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Influence of Integrated Nutrient Management on Root Characters and Economics of Ashwagandha

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ABSTRACT

The field experiments were conducted during *rabi* 2007-08 and *kharif* 2008 at College farm, ANGRAU on a sandy loam soil to study the effect of different levels of NPK, organic manures, *panchakavya* and bio-fertilizers on root yield and root growth parameters of Ashwagandha. The highest root yield (348 and 333 kg ha^{-1} during *rabi* 2007-08 and *kharif* 2008, respectively) was recorded with the conjunctive use of 150% NPK along with castor cake @ 2.5 t ha^{-1} and bio-fertilizers in Ashwagandha. The highest root length and girth werealso recorded in the same treatment. The highest benefit cost ratio was recorded with 100% NPK+BF (2.86 and 2.39 during *rabi* 2007-08 and *kharif* 2008, respectively) in both the season.

Key words : Ashwagandha, B:C ratio, Grading of roots, Organic manures, *Panchakavya*, Root parameters.

Integrated nutrient management (INM) implies the most efficient use and management of organic, inorganic and biological sources of major as well as micro nutrients so as to attain higher levels of crop productivity and to maintain the soil fertility of soil. Ashwagandha (*Withania somnifera* L.) is an important medicinal plant, belonging to the family of Solanaceae, cultivated in different states of India. Most commonly its roots and occasionally leaf and seed are used in ayurvedic and unani medicines. The estimated annual production of Ashwagandha roots in India is more than 1500 t and the requirement is about 7000 t necessitating the increase in its cultivation and higher production. In general, research on nutritional requirement of medicinal plants is very scanty. Ashwagandha crop gives very good response to application of organic manures and fertilizers (Rajeshwar Rao and Rajput, 2005; Nigam *et al*., 1984). Keeping in view, the present investigation was undertaken to generate integrated nutrient management for improving the root yield and grading of Ashwagandha grown in sandy loam soils in North Telangana Zone of Andhra Pradesh

MATERIAL AND METHODS

Field experiments were conducted at College Farm, College of Agriculture, Hyderabad during *rabi* 2007-08 and *kharif* 2008 with Ashwagandha (Variety: Poshitha). The experimental soil was sandy clay loam in texture, having pH 7.6 and 7.5, EC 0.16 and 0.18 dS m^{-1}, organic carbon 0.40 and 0.40 %, 203 and 200 kg ha^{-1} of available N, 17.08 and 17.12 kg ha^{-1} of available P, 287 and 263 kg ha^{-1} kg ha^{-1} of available K in *rabi* 2007-08 and *kharif* 2008, respectively. The experiment was laid out with split plot design having 16 treatment combinations (four main treatments-four levels of NPK fertilizers viz., 0, 50, 100 and 150% NPK and four sub treatments-no manures, castor cake@2.5 t ha^{-1}+BF, vermi compost @ 1 t ha^{-1}+BF, *panchakavya* @ 5% foliar spray+BF) with three replications. The manures were applied as per the treatments one week before sowing. The entire dose of P was applied as basal through SSP. The recommended N, P and K were applied as per treatments through urea, single super phosphate and muriate of potash, respectively. Nitrogen was applied in three equal splits as basal, 30 days after sowing and at flowering stage through urea. Entire phosphorous was applied as basal through single super phosphate. Potassium was applied in two equal splits as basal and at flowering stage through muriate of potash. Bio-fertilizers were applied by mixing each 5 kg of *Azospirillum* and PSB in 50 Kg FYM ha^{-1} and applied in two splits as basal and at 30 days after sowing in crop rows. *Panchakavya* is an organic product prepared by

as per the procedue of Natarajan (2003) mixing five products obtained from cow viz., cow dung (5 kg), cow urine (3 litres), cow milk (2 litres), cow curd (2 litres) and cow ghee (1 litre). In addition to the above products, sugarcane juice (3 litres), tender coconut water (3 litres) and riped banana (1 kg) were also added to get 20 litres of *panchakavya* stock solution. The mixture is placed in a wide mouthed mud pot and kept under shade. The contents were stirred twice a day for about 20 minutes, both in the morning and in the evening to facilitate aerobic microbial activity. About 10 days after fermentation, it was used for spraying. The dry root yield was recorded after harvest and expressed as kg ha^{-1}. Grading of roots was done in the following 5 grades based on thickness of roots (Ajay *et al.,* 2005). The statistical analysis was carried out following standard methods (Snedecor and Cochram, 1978).

Grade	Thickness
A grade root:	<8 mm in
B grade root:	8 to 10 mm
C grade root:	10 to 12 mm
D grade root:	12 to 13 mm
E grade root:	> 13 mm

RESULTS AND DISCUSSION

Root length and root girth:

The data regarding root length and girth (cm) during *rabi* 2007-2008 and *kharif* 2008 are presented in table 1.

Root length (cm):

During both the years, the root length was significantly influenced by different fertilizer levels, organic manures, *panchakavya* and BF as well as with their interaction.

In *rabi* 2007-08 and *kharif* 2008, among fertilizer levels, 150% NPK recorded the highest root length (16.84 and 15.49 cm , respectively) followed by 100% NPK. The lowest was recorded with no fertilizers (14.78 and 13.60 cm). As regards to organic manures the highest root length was noticed with castor cake (16.78 and 15.44 cm, respectively) which was on par with vermi-compost (16.64 and 15.30 cm, respectively). The lowest was obtained from no manures (15.04 and 13.84 cm, respectively) and it was at par with *panchakavya* (15.46 and 14.23 cm, respectively). Integrated use of 150% NPK + castor cake recorded the highest root length (17.18 and 16.27 cm in both the years, respectively). The lowest was noticed with control (14.06 and 12.94 cm during *rabi* 2007 and *kharif* 2007-08, respectively).

Root girth (cm):

Different levels of fertilizers, organic manures, *panchakavya* and BF as well as their interaction showed non significant difference on root girth in *rabi* 2007-2008 and *kharif* 2008. Among the fertilizer levels, during *rabi* 2007-2008 it ranged from 0.93 cm with 50% NPK to 1.07 cm with 100% NPK where as in *kharif* 2008, it ranged from 0.88 cm with 50% NPK to 1.02 cm with 100% NPK. As regards to organic manures, the highest was recorded with *panchakavya* +BF in both the years. Among the interaction effects 100% NPK + BF recorded the highest root girth (1.20 and 1.14 cm during *rabi* 2007-08 and *kharif* 2008, respectively). The higher yield attributing characters like root length and girth might abe due to higher supply of nutrients, favourable physical and biological environment in the soil leading to better root activity and nutrient absorption (Chauhan *et al*., 2005; Rao, 1998). As Ashwagandha is a root crop, improvement of soil physical environment might have helped in better development of roots.

Grading of roots:

The data pertaining to grading of roots during *rabi* 2007-2008 and *kharif* 2008 are presented in table 2 .

In *rabi* 2007-2008, among all the treatments, the highest per cent of 'A' grade roots (19%) were obtained from control whereas 50% NPK+ *PK* with BF recorded highest per cent (45%) of 'B' grade roots. Application of 100% NPK + *panchakavya* with BF resulted (43%) of 'C' grade which is highest than other treatments. The highest per cent of 'D' grade roots were recorded with 100% NPK + BF (30%) where as application of 100% NPK+ BF, 100% NPK + vermi-compost with BF received highest % of 'E' grade roots.

During *kharif* 2008, among all the nutrients, application of 50% NPK + vermi-compost with bio fertilizers recorded highest per cent of

Table 1. Effect of inorganic fertilisers, organic manures, *panchakavya* and bio fertilisers on root characters and yield of Ashwagandha during *rabi* 2007-08 and *kharif* 2008.

Treatments	*rabi* 2007-08 (I year)					*kharif* 2008 (II year)				
	Root length (cm)									
	S_1 No manures	S_2 castor cake @ 2.5 t ha^{-1} + BF*	S_3 vermi-compost @ 1 t ha^{-1} + BF	S_4 panchakavya @ 5% foliar spray + BF	Mean	S_1 No manures	S_2 castor cake @ 2.5 t ha^{-1} + BF*	S_3 vermi-compost @ 1 t ha^{-1} + BF	S_4 panchakavya @ 5% foliar spray + BF	Mean
M_1-0% NPK	14.06	15.39	15.34	14.32	14.78	12.94	14.16	14.11	13.17	13.60
M_2-50% NPK	14.76	16.72	16.38	15.08	15.74	13.58	15.38	15.07	13.87	14.48
M_3-100% NPK**	15.45	17.34	17.40	16.10	16.57	14.21	15.95	16.01	14.81	15.25
M_4-150% NPK	15.90	17.68	17.42	16.35	16.84	14.63	16.27	16.03	15.04	15.49
Mean	15.04	16.78	16.64	15.46		13.84	15.44	15.30	14.23	
				SE(m)	C.D			SE(m)	C.D	
Main				0.32	0.85			0.38	0.96	
Sub				0.28	0.63			0.47	0.44	
Main at same or different levels of sub				0.55	1.10			0.72	1.27	
	Root girth (cm)									
M_1-0% NPK	0.85	1.10	0.90	1.00	0.96	0.81	1.05	0.86	0.95	0.91
M_2-50% NPK	1.00	0.90	0.84	0.97	0.93	0.95	0.86	0.80	0.92	0.88
M_3-100% NPK**	1.20	1.03	0.95	1.10	1.07	1.14	0.98	0.90	1.05	1.02
M_4-150% NPK	1.05	1.00	0.95	1.05	1.01	1.00	0.95	0.90	1.00	0.96
Mean	1.03	1.01	0.91	1.03		0.97	0.96	0.86	0.98	
				SE(m)	C.D				SE(m)	C.D
Main				0.08	NS				0.12	NS
Sub				0.06	NS				0.08	NS
Main at same or different levels of sub				0.15	NS				0.20	NS
	Root yield (kg ha^{-1})									
M_1-0% NPK	248	298	280	267	273	242	285	279	277	271
M_2-50% NPK	265	320	294	277	289	269	308	294	283	289
M_3-100% NPK**	279	344	315	289	307	281	325	310	300	304
M_4-150% NPK	287	348	317	305	315	287	333	318	308	311
Mean	273	328	302	285		272	313	301	292	
				SE(m)	C.D				SE(m)	C.D
Main				5.47	2.79				3.92	2.00
Sub				5.03	2.56				4.50	2.30
Main at same or different levels of sub				10.73	5.47				8.14	4.15

BF* - Bio fertilisers (*Azospirillum* + Phosphorous Solubilizing Bacteria)
100% NPK** = 60 - 50 - 40 kg NPK ha^{-1}

Table 2. Effect of inorganic fetrilizers, organic manures, panchakavya and bio fertilizers on grading of roots of Ashwagandha during *rabi* 2007-08 and *karif* 2008.

Treatments	Grading of roots* (%)									
	rabi 2007 - 2008					*kharif* 2008				
	A grade	B grade	C grade	D grade	E grade	A grade	B grade	C grade	D grade	E grade
T_1 - No fertilizers + BF	19	32	25	15	11	27	30	16	20	7
T_2 - Castor cake (CC) + BF	12	30	35	10	13	22	41	23	4	10
T_3 - Vermi-compost (VC) + BF	10	37	20	24	18	14	37	20	17	12
T_4 - *panchakavya (PK)* + BF	12	36	28	14	10	10	38	34	8	10
T_5 - 50% NPK + BF	14	40	35	7	4	20	35	9	14	22
T_6 - 50% NPK + CC + BF	10	37	32	10	21	16	27	31	10	16
T_7 - 50% NPK + VC + BF	16	40	30	10	4	38	20	26	9	7
T_8 - 50% NPK + *PK*+ BF	10	45	26	13	6	14	38	13	11	14
T_9 - 100% NPK + BF	4	19	25	30	22	6	48	25	12	9
T_{10} - 100% NPK + CC + BF	8	32	30	17	13	12	40	17	24	7
T_{11} - 100% NPK + VC + BF	15	28	30	15	22	8	35	25	18	14
T_{12} - 100% NPK + *PK* + BF	8	26	43	17	6	10	22	40	8	20
T_{13} - 150% NPK + BF	17	24	22	14	13	16	30	24	12	18
T_{14} - 150% NPK + CC + BF	12	38		10	18	4	37	15	16	28
T_{15} - 150% NPK + VC + BF	12	40	25	13	10	10	26	30	10	24
T_{16} - 150 % NPK + *PK* + BF	10	25	36	18	11	14	35	27	16	8

*Root grade based on thickness in mm: A = <8; B = > 8-10; C => 10-12; D = > 12-13; E = > 13

Table 3. Effect of inorganic fertilisers, organic manures, panchakavya and bio fertilisers on additional benefit cost ratio during *rabi* 2007 - 2008 (I year) and kharif 2008 (II year).

Treatments	Additional benefit cost ratio	
	rabi 2007 - 2008	*kharif* 2008
T1 - No fertilizers + BF	-	-
T2 - Castor cake (CC) + BF	0.31	0.38
T3 - Vermi-compost (VC) + BF	1.38	1.26
T4 - panchakavya (PK) + BF	1.22	0.70
T5 - 50% NPK+ BF	2.79	1.85
T6 - 50% NPK + CC + BF	0.47	0.54
T7 - 50% NPK + VC + BF	1.69	1.58
T8 - 50% NPK + PK+ BF	1.26	0.94
T9 - 100% NPK + BF	2.86	2.39
T10 - 100% NPK + CC + BF	0.57	0.70
T11 - 100% NPK + VC + BF	1.96	2.03
T12 - 100% NPK + PK + BF	1.59	1.18
T13 - 150% NPK + BF	2.56	2.33
T14 - 150% NPK + CC + BF	0.61	0.71
T15 - 150% NPK + VC + BF	1.97	1.88
T16 - 150 % NPK + PK + BF	1.63	1.48

'A' grade tubers (38%) followed by control (27%). The 'B' grade roots were highest with application of 100% NPK + bio fertilizers (48%) followed by castor cake + bio fertilizers (41%). Foliar spray of *panchakavya* with 100% NPK+BF showed highest 'C' grade roots (40%). The 'D' grade roots were higher (24%) in 100% NPK + castor cake+BF whereas application of 150% NPK + castor cake + bio fertilizers showed highest per centage of 'E' grade roots (28%).

Root yield:

Different levels of fertilizers, organic manures as well as their interaction showed significant effect on dry root yield during both *rabi* 2007-08 and *kharif* 2008. Among the levels of NPK, 150% NPK showed the highest root yield during *rabi* 2007-08 and *kharif* 2008 (315 and 311 kg ha^{-1}, respectively) followed by 100% NPK. Among organic manures, application of castor cake with BF recorded the highest root yield (328 and 313 kg ha^{-1}, respectively). In different combinations, integrated use of 150% NPK + castor cake + BF showed significantly the highest yield (348 and 333 kg ha^{-1}, respectively). The organic manures which have improved the soil physical conditions like soil structure, aeration, water holding capacity and soil micro organisms activity, which help in sufficient supply of nutrients leading to more number of branches, leaves, leaf area which this might have helped in the efficient synthesis and translocation of photosynthates from source to sink resulting up better root growth and yield (Joy *et al*., 2005 and Praveen, 2000).

Benefit cost ratio:

The data on benefit cost ratio are presented in table 3. During *rabi* 2007-2008, among all the treatments the additional benefit cost ratio ranged from 0.31 to 2.86. The maximum benefit cost ratio recorded with 100% NPK + BF (2.86) followed by 50% NPK+BF (2.79). The minimum was noticed with castor cake @ 2.5 t ha^{-1} + BF (0.31). Though application of 150% NPK+ castor cake @ 2.5 t ha^{-1} + BF gave higher dry root yields the benefit cost ratio was less (0.61) due to high cost of castor

cake. Similarly in *kharif* 2008 also the highest benefit cost ratio was noticed with 100% NPK (2.39) followed by 150% NPK+BF (2.33). The application of *panchakavya* +BF recorded the of BC vality 1.22 and 0.79 in *rabi* 2007-08 and *kharif* 2008, respectively. However integrated use of 100% NPK with *panchakavya* and BF recorded 1.59 and 1.18 of benefit cost ratio during *rabi* 2007-08 and *kharif* 2008, respectively.

It is concluded that integrated application of 150% NPK + castor cake + bio fertilizers recorded the highest dry root yield. The highest additional benefit cost ratio was recorded with 100% NPK and BF.

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