at branching or flowering (Table 2). At harvest, dry matter accumulation in stem (stem + leaf), pods and plant increased to the tune of 11, 33 and 26% respectively with dual application of the sources than application at flowering alone. The significant improvement in the accumulation of dry matter in plant and its distribution in different plant parts in the study was attributed to increased supply of plant nutrients, specific weight of leaf, chlorophyll synthesis, nitrogen metabolism, root nodules and phytohormones with the application of *panchgavya* and *panchgavya* plus 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 chlorophyll synthesis and for a given species, photosynthesis in green leaves strongly related to the specific leaf area, chlorophyll content and N concentration per unit dry mass (Khanzada *et al*. 2003).

Table 1 Physico-chemical properties of soil and foliar applied *panchgavya* and plant leaf solutions

†Physicochemical properties	Soil	*Panchgavya* solution	*Neem* leaf-extract	*Datura* leaf-extract	*Tumba* leaf-extract
*p*H	9.2	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	5 800	10 500	8 600	8 300
P content (ppm)	2.86	900	7 800	7 600	3 900
K content (ppm)	95.90				
S content (ppm)	3.08				
$CaCO_3$ content (%)	7.55				

†EC, Electrical conductivity; OC, organic carbon

Table 2 Effect of foliar sources and their stage of application on dry matter accumulation (g/plant) in different plant parts of clusterbean, mean of *kharif* 2006 and 2007

Treatments	45 DAS			65 DAS			Harvest			
	Stem	Leaf	Plant	Stem	Leaf	Pod	Plant	Stem	Pods	Plant
Sources of foliar application										
Control	3.70	5.51	9.21	7.31	8.25	12.64	28.19	17.38	27.05	44.43
Panchgavya	4.41	6.80	11.20	11.38	11.56	13.43	36.37	21.70	33.95	55.65
Neem	6.03	7.95	13.99	14.97	16.00	16.57	47.54	29.35	43.70	73.05
Datura	5.20	7.41	12.61	13.43	14.13	13.74	41.30	27.21	39.08	66.29
Tumba	5.36	7.75	13.11	13.84	14.66	15.30	43.79	24.69	38.94	63.63
SEm±	0.17	0.14	0.24	0.25	0.32	0.38	0.53	0.62	0.96	1.26
CD (*P*=0.05)	0.47	0.40	0.68	0.72	0.90	1.06	1.51	1.74	2.72	3.57
Stages of application										
Branching	5.46	7.84	13.29	12.08	12.59	14.43	39.11	23.59	36.67	60.26
Flowering	3.90	5.74	9.63	11.14	12.05	12.29	35.48	22.37	31.33	53.70
B + F	5.47	7.67	13.14	13.33	14.12	16.28	43.74	26.24	41.64	67.88
SEm±	0.13	0.11	0.19	0.20	0.25	0.29	0.41	0.48	0.74	0.98
CD (*P*=0.05)	0.36	0.31	0.53	0.56	0.70	0.82	1.17	1.35	2.11	2.77

B, Branching; F, flowering; DAS, days after sowing

Improved nutrition present in *panchgavya* and plant leaf extracts or foliar sources (Table 1) might have enabled greater leaf area production that resulted in greater interception of light that lead to increased dry matter productivity. Apart from nutrient supply, *panchgavya* contain proven biofertilizers, such as *Azospirillum*, *Azotobacter*, *Phosphobacter*, *Pseudomonas* that played important role in stimulation of plant growth by secreting IAA and GA_3 (Mahalingam and Sheela 2003).

Yield attributes

Yield attributes were recorded in terms of pod length, pods/plant, pod weight/plant, seeds/pod, seed weight/plant and 100-seed weight (Table 3). Yield attributes were significantly influenced both with sources of application and their stages of application. Though foliar application of *tumba* plus *panchgavya* recorded significantly higher pod length, number of pods, weight of pods, seeds/pod and weight of seeds/plant on main shoot of the plant compared to rest of the sources, foliar application of *neem* plus *panchgavya* recorded significantly higher values of these yield attributes on primary branches of the plant. Foliar application of *neem* plus *panchgavya* however recorded significantly higher values of the yield attributes and increased the average pod length from 5.02 to 5.32 cm, total pods/plant 80.32 to 128.95, total pod weight/plant 2.05 to 43.70 g, average seeds/pod 7.53 to 8.20, total seed weight/plant 14.86 to 23.04 g and average 100-seed weight 3.17 to 3.27 g compared to control. Similar to dry matter accumulation dual application of the sources both at branching plus flowering recorded significantly higher values of yield attributes than application either at branching or flowering. However, pod length, seeds/pod and 100-seed weight in pods borne on main shoot do not respond to the frequency of foliar application. The significant improvement in yield attributes with sources of foliar application was ascribed to increased crop growth, chlorophyll content, nitrate reductase activity and root nodule weight of the plant with these sources. Since dry matter accumulation/plant had shown consistent increase with these sources of application. Thus, the increased dry matter contributed for higher yield attributes compared to control. Selvaraj (2003) also observed similar results in Frenchbean with application of vermicompost + *panchgavya*. Significantly higher pod length, number of pods, weight of pods, seeds/pod and weight of seeds/plant on main shoot with *tumba* plus *panchgavya* might be due to phytohormonal growth promotive effect of cucurbitacin present in the *tumba* leaves (Kumawat *et al*. 2006). The overall higher yield attributes with *neem* plus *panchgavya* might be ascribed to higher nutrient content of the medium solution used in the study compared to other sources (Table 1). Increased pod intensity/plant with application of neem leaf extract has been reported by Oparaeke *et al*. (2001) in cowpea.

Yield and harvest index

Grain, straw and biological yields increased significantly with the foliar application of leaf extracts of *neem* plus *panchgavya*, *datura* plus *panchgavya* and *tumba* plus *panchgavya* compared to control and alone application of *panchgavya* (Fig 1). Although foliar application of *neem* plus *panchgavya*, *datura* plus *panchgavya* and *tumba* plus *panchgavya* recorded at par grain yield, the straw and biological yields were recorded significantly higher with *neem* plus *panchgavya* and *datura* plus *panchgavya*. Application of *neem* plus *panchgavya* recorded 34, 21 and 25% higher grain, straw and biological yield compared to

Table 3 Effect of foliar sources and their stage of application on yield attributes of clusterbean, mean of *kharif* 2006 and 2007

Treatment	Pod length (cm)			Pods/plant		Pods weight/plant (g)			Seeds/pod			Seed weight/plant (g)			100 seed weight (g)		
	Main shoot	Primary branches	Average	Main shoot	Primary branches	Total	Main shoot	Primary branches	Total	Main shoot	Primary branches	Average	Main shoot	Primary branches	Total	Main shoot	Primary branches	Average
Sources of foliar application																		
Control	5.10	4.93	5.02	26.93	53.38	80.32	9.35	17.70	27.05	7.65	7.42	7.53	5.32	9.54	14.86	3.19	3.15	3.17
Panchgavya	5.22	5.06	5.14	31.26	71.63	102.89	11.36	22.59	33.95	8.07	7.77	7.92	5.42	12.12	17.54	3.17	3.17	3.17
Neem	5.28	5.37	5.32	32.18	96.76	128.95	12.21	31.49	43.70	8.14	8.26	8.20	5.80	17.23	23.04	3.25	3.29	3.27
Datura	5.37	5.26	5.32	33.87	87.80	121.67	10.99	28.09	39.08	8.21	8.31	8.26	6.00	15.50	21.51	3.11	3.14	3.13
Tumba	5.44	5.15	5.30	37.46	78.88	116.35	13.24	25.70	38.94	8.48	7.98	8.23	7.41	14.23	21.64	3.25	3.20	3.23
SEm±	0.03	0.05	0.03	0.91	1.88	2.18	0.41	0.82	0.96	0.06	0.10	0.07	0.26	0.38	0.50	0.03	0.03	0.03
CD (*P*=0.05)	0.09	0.13	0.08	2.59	5.33	6.18	1.16	2.33	2.72	0.18	0.29	0.19	0.72	1.08	1.41	0.10	0.09	0.08
Stages of application																		
Branching	5.29	5.16	5.23	32.20	76.26	108.45	11.33	25.34	36.67	8.15	7.92	8.03	6.02	13.52	19.54	3.18	3.15	3.17
Flowering	5.23	5.11	5.17	29.68	70.09	99.77	9.80	21.53	31.33	7.99	7.89	7.94	5.43	11.47	16.90	3.16	3.16	3.16
B + F	5.31	5.20	5.26	35.15	86.73	121.88	13.16	28.48	41.64	8.19	8.03	8.11	6.52	16.18	22.70	3.23	3.26	3.25
SEm±	0.02	0.04	0.02	0.71	1.46	1.69	0.32	0.64	0.74	0.05	0.08	0.05	0.20	0.30	0.39	0.03	0.03	0.02
CD (*P*=0.05)	NS	NS	0.06	2.01	4.13	4.78	0.90	1.80	2.11	0.14	NS	NS	0.56	0.84	1.09	NS	0.07	0.06

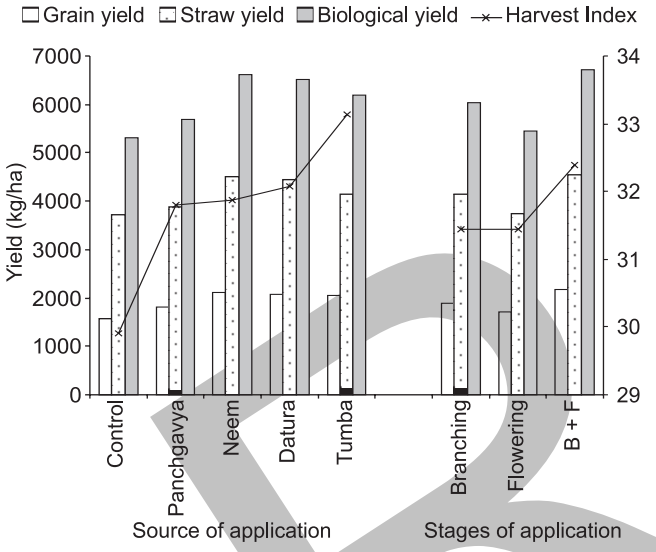

Fig 1 Effect of foliar sources and their stage of application on the yield (kg/ha) and harvest index (%) of clusterbean, mean of 2006 and 2007

control. Dual application of these plant sources at branching plus flowering recorded significantly higher biological and grain yield than single spray either at branching or flowering (Fig 1). The grain, straw and biological yields recorded 26, 22 and 23% increase, respectively with dual application of sources both at branching plus flowering compared to spray at flowering only. Although all the sources of foliar application recorded significantly higher harvest index compared to water sprayed control, foliar application of tumba plus *panchgavya* recorded significantly the highest (33.1%). Similarly, dual application at branching plus flowering recorded significantly higher harvest index of 32.4% compared to single application either at branching or flowering The significant improvement in grain and biological yield with all the foliar sources might be associated with increased dry matter accumulation of plant due to concomitant increase in chlorophyll content, nitrate reductase activity and supply of all the plant nutrients. Further grain yield/ha is positively correlated with all these factors. Similarly, 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 alone may not supply nutrients in sufficient amount required for full development of the plants. Hence, dual application of these plants leaf extracts both at branching plus flowering recorded higher plant dry matter/plant and biological and grain yields in the experiment.

Nutrient content and uptake

The N and P content in plant parts increased with foliar application of the sources at all the observed stages (45 days after sowing, 65 days after sowing and harvest) compared to

Table 4 Effect of foliar sources and their stage of application on nutrient content and uptake in different plant parts of clusterbean, mean of *kharif* 2006 and 2007

Treatment	N content (%)							N uptake (kg/ha)		
	45 DAS		65 DAS			Harvest				
	Stem	Leaf	Stem	Leaf	Pod	Stem	Grain	*Stem	Grain	Plant
Sources of application										
Control	1.35	1.52	1.26	2.40	2.03	0.83	4.64	29.29	72.68	103.68
Panchgavya	1.39	1.63	1.37	2.57	2.10	0.75	5.09	31.00	91.95	121.25
Neem	1.49	1.81	1.43	2.70	2.24	0.90	5.26	40.99	111.00	151.99
Datura	1.55	1.91	1.49	2.73	2.28	0.79	5.24	35.43	108.33	143.76
Tumba	1.68	1.92	1.50	2.75	2.30	0.76	5.18	31.94	106.35	138.28
CD (*P*=0.05)	0.05	0.06	0.04	0.07	0.07	0.06	0.30	3.98	7.14	8.60
Stages of application										
Branching	1.52	1.78	1.39	2.61	2.18	0.80	5.09	33.48	96.01	129.49
Flowering	1.45	1.73	1.38	2.58	2.15	0.74	4.93	27.94	84.71	112.65
B + F	1.50	1.78	1.46	2.69	2.24	0.87	5.22	39.77	113.47	153.24
CD (*P*=0.05)	0.04	0.05	0.03	0.05	0.05	0.04	0.23	3.08	5.53	6.66
Treatment	P Content (%)							P uptake (kg/ha)		
	45 DAS		65 DAS			Harvest				
	Stem	Leaf	Stem	Leaf	Pod	Stem	Grain	*Stem	Grain	Plant
Sources of application										
Control	0.25	0.27	0.13	0.22	0.22	0.19	0.27	7.13	4.30	11.42
Panchgavya	0.26	0.28	0.15	0.24	0.24	0.19	0.29	7.39	5.31	12.69
Neem	0.28	0.29	0.17	0.26	0.30	0.22	0.39	10.04	8.33	18.37
Datura	0.28	0.29	0.18	0.28	0.24	0.21	0.35	9.58	7.29	16.87
Tumba	0.30	0.30	0.20	0.29	0.27	0.20	0.31	8.46	6.35	14.81
CD (*P*=0.05)	0.009	0.009	0.005	0.008	0.008	0.011	0.014	0.91	0.50	1.11
Stages of application										
Branching	0.28	0.29	0.16	0.26	0.25	0.21	0.32	8.71	6.09	14.80
Flowering	0.27	0.28	0.16	0.25	0.25	0.17	0.31	6.53	5.37	11.89
B + F	0.28	0.29	0.17	0.27	0.26	0.22	0.34	10.32	7.48	17.80
CD (*P*=0.05)	0.007	0.007	0.004	0.006	0.006	0.009	0.011	0.71	0.38	0.86

*Stem, stem+ pod shell

control (Table 4). At 45 and 65 days after sowing foliar application of tumba plus *panchgavya* recorded significantly the higher content of these nutrients while at harvest neem plus *panchgavya* found significantly superior among the sources of foliar application in this regard. Similarly, uptake of N and P in different plant parts were recorded significantly higher with *neem* plus *panchgavya*. It increased the uptake of N by 40, 53 and 47% and P by 41, 94 and 61% in stem (stem + pod shell), grain and plant, respectively over control. The content and uptake of N and P in different plant parts were also affected significantly with stages of foliar application, with dual application of sources both at branching plus flowering recording significantly higher content and uptake of N and P at 65 DAS and harvest. At harvest foliar application both at branching plus flowering increased uptake of N by 42, 34 and 36% and P by 58, 39 and 50% over application at flowering only, respectively in stem (stem + pod shell), grain and plant. 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 above cited physiological processes favourably. Further increased dry matter in above ground parts favours translocation of more carbohydrates towards developing roots. Increased allocation of food material to roots in turn enhances the root volume and weight of root nodules, thereby concomitantly increased uptake of more plant nutrients (Poorter and Nagel 2000).

It is concluded from the experiment that the foliar application of *panchgavya* plus leaf extracts increased the dry matter accumulation in plants significantly compared to water sprayed control 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. Among the sources of foliar application *neem* plus *panchgavya* recorded significantly higher dry matter accumulation, yield attributes, yields and nutrient uptake due to its richness in plant nutrients compared to other sources. This low cost technology of organic farming has the potential to harvest reasonable yields from clusterbean. Further research work on other crops certainty required to authenticate the validity of the technology.

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