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Influence of various cow-based bio-enhancers and botanicals on yield, nutrient uptake of organic wheat (*Triticum aestivum* L.) and soil properties

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Abstract
A field experiment was conducted on organically managed medium black calcareous clayey soil at Junagadh (Gujarat) during *rabi* 2016-17 and 2017-18 to study the some cow-based bio-enhancers and botanicals for organic cultivation of wheat (*Triticum aestivum* L.). Twelve treatments comprising *Panchagavya* as foliar spray @ 3% at 30, 45 and 60 DAS, Jivamrut @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS, Banana sap as foliar spray @ 1% at 30, 45 and 60 DAS and Seaweed extract as foliar spray @ 3.5% at 30, 45 and 60 DAS were evaluated alone and supplemented with FYM 6 t/ha) in comparison to Vermi compost 4 t/ha + FYM 6 t/ha + Bio fertilizers, FYM 24 t/ha, Control and 100% RDF (outside the organic plot) in randomized block design with three replications. The experiment results revealed that next to 100% RDF, application of FYM 24 t/ha and *Panchagavya* as foliar spray @ 3% at 30, 45 and 60 DAS + FYM 6 t/ha were found superior in respect of the higher grain yield, straw yield, total uptake of NPK, available NPK, organic carbon and bulk density.

Keywords: Wheat, *Panchagavya, jivamrut*, seaweed extract, banana sap, organic farming, soil properties

Introduction
Wheat (*Triticum aestivum* L.) is the second most important cereal crop next to rice in the world belongs to the family *Poaceae*. It is the leading cereal grain, where 40% of the world population uses as a staple food (Anon., 2007) [1]. Its increasing demand, day by day, is due to increase in the population of India. India is the largest producer of wheat both in terms of area (30, 60, 521 ha) and production (98, 51, 428 tonnes) with an average productivity of 3219 kg/ha. It is cultivated as commercial crop in Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Gujarat and Maharashtra. In Gujarat, irrigated wheat occupies an area of 9.95 lakh hectares with production of 27.37 lakh tonnes and productivity of 2751 kg/ha (DOA, 2017) [5]. India is predominantly an agricultural country and green revolution has brought a significant change in Indian agriculture. The achievements were mainly due to use of high yielding varieties, fertilizer responsive crop cultivars and increased fertilizer use. Dependence on chemical fertilizers and chemical pesticides for the future agricultural growth will result in further loss of soil quality, acidification of soil, possibility of ground water contamination and hence loss of ecological balance. Sustained production strategies often involve application of organic sources. With increased awareness on organic farming among the farming community, they are using of many organic formulations in crop production. During the last few years there has been increasing interest in the use of Panchagavya, Jivamrut and other liquid organic formulations. Panchagavya and Jivamrut are two organic products which have received wide spread attention and acceptability among organic farming practitioners. Application of cow-based bio-enhancers, botanicals, organic manures and bio fertilizers such as Panchagavya, Jivamrut, banana sap, seaweed extract, cattle manure, vermicompost and Azotobacter, PSB and KSB has led to a decrease in the use of chemical fertilizers and has provided high quality products free of harmful agrochemicals for human safety.
Taking note of the facts highlighted above, a field experiment was conducted to study the effect of various cow-based bio-enhancers and botanicals on yield, nutrient uptake of organic wheat and post-harvest soil fertility.

Materials and Methods
A field experiment was conducted on a medium black clayey soil Certified Organic Farming

Plot of Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) in *rabi* season of 2016-17 and 2017-18. Geographically, Junagadh is situated at 21.5 ºN latitude and 70.5º E longitude with an altitude of 60 m above the mean sea level. The experimental soil was slightly alkaline in reaction with pH 7.8 and EC 0.56 dS/m, low in available nitrogen (265 kg/ha), low in available phosphorus (25 kg/ha) and medium in available potash (252 kg/ha). The mean maximum and minimum temperature during the crop period ranged from 27.3 to 36.6 °C and 11.7 to 18.7 °C, respectively. During the crop period, the relative humidity was in the range of 33 to 55%. Twelve treatments comprising Panchagavya as foliar spray @ 3% at 30, 45 and 60 DAS, Jivamrut @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS, Banana sap as foliar spray @ 1% at 30, 45 and 60 DAS and Seaweed extract as foliar spray @ 3.5% at 30, 45 and 60 DAS were evaluated alone and supplemented with FYM 6 t/ha) in comparison to Vermicompost 4 t/ha + FYM 6 t/ha + Bio fertilizers, FYM 24 t/ha, Control and 100% RDF (outside the organic plot) in randomized block design with three replications. All the recommended cultural operations were followed throughout the experimentation. Irrigation to 5 cm depth applied during cropping period. Five random plants were selected from each plot excluding the border row for taking observation on growth and yield. Soil and plant analysis was carried out adopting standard methods (Jackson, 1974) [7].

Preparation of Panchagavya

A wide mouth plastic container was taken. It was clean and sun-dried for a day or two to sterilize it. Then the cow dung (7kg) and ghee (1kg) were mixed in the container using a wooden stick. It was stirred clockwise direction in a rhythmic motion. Then it stirred in anti-clockwise direction. The container was covered using thick cloth to protect it from insects. This mixture was left for three days. After 3 days cow urine (10 L) and water (10 L) were mixed than kept for 15 days with regular mixing both in morning and evening hours. After 15 days cow milk (3L), cow curd (2 L), tender coconut water (3 L), Jaggery (3 kg) and well ripened banana (12no.) were mixed. Panchagavya was ready after 30 days.

Preparation of Jivamrut

Jivamrut was prepared by mixing 10kg desi cow dung, 10L cow urine, 2 kg Jaggery, 2 kg Pigeon pea flour and hand full of soil collected from rhizosphere of Banyan tree. All these were put in 200L capacity plastic drum and mixed thoroughly and volume was made up to 200L. The mixture was stirred well in clock wise direction and kept in shade covered with wet jute bag up to nine days and it was used for soil application.

Results and discussion

Effect on crop yield

A close perusal of data on grain yield and straw yield revealed that different treatments significantly influenced the grain and straw yields (Table 1) of wheat in pooled results.

Next to 100% RDF, higher grain yield was noticed under the treatments of FYM 24 t/ha (4148 kg/ha), followed by Panchagavya as foliar spray @ 3% at 30, 45 and 60 DAS+FYM 6t/ha. Similarly, higher straw yield of wheat was recorded under FYM 24t/ha (6383 kg/ha) and Panchagavya as foliar spray @ 3% at 30, 45 and 60 DAS+FYM 6 t/ha besides 100% RDF. Organic point of view, grain and straw yields of wheat were significantly increased by Panchagavya as foliar spray @ 3% at 30, 45 and 60 DAS+FYM 6t/ha, followed by Jivamrut @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS+FYM 6 t/ha, which might due to an enhanced release of growth promoting substances produced by the microbes present in Panchagavya. Adequate quantity of enzymes present in the cells might have favoured rapid growth and yield. FYM might have improved the biochemical properties of the soil and increased the activities of beneficial microorganisms which resulted in to production of growth promoting substances and improved nutrient availability for longer period and thus, beneficial effects on growth and yield parameters of wheat. The overall improvement of crop growth reflected into better source-sink relationship, which in turn enhanced the grain and straw yields. The present findings are in close agreement with the results obtained by Shubha *et al*. (2014) [14] and Basavaraj *et al*. (2015) [3].

Effect on nutrient uptake

The data given in Table 1 showed that significantly the highest uptake of nitrogen (132.1 kg/ha), phosphorus (27.84 kg/ha) and potassium (78.90 kg/ha) was noted under the treatment100% RDF (T_{11}), but it was found statistically comparable to the treatment of FYM 24 t/ha (T_{10}). Among the different cow-based bio-enhancers, the highest total uptake of nitrogen (103.30 kg/ha), phosphorus (21.00 kg/ha) and potassium (61.22 kg/ha) was observed under Panchagavya as foliar spray @ 3% at 30, 45 and 60 DAS + FYM 6 t/ha (T_2) in pooled data. Among botanicals, Seaweed extract as foliar spray @ 3.5% at 30, 45 and 60 DAS + FYM 6 t/ha (T_8) gave the highest total uptake of nitrogen (84.50 kg/ha), phosphorus (17.48 kg/ha) and potassium (51.11 kg/ha).

The treatment T_2(*Panchagavya* as foliar spray @ 3% at 30, 45 and 60 DAS + FYM 6 t/ha) registered significantly the highest total uptake of zinc (884 g/ha), iron (2273 g/ha), manganese (1040 g/ha) and copper (772 g/ha) respectively, and it was found statistically equivalent to FYM 24 t/ha (T_{10}) and with FYM 24 t/ha (T_{10}) and *Jivamrut* @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS + FYM 6 t/ha (T_4).However, significantly the lowest total uptake of zinc (308 g/ha), iron (1081 g/ha), manganese (411 g/ha) and copper (272 g/ha) was registered under the treatment T_{12} (Control). These might be due to quick build-up of soil micro flora and fauna which has consequently increased the enzymatic activity and helped in mineralization, solubilisation of native and applied nutrients and making them available in the soil for plant uptake and 500 L *Jivamrut* might have added some quantity of nutrients in the soil. The present findings are in accordance with those reported earlier (Palekar, 2006; Manjunatha *et al*., 2009 and Shwetha *et al*., 2009) [11, 10, 15].

Effect on soil properties

The data given in Table 2 showed that significantly the highest available nitrogen, (336 kg/ha) phosphorus(39 kg/ha) and potash(294 kg/ha) were recorded with application of FYM 24 t/ha (T_{10}), which remained statistically equivalent to Vermicompost 4 t/ha + FYM 6 t/ha + Biofertilizers (*Azotobacter* + PSB + KSB) (T_9) and *Jivamrut* @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS + FYM 6 t/ha (T_4) in most of the cases over the treatment T_{12} (Control). These might be due to addition of FYM, the available nutrient status of soil increases considerably due to mineralization of native soil as well as its own nutrient contents. Availability of P might be due to the organic acids, which were released during microbial decomposition of organic matter which might have helped in solubility of native phosphates. Higher availability of K might be due to beneficial effects of manures and reduction of potassium fixation. Similar results were also reported by Malik *et al.* (2009) [9] and Ansari and Kumar (2010) [2].

Significantly higher uptake of micronutrients (Zn, Fe, Mn and Cu) were noted with the treatment of Vermicompost 4 t/ha + FYM 6 t/ha + Biofertilizers (*Azotobacte*r + PSB + KSB) (T_9), and it was found statistically equivalent to *Jivamrut* @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS + FYM 6 t/ha(T_4), *Jivamrut* @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS (T_3) and FYM 24 t/ha (T_{10}). However, significantly the lowest micronutrients content in soil were observed in the treatment T_{12} (Control). Microbial decomposition of organic manures with simultaneous release of organic acids might have favoured the availability of micronutrients in soil. This may be due to the faster decomposition of organic sources of nutrients. This increases the available cationic micronutrient concentration in soil solution thereby increasing the uptake of these micronutrients by wheat. The present findings are within the close vicinity of those reported by Patel (2012) [12], Hussain *et al*. (2013) [6] and Kiran (2014) [8].

The data furnished in Table 2 indicated that Significantly the lowest bulk density and higher organic carbon were recorded under the treatment T_{10} (FYM 24 t/ha), it was found statistically comparable to Vermicompost 4 t/ha + FYM 6 t/ha + Biofertilizers (*Azotobacte*r + PSB + KSB) (T_9), *Jivamrut* @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS + FYM 6 t/ha(T_4) and *Jivamrut* @ 500 L/ha with irrigation at sowing, 30, 45 and 60 DAS (T_3) in most of the cases. In contrast, the highest bulk density and the lowest organic carbon content were recorded under the treatment of T_{12} (Control).This was possible because of enrichment of soil with organic matter resulting in stable aggregation and favourable pore geometry in soil, ultimately reduced the bulk density and also, increased organic carbon by direct addition of organic matter through FYM. These results are in conformity with those reported by Dey and Nath (2015) [4] and Premanandarajah and Shanika (2016) [13].

Table 1: Effect of different treatments on grain yield, straw yield and total nutrient uptake by plant (Pooled over two years)

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Zn uptake (g/ha)	Fe uptake (g/ha)	Mn uptake (g/ha)	Cu uptake (g/ha)
T_1: *Panchagavya* @ 3%	3064^{bc}	5002^{de}	77.3	15.15	44.37	539	1680	683	515
T_2: *Panchagavya* @ 3% +FYM 6 t/ha	3877^{ab}	6176^{abc}	103.3	21.00	61.22	884	2273	1040	772
T_3: *Jivamrut* @ 500 L/ha	3054^{bc}	4954^{de}	79.7	15.77	46.36	499	1539	631	361
T_4: *Jivamrut* @ 500 +FYM 6 t/ha	3229^{bc}	5753^{bcd}	96.2	20.40	62.63	699	2053	878	651
T_5: Banana sap @ 1%	3040^{c}	5302^{cde}	79.6	16.08	46.92	572	1498	614	422
T_6: Banana sap @ 1% +FYM 6 t/ha	3122^{bc}	4793^{e}	80.8	16.26	46.44	609	1711	705	546
T_7: Seaweed extract @ 3.5%	2982^{c}	4931^{de}	74.9	13.79	43.11	667	1675	609	481
T_8: Seaweed extract @ 3.5% + FYM 6 t/ha	3098^{bc}	5049^{de}	84.6	17.48	51.11	556	1674	733	572
T_9: Vermi compost 4 t/ha + FYM 6 t/ha + Bio fertilizers	3151^{bc}	5281^{de}	104.4	20.63	59.99	607	1780	734	458
T_{10}: FYM 24 t/ha	4148^{a}	6383^{ab}	129.7	22.50	64.44	759	2145	895	690
T_{11}: 100% RDF	4416^{a}	7046^{a}	132.1	27.84	78.90	630	2120	759	571
T_{12}: Control	2626^{c}	3804^{f}	54.1	10.89	32.30	308	1081	411	272
S.Em.±	112	265	4.5	0.87	2.95	32.96	79	39	39
C.D. at 5%	320	755	12.8	2.47	8.40	94	225	111	112
C.V.%	8.28	12.07	12.0	11.70	13.58	13.22	10.91	13.14	18.37

Table 2: Effect of different treatments on post-harvest soil fertility (Pooled over two years)

Treatment	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	DTPA-extractable Zn (ppm)	DTPA-extractable Fe (ppm)	DTPA-extractable Mn (ppm)	DTPA-extractable Cu (ppm)	Bulk density (Mg/m^3)	Organic carbon (%)
T_1: *Panchagavya* @ 3%	272	26.01	267	1.40	2.91	2.75	0.256	1.46	0.63
T_2: *Panchagavya* @ 3% +FYM 6 t/ha	296	29.49	273	1.43	2.99	2.94	0.283	1.34	0.72
T_3: *Jivamrut* @ 500 L/ha	279	27.91	271	1.55	3.26	3.11	0.320	1.33	0.76
T_4: *Jivamrut* @ 500 +FYM 6 t/ha	309	34.53	277	1.57	3.45	3.13	0.333	1.31	0.78
T_5: Banana sap @ 1%	276	27.18	263	1.39	2.87	2.83	0.232	1.47	0.66
T_6: Banana sap @ 1% +FYM 6 t/ha	289	32.59	274	1.42	2.91	2.90	0.266	1.35	0.69
T_7: Seaweed extract @ 3.5%	271	26.19	265	1.35	2.72	2.89	0.222	1.46	0.62
T_8: Seaweed extract @ 3.5% + FYM 6 t/ha	286	28.52	272	1.50	3.05	2.90	0.303	1.42	0.68
T_9: Vermi compost 4 t/ha + FYM 6 t/ha + Bio fertilizers	321	34.00	286	1.72	4.02	3.20	0.357	1.27	0.68
T_{10}: FYM 24 t/ha	336	39.00	294	1.52	3.16	3.08	0.309	1.26	0.79
T_{11}: 100% RDF	271	29.95	278	1.27	2.69	2.75	0.217	1.48	0.66
T_{12}: Control	252	20.83	250	1.26	2.67	2.62	0.183	1.49	0.60
S.Em.±	6.84	1.07	6.32	0.04	0.12	0.09	0.018	0.04	0.02
C.D. at 5%	19.50	3.20	18.93	0.11	0.36	0.24	0.051	0.11	0.07
C.V.%	8.52	9.61	8.92	6.74	10.01	7.14	16.01	6.84	8.81

Conclusion

Based on the experimental results, it seems quite logical to conclude that higher production along with improved soil fertility in wheat (var. GW-366) under organic farming can be secured by application of Panchagavya as foliar spray @ 3% at 30, 45 and 60 DAS along with FYM 6 t/ha on medium black calcareous clayey soil under South Saurashtra Agro-Climatic Zone.

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