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Evaluation of *Kunapa jala* and *Pancha gavya* on plant quality, physiology, biochemistry, yield and growth attributes – A case study of *Withania somnifera* Dun.

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ABSTRACT

Background: '*Vrikshayurveda*', an ancient science of plant life described by *Surapala*, has clearly outlined a systematized agricultural practice that insisted on the use of *Kunapa jala* (*KJ*) and *Pancha gavya* (*PG*) to enhance the yield and quality of plants.
Objective: An experiment was conducted to evaluate the effect of *KJ* and *PG* on growth, physiological, biochemical, quality attributes and yield of *Withania somnifera* Dun.
Materials and methods: The effect of *KJ* and *PG* was evaluated in comparison with control, organic (farmyard manure and humic acid) and inorganic (NPK) fertilizer at 60, 90, 120 and 150 days after sowing (DAS). The study was conducted in randomized complete block design method.
Results: *KJ* group were higher in, total leaf area (1707.89 cm^2) at 120 DAS, leaf area index (3.795) at 120 DAS, crop growth rate (0.256 g m^{-2} day^{-1}) at 60–90 DAS, leaf area duration (101.909) at 120–150 DAS, relative growth rate (0.0170 g g^{-1} day^{-1}) at 60–90 DAS, net assimilation rate (0.0537 g m^{-2} day^{-1}) at 60–90 DAS. Leaf area ratio was higher in *PG* group (37.937 m^2 g^{-1}) at 60 DAS. The higher levels of chlorophyll a, b and carotenoids were in *KJ* group (1.877, 0.745 and 1318.14 mg g^{-1} respectively) at 90 DAS. Yield and quality attributes at harvest (150 DAS) indicated, higher dry root yield (5.93 quintal $hectare^{-1}$), root length (15.66 cm) were higher in *KJ* group and root diameter was higher in *PG* group (1.36 cm).
Conclusion: *Vrikshayurveda* practices viz. *Kunapa jala* and *Pancha gavya* were effective on studied parameters of *W. somnifera*. Economical and eco-friendly *Vrikhayurveda* practices can be initiated for sustainable agriculture.

1. Introduction

India has 15 agro climatic zones and 17,000–18,000 species of flowering plants of which 6000–7000 species are estimated to have medicinal usage in folk and other systems of medicine like, Ayurveda, Siddha, Unani and Homoeopathy [1]. Amongst them one of the important medicinal plants is *Withania somnifera* Dun. (Solanaceae), also known as '*Ashwagandha*', and has been listed in 32 prioritized medicinal plants of India [2]. The estimated production of *W. somnifera* roots in India is more than 1500 tonnes and the annual requirement is about 7000 tonnes necessitating the increase in its cultivation and higher production [3]. In India, the popular approach to achieve the increased yield and production is by application of inorganic fertilizers. Knowing the demerits of using these chemicals, there is a thrust for alternatives for better yield and quality, which are eco-friendly too. Such practices for cultivation are available in the literature of ancient India, the major one being *Vrikshayurveda*. '*Vrikshayurveda*', an ancient science of plant life deals with healthy growth of plants and their productivity. It is an age old agro practice which is of great relevance even today in agriculture and horticulture sectors. It deals with pest and

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disease management of plants and also encompasses storage of seeds, sowing, germination, plant propagation, manuring etc. [4–6].

Though, the chemical fertilizers can enhance the yield, however it will be at the cost of the soil fertility. Meantime, the alternatives such as age old *Vrikshayurveda* practices which are organic in nature should be evaluated on medicinal plants for their acceptance and wider utility. To the best of our knowledge, there are no reports available as on date of evaluation of such practices especially on medicinal plants of high demand like *W. somnifera*. Hence, the present work was designed to evaluate the effect of two of the *Vrikshayurveda* treatments *viz*. *Kunapa jala* (*KJ*) and *Pancha gavya* (*PG*) in comparison with control, organic and inorganic fertilizer treatments on growth, physiological, biochemical, yield and quality attributes of *W. somnifera* harvested at different stages.

2. Materials and methods

2.1. Land preparation, sowing and treatments

The treatment groups comprised of control, *Kunapa jala* (*KJ*), *Pancha gavya* (*PG*), farmyard manure (FYM), inorganic fertilizer (NPK) and humic acid (HA). Mature seeds of *Ashwagandha* (variety: Jawahar *Ashwagandha* 20) were procured from KRC College of Horticulture, Arabhavi, India. The plant specimen has been authenticated and voucher specimen was deposited at Regional Medical Research Centre (ICMR), Belagavi, India for future reference (Voucher specimen no. RMRC-1100). Other raw materials required for preparation of *KJ*, *PG*, FYM, branded HA and NPK were obtained from local market and manufacturers.

A field experiment was conducted at Horticulture Research Station, Kanabargi, India. The soil was sandy loam with pH 7.31, Electrical Conductivity (EC) 0.098 ds m^{-1} and Organic Carbon (OC) 0.79%. The available N, P and K were 220, 18.86 and 280 kg ha^{-1} respectively. The net plot sizes were 2.0 m × 2.0 m. The seeds were sown in field at depth of 1 cm. Light irrigation was provided immediately after sowing. The crop was thinned at 30 days after sowing (DAS) to retain one seedling per hill with spacing of 30 × 15 cm. Full dose of *KJ*, *PG*, FYM and HA and inorganic fertilizer *viz*. phosphorus (P) in the form of Diammonium phosphate (DAP), potassium (K) in the form of Muriate of Potash (MOP) and 50% nitrogen (N) in the form of urea were applied to soil a week before sowing, remaining half dose of N and full dose of *KJ*, *PG*, FYM and HA were top dressed at 45 DAS to respective groups (Based on the results of pilot studies, only 10% of *KJ* and *PG* were used for full dose application).

2.2. Preparation of Kunapa jala and Pancha gavya

Vrikshayurveda texts explains various methods for preparation of *KJ* based on ingredients involved. In the present study, *KJ* was prepared as per *Sharangadhara* [7] and Sadhale [4], with minor modifications. The ingredients, 1.5 kg each of sheep/goat meat, chicken meat and 1 kg of Indian mackerel fish (*Rastrelliger kanagurta*) were boiled in 16 L of water till properly cooked and transferred to an earthen pot. Each 500 g powders of black gram (*Vigna mungo* L.) and sesame (*Sesamum indicum* L.) were added along with locally available Indian breed cow's milk (1 L), ghee (250 g) and honey (500 g). The pot was closed with lid and kept in warm place (the room temperature was maintained at 35 °C) for 30 days with stirring clockwise and anticlockwise direction manually at regular intervals for an hour. The content of the pot was filtered on 31st day and the resultant filtrate is *KJ*.

The *PG* was prepared referring to Sarkar et al. [8] and John De et al. [9]. All the ingredients were collected from native Indian breed cow. Twenty kg of dung, 10 L of urine and 10 L of tap water were added in an earthen pot and kept for 15 days with stirring every day manually for an hour in clockwise and anticlockwise direction. On 16th day 5 kg of ghee was added, thoroughly mixed by stirring every day and kept for 5 more days. On 21st day, 10 L each of milk and curd were added and stirred every day till 30th day. On 31st day the content of the pot was filtered.

2.3. Growth and physiological attributes

Plants were harvested at different growth stages (60, 90, 120 and 150 DAS). Height of the plant (cm), number of leaves and number of branches per plant were measured. The fresh leaves were detached and total leaf area (cm^2) was measured using Leaf area meter (Biovis). Plants were dried at ambient temperature to constant weight. Physiological characteristics *viz.* leaf area index (LAI), leaf area ratio (LAR), specific leaf area (SLA), specific leaf weight (SLW), crop growth rate (CGR), leaf area duration (LAD), relative growth rate (RGR) and net assimilation rate (NAR) were studied referring to methods explained by Azarpour et al. [10] and Prakash et al. [11].

2.4. Biochemical attributes

Leaf pigments *viz*. chlorophyll a, b and the carotenoids (xanthophylls and carotenes) were estimated at different growth stages as mentioned by Lichenthaler et al. [12] using Thermo Scientific multiskan Go 1510 spectrophotometer. The results were expressed in terms of mg g^{-1} fresh weight.

2.5. Yield and quality attributes

Yield was calculated as dry weight of the plant (g) and dry weight of the root (g). Quality of the yield was calculated on the basis of root length (cm) and root diameter (cm).

2.6. Statistical analysis

Various observations collected during study were subjected to statistical analysis using Fisher's method of analysis of variance (ANOVA) [13]. Significance of mean (n = 4) treatment squares and replication mean squares were compared by error mean squares referring to F table value at 5% probability.

3. Results and discussions

Results of growth attributes (Table 1.) indicated, height of the plant was maximum in *KJ* group (44.54 cm) at 150 DAS, number of leaves were found to be highest in NPK group (94.25) at 120 DAS, number of branches were found to be highest in *KJ* (8) and NPK (8) groups at 120 DAS and total leaf area was found to be highest in *KJ* group (1707.89 cm^2) at 120 DAS, which was on par with *PG* group (1682.07 cm^2). As the leaf area is an indicator of photosynthetic efficiency of the plants and plants grown under favourable conditions will tend to have good vegetative growth, increased number of branches, number of leaves and leaf area which was observed in *KJ* and *PG* treated groups, this observation is in lines with report of Al-Doghachi et al. [14].

Tables 2 and 3 show the effect of treatments at different stages of *W. somnifera* on physiological attributes. The LAI increased with advancement of crop age up to 120 DAS and thereafter declination was observed due to senescence and shedding of leaves, the results are in accordance with Nadukeri [15] in Coleus. In the present study, highest LAI was observed in *KJ* treated group (3.795) which was on par with *PG* group (3.738) at 120 DAS. A study conducted by

Table 1
Growth attributes.

Treatment n = 4	Height of the plant (cm)				No. of leaves per plant				No. of branches per plant				Total leaf area (cm^2)			
	60	90	120	150	60	90	120	150	60	90	120	150	60	90	120	150
Contr	15.75	31.50	41.40	42.15	21.25	55.00	85.00	65.25	1.25	5.00	7.00	6.25	450.66	1112.94	1580.57	1188.06
KJ	16.75	38.00	43.79	44.54	21.50	64.75	91.75	67.75	1.25	6.00	8.00	7.25	516.51	1254.24	1707.89	1349.36
PG	17.13	35.50	44.10	43.21	21.75	66.50	92.50	67.75	1.50	6.50	7.75	7.00	506.96	1215.63	1682.07	1305.75
FYM	15.50	32.25	42.10	42.06	18.25	55.25	93.50	70.25	1.00	5.50	7.25	6.50	464.18	1138.96	1593.84	1217.08
NPK	17.25	34.00	43.56	43.61	22.00	65.50	94.25	69.00	1.50	6.75	8.00	7.25	494.90	1189.22	1664.17	1279.34
HA	15.75	31.25	42.04	42.03	20.25	65.25	91.50	66.75	1.25	6.25	7.25	6.50	477.69	1067.80	1615.14	1152.87
SEm ±	0.59	1.83	1.19	1.15	1.47	3.98	2.52	2.77	0.22	0.73	0.61	0.61	15.62	23.52	8.79	23.52
CD at 5%	1.78	5.51	3.59	3.46	4.43	12.01	7.60	8.36	0.65	2.20	1.84	1.84	47.07	70.91	26.48	70.91
CV%	7.20	10.84	5.56	5.35	14.09	12.84	5.52	8.18	33.40	24.28	16.22	18.02	6.44	4.05	1.07	3.77

60; 90; 120; 150: days after sowing; Contr: Control; *KJ*: *Kunapa jala*; *PG*: *Pancha gavya*; Fym: Farmyard manure; FYM: Inorganic fertilizer; HA: Humic acid; SEm: Standard error of mean; CD: Critical difference; CV: Coefficient of variation.

Table 2
Physiological attributes with respect to LAI, LAR, SLA and SLW.

Treatment n = 4	LAI				LAR ($cm^2\ g^{-1}$)				SLA ($cm^2\ g^{-1}$)				SLW ($mg\ cm^{-2}$)			
	60	90	120	150	60	90	120	150	60	90	120	150	60	90	120	150
Contr	1.001	2.473	3.512	2.640	35.226	31.721	23.395	24.193	0.0614	0.0856	0.0709	0.0768	162.843	117.705	141.177	130.658
KJ	1.148	2.787	3.795	2.999	37.587	28.265	22.042	22.810	0.0690	0.0777	0.0717	0.0748	145.455	130.159	139.516	135.289
PG	1.127	2.701	3.738	2.902	37.937	28.704	22.608	23.748	0.0687	0.0756	0.0729	0.0789	146.687	134.249	137.453	128.304
FYM	1.032	2.531	3.542	2.705	35.316	29.463	22.597	23.336	0.0622	0.0780	0.0712	0.0758	161.141	129.244	140.735	133.267
NPK	1.100	2.643	3.698	2.843	35.916	28.892	22.744	23.139	0.0641	0.0786	0.0724	0.0771	157.148	128.004	138.416	131.072
HA	1.062	2.373	3.589	2.562	36.184	27.749	22.398	21.657	0.0645	0.0718	0.0710	0.0718	155.051	139.637	141.052	139.603
SEm ±	0.035	0.052	0.020	0.052	1.460	0.759	0.208	0.444	0.0023	0.0021	0.0009	0.0017	4.886	3.623	1.851	3.008
CD at 5%	0.105	0.158	0.059	0.158	4.402	2.287	0.627	1.339	0.0070	0.0062	0.0028	0.0052	14.727	10.920	5.579	9.066
CV%	6.438	4.045	1.071	3.768	8.033	5.209	1.838	3.837	7.1574	5.3232	2.6047	4.5333	6.316	5.581	2.649	4.522

60; 90; 120; 150: days after sowing; Contr: Control; *KJ*: *Kunapa jala*; *PG*: *Pancha gavya*; Fym: Farmyard manure; FYM: Inorganic fertilizer; HA: Humic acid; LAI: Leaf area index; LAR: Leaf area ratio; SLA: Specific leaf area; SLW: Specific leaf weight; SEm: Standard error of mean; CD: Critical difference; CV: Coefficient of variation.

Table 3
Physiological attributes with respect to CGR, LAD, RGR and NAR.

Treatment n = 4	CGR ($g\ m^{-2}\ day^{-1}$)			LAD			RGR ($g\ g^{-1}\ day^{-1}$)			NAR ($g\ m^{-2}\ day^{-1}$)		
	60–90	90–120	120–150	60–90	90–120	120–150	60–90	90–120	120–150	60–90	90–120	120–150
Contr	0.185	0.271	−0.154	52.120	89.784	92.288	0.0146	0.0095	−0.0046	0.0440	0.0354	−0.0194
KJ	0.256	0.276	−0.152	59.025	98.738	101.909	0.0170	0.0081	−0.0039	0.0537	0.0327	−0.0174
PG	0.243	0.266	−0.161	57.420	96.590	99.594	0.0167	0.0081	−0.0044	0.0525	0.0323	−0.0189
FYM	0.212	0.266	−0.153	53.438	91.093	93.697	0.0156	0.0087	−0.0044	0.0493	0.0343	−0.0190
NPK	0.228	0.266	−0.148	56.137	95.113	98.117	0.0158	0.0083	−0.0040	0.0504	0.0329	−0.0176
HA	0.211	0.280	−0.157	51.517	89.432	92.267	0.0155	0.0091	−0.0044	0.0501	0.0367	−0.0199
SEm ±	0.005	0.007	−0.924	0.959	0.990	0.990	0.0003	0.0003	0.0001	0.0018	0.0010	0.0006
CD at 5%	0.016	0.022	0.013	2.889	2.985	2.985	0.0010	0.0009	0.0004	0.0055	0.0031	0.0019
CV%	4.893	5.457	−5.706	3.489	2.120	2.057	4.37	6.56	−5.6520	7.26	6.1323	−6.7610

60–90; 90–120; 120–150: days after sowing; Contr: Control; *KJ*: *Kunapa jala*; *PG*: *Pancha gavya*; Fym: Farmyard manure; FYM: Inorganic fertilizer; HA: Humic acid; CGR: Crop growth rate, LAD: Leaf area duration, RGR: Relative growth rate, NAR: Net assimilation rate; SEm: Standard error of mean; CD: Critical difference; CV: Coefficient of variation.

Vaidya et al. [16] on *W. somnifera* revealed highest LAI as 2.42, whereas in the present study better results were observed at given conditions. A field experiment conducted by Kubsad et al. [17] on *Ashwagandha* observed highest LAI as 3.918 when fertilizer was applied at the level of 24 kg N/ha and 48 kg P/ha, which are closer to the results of *KJ* treated group from our study. It was observed from all treatment groups, the value of LAR was highest at early growth stages and later it was reduced, similar observations were made by Azarpour et al. [10] and Parmar et al. [18].

At 90 DAS highest LAR was recorded in the control group (31.721 $m^2\ g^{-1}$) whereas *KJ* group shown lowest (28.265 $m^2\ g^{-1}$). SLA indicates the ratio of photosynthetic tissues surface to the weight of photosynthetic tissues. Higher SLA is indicative of more leaf area and lesser dry weight, hence the reduction of SLA increases photosynthetic efficiency of leaves. Though, amongst 4 growth stages 60 DAS shown lowest SLA in all treatment groups may be because of lowest leaf area and dry weight. However in subsequent stages 90 DAS shown highest SLA followed by 150 and 120 DAS. Amongst the treatment groups at 90 DAS, lowest SLA was recorded in HA (0.0718 $cm^2\ g^{-1}$). Parmar et al. [18] explains high rate of photosynthesis requires a large amount of enzymes and light harvesting complexes per unit leaf area and possibly an extra layer of palisade parenchyma, all of which decrease SLA and thus LAR. Often SLW is related to photosynthetic efficiency of the crop plants, higher values indicate increased photosynthetic efficiency. HA group shows 139.637 mg cm^{-2} SLW, indicating respective photosynthetic activity.

The CGR is the rate of dry matter accumulation per unit ground per unit time and it is increased with the advancement of crop age. The highest CGR was recorded in HA group (0.280 g $m^2\ day^{-1}$) at 90–120 DAS (Table 3.). However highest CGR was obtained at 60–90 DAS in *KJ* group (0.256 g $m^2\ day^{-1}$), which was on par with *PG* group (0.243 g $m^2\ day^{-1}$). The increase in the CGR at 90–120 DAS might be due to the maximum plant height, number of

branches and leaves per plant resulting in maximum dry matter accumulation in plants, this is in accordance with Venkatesha et al. [19]. It is also observed that negative values of CGR at 120–150 DAS suggesting defoliation or senescence, this is in compliance with Pirzad et al. [20] and Azarpour et al. [10]. The LAD signifies the duration of the functional activity of the leaves, it denotes the ability of the plant with reference to the photosynthetic duration. The results indicate (Table 3.), highest LAD was achieved in *KJ* treated group (101.909) at 120–150 DAS, which was on par with *PG* group (99.594). The influence of treatments on the LAD was similar to LAI because it was derived from the LAI data, which is justified by Irshad et al. [21]. The RGR denotes the rate of increase in dry matter per unit dry matter present. The RGR decreased with advancement of crop growth. The results show (Table 3), higher RGR was recorded at 60–90 DAS, which indicates grand growth period. In this period highest RGR was recorded in *KJ* treated group (0.0170 g g day^{-1}), which was on par with *PG* group (0.0167 g g day^{-1}). These results are in accordance with Pirzad et al. in *Pimpenella anisum* [20] and Nadukeri et al. in coleus [15]. The highest NAR was recorded at 60–90 DAS and it decreased thereafter till harvest due to lower LAI. The NAR is essentially an estimation of canopy photosynthesis achieved per unit leaf area which can measure photosynthetic efficiency. The results indicate (Table 3), that the highest NAR was recorded in *KJ* group (0.0537 g m^2 day^{-1}) which was on par with *PG* (0.0525 g m^2 day^{-1}), NPK (0.0504 g m^2 day^{-1}), HA (0.0501 g m^2 day^{-1}) and FYM (0.0493 g m^2 day^{-1}) at 60–90 DAS. Maximum NAR in all the treatments was observed at the beginning stage (60–90 DAS) and when dry matter accumulation reached to its maximum, NAR declined to zero and thereafter to negative values. Similar changes in NAR curve were reported by Singh et al. [22] and Yang et al. [23]. As stated by Azarpour et al. [10] and also evident from our study, the reason of declination of CGR, RGR and NAR curves pattern to negative levels may be due to acceleration in leaf production and early closure of canopy. This condition enables absorption of less solar radiation by the leaves resulting into declination of values.

As the chlorophylls and carotenoids absorb light energy and transfer it into the photosynthetic apparatus of leaves, determination of leaf pigments will provide a valuable tool to integrate and understand the physiological and biochemical function of leaves [24]. Results of biochemical estimation (Tables 4–6) suggest that chlorophyll a, b and carotenoids contents were found to be highest in *KJ* treated group (1.877, 0.745 and 1318.14 mg g^{-1} respectively) at 90 DAS. Kannan et al. [25] and Lichenthaler et al. [12] reported, lower level of leaf pigments due to stressed conditions; similar observations were made in the present study treatment groups with lower level of leaf pigments. Sarkar et al. [8] reported, chilli, tomato and cow pea plants showed higher chlorophyll contents in *PG* and *KJ* combination treatment group which is supportive to the present study.

Results of yield and quality parameters at harvest (Table 7.) indicated that the highest dry root yield was recorded in *KJ* group (118.63 g plot^{-1} or 5.93 quintal hectare^{-1}), which was on par with *PG*, NPK and HA groups. Wankhade et al. [26] observed 5.47 quintal hectare^{-1} root yield at maturity stage. Vajantha et al. [27] observed, the dry root yield was significantly influenced by different treatments of *Panchakavya* on *Ashwagandha*, which is in compliance with present study results of *Vrikshayurveda* treatment groups. The quality of yield was assessed on the basis of root length and diameter. Root length was found to be highest in *KJ* group (15.66 cm) which was on par with *PG*, FYM and HA and root diameter was found to be highest in *PG* group (1.36 cm) which was on par with NPK, *KJ* and HA. According to Hasanuzzaman et al. [28]

Table 4
Estimation of Chlorophyll A (mg g^{-1}).

Treatment n = 4	60	90	120	150
Contr	0.909	1.078	0.996	0.650
KJ	1.338	1.877	1.617	1.096
PG	1.023	1.379	1.226	0.870
FYM	0.853	1.118	0.998	0.733
NPK	1.194	1.420	1.150	0.926
HA	1.221	1.328	1.160	0.878
SEm ±	0.073	0.091	0.063	0.049
CD 5%	0.221	0.275	0.190	0.148
CV%	13.462	13.348	10.562	11.416

60; 90; 120; 150: days after sowing; Contr: Control; *KJ*: *Kunapa jala*; *PG*: *Pancha gavya*; Fym: Farmyard manure; FYM: Inorganic fertilizer; HA: Humic acid; SEm: Standard error of mean; CD: Critical difference; CV: Coefficient of variation.

Table 5
Estimation of Chlorophyll B (mg g^{-1}).

Treatment n = 4	60	90	120	150
Contr	0.292	0.376	0.385	0.035
KJ	0.498	0.745	0.517	0.223
PG	0.442	0.571	0.478	0.242
FYM	0.412	0.457	0.419	0.237
NPK	0.417	0.534	0.571	0.172
HA	0.377	0.535	0.534	0.154
SEm ±	0.009	0.029	0.030	0.015
CD 5%	0.027	0.089	0.090	0.044
CV%	4.368	10.970	12.289	16.553

60; 90; 120; 150: days after sowing; Contr: Control; *KJ*: *Kunapa jala*; *PG*: *Pancha gavya*; Fym: Farmyard manure; FYM: Inorganic fertilizer; HA: Humic acid; SEm: Standard error of mean; CD: Critical difference; CV: Coefficient of variation.

Table 6
Estimation of Carotenoids (mg g^{-1}).

Treatment n = 4	60	90	120	150
Contr	779.11	900.57	815.72	451.58
KJ	1112.24	1318.14	1113.25	979.03
PG	907.53	1052.01	994.55	931.10
FYM	780.51	936.02	832.80	645.42
NPK	976.66	1075.52	1038.95	836.45
HA	935.54	1066.52	981.51	869.73
SEm ±	47.29	44.77	48.61	58.85
CD 5%	142.54	134.95	146.51	177.40
CV%	10.33	8.46	10.10	14.98

60; 90; 120; 150: days after sowing; Contr: Control; *KJ*: *Kunapa jala*; *PG*: *Pancha gavya*; Fym: Farmyard manure; FYM: Inorganic fertilizer; HA: Humic acid; SEm: Standard error of mean; CD: Critical difference; CV: Coefficient of variation.

Table 7
Quality and Yield attributes at harvest (150 DAS).

Treatment n = 4	Dry root yield		Root length (cm)	Root diameter (cm)
	g plot^{-1}	q hect^{-1}		
Contr	92.40	4.62	13.98	1.17
KJ	118.63	5.93	15.66	1.26
PG	116.41	5.82	15.56	1.36
FYM	95.44	4.77	14.98	1.20
NPK	108.65	5.43	14.31	1.28
HA	107.88	5.39	14.85	1.19
SEm ±	4.13	0.21	0.53	0.05
CD at 5%	12.44	0.62	1.59	0.16
CV%	7.74	7.74	7.10	8.57

Contr: Control; *KJ*: *Kunapa jala*; *PG*: *Pancha gavya*; Fym: Farmyard manure; NPK: Inorganic fertilizer; HA: Humic acid; g: gram; q: quintal; hect: hectare; SEm: Standard error of mean; CD: Critical difference; CV: Coefficient of variation.

an increased trend of plant weight was observed with the increase of cow dung amount due to the beneficial effect of organic matter in soil properties and plant growth. Similar trends were observed in *KJ* and *PG* groups.

4. Conclusion

Vrikshayurveda treatments were effective in terms of growth, physiological, biochemical, yield and quality attributes. Further studies are needed to evaluate the effect of *Vrikshayurveda* treatments on quality and quantity of biomedically important phytocompounds. Consequently, to reduce the pressure on agriculture for higher production, the economical and ecofriendly *Vrikhayurveda* practices can be initiated for sustainable agriculture and can be considered as an alternative to conventional agricultural practices.

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Conflict of interest

None.

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References

[1] National Medicinal Plants Board, Ministry of AYUSH, Government of India. http://nmpb.nic.in/ [Accessed 31 March 2016].
[2] National Medicinal Plants Board, Ministry of AYUSH, Government of India. Annual Demand of 32 Prioritized Medicinal Plants and Its Uses. http://www.nmpb.nic.in/index1.php?level=2&sublinkid=688&lid=246 [Accessed 31 March 2016].
[3] TNAU Agritech Portal. http://agritech.tnau.ac.in/farm_enterprises/Farm%20enterprises_%20Ashwagantha.html [Accessed 31 March 2016].
[4] Sadhale N. Surapala's Vrikshayurveda (the science of plant life by Surapala). Secunderabad: Asian Agri History Foundation; 1996.
[5] Nene YL. Kunapajala – a liquid organic manure of antiquity. Secunderabad: Asian Agri-History Foundation; 2006.
[6] Aralelimath GT, Nayak SU, Ankad GM, Hegde HV, Hegde L. Comparative study on effects of Vrikshayurveda and modern techniques on germination of Bakuchi (*Psoralea corylifolia* L.) seeds. Natl Acad Sci Lett 2016. http://dx.doi.org/10.1007/s40009-016-0446-0.
[7] Savitha DB, Ashok BK, Rabinarayan A, Ravishankar B. Importance of Kunapajala (traditional liquid organic manure) of vrikshayurveda in medicinal plant cultivation. Glob J Res Med Plants Indegenous Med 2012;1(7):272–9.
[8] Sarkar S, Kundu SS, Ghorai D. Validation of liquid organics - *Panchagavya* and *Kunapajala* as plant growth promoters. Indian J Traditional Knowl 2014;13(2):398–403.
[9] John DBA, Sorna GL. Investigations on the effect of organic and inorganic farming methods on black gram and green gram. Indian J Agric Res 2006;40(3):204–7.
[10] Azarpour E, Moraditochaee M, Bozorgi HR. Effect of nitrogen fertilizer management on growth analysis of rice cultivars. Int J Biosci 2014;4(5):35–47.
[11] Prakash M, Suganthi S, Gokulakrishnan J, Sabesan T. Effect of homobrassinolide on growth, physiology and biochemical aspects of sesame. Karnataka J Agric Sci 2008;20(1):110–2.
[12] Lichtenthaler H, Wellburn A. Determination of total carotenoids and chlorophyll a and b of leaf extracts in different solvents. Biochem Soc Trans 1983;603:591–2.
[13] Panse VG, Sukhatme PV. Statistical methods for agricultural workers. New Delhi: ICAR Publication; 1957. p. 125–48.
[14] Al-Doghachi EHA, Abdul-Razzak OH, Faris NN. Response of Ashwagandha (*Withania somnifera* L.) to sowing dates and organic liquid fertilizer (Vit-ORG). Asian J Plant Sci Res 2016;6(1):1–7.
[15] Nadukeri S, Kattimani KN. Integrated nutrient management in coleus (*Coleus forskohlii* Briq.). Karnataka J Agric Sci 2012;25(3):407–8.
[16] Vidya KM, Hegde L, Saraswathi BM, Vijay Kumar BM. Evaluation of diploids and autotetraploid genotypes of Ashwagandha (*Withania somnifera* Dunal.) for growth, yield and quality characters. Asian J Hortic 2013;8(1):97–100.
[17] Kubsad VS, Palled YB, Mansur CP. Effect of spacing and fertilizer levels on physiological parameters in relation to productivity of Ashwagandha (*Withania somnifera*). Indian J Agric Sci 2009;79(7):501–5.
[18] Parmar NG, Chanda SV. Growth analysis using curve fitting method in early and late sown sunflower. Plant Breed Seed Sci 2002;46(1):61–9.
[19] Venkatesha NT, Kattimani KN, Madalageri MB, Hanamasheti SI, Gangadharappa PM, Devappa V. Integrated nutrient management in Isabgol (*Plantago ovata* Forsk.). J Asian Hort 2007;3(4):263–6.
[20] Pirzad A, Khoshbakht M, Siadat AA, Fathi GA, Bakhshandeh AM. Growth analysis of *Pimpinella anisum* under different irrigation regimes and amounts of super absorbent polymer. Int Res J Appl Basic Sci 2012;3(1):112–22.
[21] Irshad A, Cheema ZA. Growth analysis of transplanted fine rice under different competition durations with barnyard grass. Int J Agric Biol 2002;4(1):123–6.
[22] Singh P, Agrawal M, Agrawal SB. Evaluation of physiological, growth and yield responses of a tropical oil crop (*Brassica campestris* L. var. Kranti) under ambient ozone pollution at varying NPK levels. Environ Pollut 2009;157:871–80.
[23] Yang L, Liu H, Wang Y, Zhu J, Huang J, Liu G, et al. Impact of elevated CO_2 concentration on inter-subspecific hybrid rice cultivar Liangyoupeijiu under fully open-air field conditions. Field Crops Res 2009;112:7–15.
[24] Sims DA, Gamon JA. Relationships between leaf pigment content and spectral reflectance across a wide range of species, leaf structures and developmental stages. Remote Sens Environ 2002;81:337–54.
[25] Kannan ND, Kulandaivelu G. Drought induced changes in physiological, biochemical and phytochemical properties of *Withania somnifera* Dun. J Med Plants Res 2011;5(16):3929–35.
[26] Wankhade SG, Gholap SV, Patil M. Harvesting period management for production of quality roots of Ashwagandha (*Withania somnifera*.Dunal). Ann Pharm Pharm Sci 2010;2(10):71–3.
[27] Vajantha B, Umadevi M, Patnaik MC, Rajkumar M. Dry matter production, root characters and seed yield of Ashwagandha (*Withania somnifera*) as influenced by panchakavya. Glob J Biosci Biotechnol 2014;3(4):354–8.
[28] Hasanuzzaman M, Ahamed KU, Khalequzzaman KM, Shamsuzzaman AMM, Nahar K. Plant characteristics, growth and leaf yield of *Aloe vera* as affected by organic manure in pot culture. Aust J Crop Sci 2008;2(3):158–63.