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RESEARCH PAPER

Growth and yield of ashwagandha (*Withania somnifera* L.) as effected by INM and *Panchagavya*

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Abstract **:** Investigations were carried out for two years to study the effect of different levels of NPK (0, 50, 100 and 150%), organic manures (castor cake @ 2.5 t ha^{-1} and vermi-compost @ 1 t ha^{-1}), *panchagavya* and bio fertilizers (*Azospirillum* and phosphorus solubilising bacteria each of 5 kg ha^{-1}) on growth and root yield of medicinal crop Ashwagandha at College Farm, College of Agriculture, Hyderabad during *Rabi* 2007-08 and *Kharif* 2008 by using split plot design. During both the years at flowering and harvest, the highest dry matter production (3314 and 3083 kg ha^{-1} and 6204 and 5101 kg ha^{-1}) and dry root yield (127 and 125 kg ha^{-1} and 348 and 333 kg ha^{-1}, respectively) was recorded with conjunctive use of 150 per cent NPK with castor cake @ 2.5 t ha^{-1}.

Key Words **:** Ashwagandha, Castor cake,Vermi-compost, *Panchagavya, Azospirillum*, Phosphorus solubilising bacteria, Root yield, Dry matter production

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INTRODUCTION

Ashwagandha is one of the most important medicinal plant. It is coined with two words *viz.*, Ashwini and Gandha. Ashwini means horse and Gandha means power. It belongs 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. It has significant value in the pharmacological activity due to the presence of alkaloids in roots. Roots contain several pyrazole alkaloids namely withasomnine and steroldal, withaferin A and withanolides (Dastur, 1970). Now a days use of Ayurvedic medicines is increasing due to less side effects. There is good demond to root of ashwagandha. There is necessity to increase the production by supplying adequate amount of fertilizers and organic manures. In general, research on nutritional requirement of medicinal plants is very scanty. Ashwagandha crop gives very good response to application of organic manures (Rajeshwar Rao and Rajput, 2005). The present investigation was carried out to study the effect of inorganic fertilizers, different organic manures, bio-fertilizers and *panchagavya* on performance of ashwagandha in terms of dry matter production and root yield.

MATERIALS AND METHODS

The field experiments was conducted to study the effect of different organic manures, *panchagavya* and bio-fertilizers in combination with different levels of NPK at College farm, College of Agriculture, Rajendranagar, Hyderabad. It is located at Latitude of $17^0 19^{/} 39^{//}$ N and Longitude of $78^0 24^{/} 09^{//}$ E and at an altitude of 568.3 m above mean sea level. The crop was grown during *Rabi* 2007 – 2008 and *Kharif* 2008. The initial soil properties of experimental site during both the years are presented in Table A. The field experiment was laid out with split plot design having four main treatments M_1 - Control (no fertilizers), M_2 - 50 per cent NPK (30-25-20 kg ha^{-1}), M_3 - 100 per cent NPK (60-50-40 kg ha^{-1}) and M_4 - 150 per cent NPK (90-75-60 kg ha^{-1})) and four sub treatments S_1 - No manures + Bio-Fertilizers (BF) (*Azospirillum* +PSB), S_2 - Castor cake @ 2.5 t

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Table A : Salient features of soil of the experiment site

Sr. No.	Properties	Value	
		Rabi 2007 - 2008 (I year)	*Kharif* 2008 (II year)
1.	**Physical properties**		
	Sand (%)	58.33	69.43
	Slit (%)	13.24	4.69
	Clay (%)	28.43	25.88
	Textural class	Sandy clay loam	Sandy clay loam
	Bulk density (g cm^{-3})	1.52	1.41
2.	**Physico-chemical properties**		
	pH 1:2 (soil water suspension)	7.60	7.54
	EC 1:2 (soil water suspension) dS m^{-1}	0.16	0.182
	Organic carbon (%)	0.40	0.40
3.	**Chemical properties**		
	Available N (kg ha^{-1})	203	200
	Available P (kg ha^{-1})	17.08	17.12
	Available K (kg ha^{-1})	287	263

ha^{-1} +BF, S_3 - Vermi-compost @ 1 t ha^{-1} +BF and S_4 - *Panchagavya* @ 5 per cent foliar spray at 30, 60 and 90 DAS + BF. The recommended N, P and K were applied as per the treatments through urea, single super phosphate and muriate of potash, respectively. Nitrogen was applied in three equal splits at basal, 45 DAS and at flowering stage (90 DAS) through urea. Entire recommended phosphorus was applied at basal through single super phosphate. Potassium was applied in two equal splits at basal and at flowering stage through muriate of potash. Bio-fertilizers were applied by mixing each 2 kg of *Azospirillum* and PSB (Phosphorus solubilising bacteria) in 50 kg FYM ha^{-1} and applied in two splits at basal and at 30 DAS in crop rows. Organic manures like castor cake and vermicompost were applied as a basal dose as per the treatments. *Panchagavya* made from cow products were sprayed as per treatments at different days after sowing in different concentrations. *Panchagavya* is an organic product prepared by 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 *panchagavya* stock solution. The mixture was 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 (Natarajan, 2003). The crop was harvested at 203 and 175 days after sowing during *Rabi* 2007-2008 and *Kharif* 2008, respectively when roots attained pencil thickness size and the leaves were dried and berries became yellowish red in color. At flowering and harvest, the dry matter production, fresh and dry root yields were recorded.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Dry matter production:

The data pertaining to dry matter production at flowering and harvest during *Rabi* 2007-2008 and *Kharif* 2008 are presented in Tables 1 and 2, respectively. At both the stages in both the years it was significantly influenced by fertilizer levels, organic manures, *panchagavya* and bio fertilisers as well as with their interaction.

Flowering:

Among the fertilizer levels the dry matter production was gradually increased from 0 per cent NPK to 150 per cent of recommended NPK. Every increment of NPK levels has resulted in significant increase in dry matter production. During both the years, application of 150 per cent NPK recorded significantly the highest dry matter production (2664 and 2472 kg ha^{-1}) followed by 100 per cent NPK (2346 and 2170 kg ha^{-1}) and 50 per cent NPK (2026 and 1857 kg ha^{-1}) and the lowest was noticed with no fertilizers (1494 and 1367 kg ha^{-1}), respectively (Table 1).

Among the organic manures, *panchagavya* and bio-fertilizers, the highest dry matter production was noticed with castor cake @ 2.5 t ha^{-1} + BF (2652 and 2453 kg ha^{-1}) followed by vermi-compost @ 1 t ha^{-1} + BF (2229 and 2057 kg ha^{-1}) and *panchagavya* @ 5 per cent foliar spray + BF (1994 and 1826 kg ha^{-1}) and the lowest was noticed with no manures + BF (1654 and 1529 kg ha^{-1}), respectively.

Among the interactions, in both the years, among different combinations application of 150 per cent NPK along

with castor cake @ 2.5 t ha^{-1} + BF resulted in significantly the highest dry matter production (3314 and 3083 kg ha^{-1}, respectively) (M_4S_2). The treatments 100 per cent NPK with castor cake @ 2.5 t ha^{-1} + BF (2927 and 2732 kg ha^{-1}) (M_3S_2) and 150 per cent NPK with vermi-compost @ 1 t ha^{-1} + BF (2901and 2689 kg ha^{-1}) (M_4S_3) were at par with each other. The lowest was recorded with control (1237 and 1131 kg ha^{-1}) (M_1S_1). It is interesting to note that application of castor cake @ 2.5 t ha^{-1} + BF (1730 and 1583 kg ha^{-1}) (M_1S_2) and vermi-compost @ 1 t ha^{-1} + BF (1586 and 1453 kg ha^{-1}) (M_1S_3) recorded higher dry matter production than 50 per cent NPK + BF (1506 and 1382 kg ha^{-1}) (M_2S_1).

Harvest:

The dry matter production of ashwagandha with different treatments at harvest followed the same trend as explained in flowering. Among fertilizer levels, the highest dry matter production was obtained from 150 per cent NPK (4981 and 4095 kg ha^{-1}) followed by 100 per cent NPK (4380 and 3604 kg ha^{-1}) and 50 per cent NPK (3792 and 3119 kg ha^{-1}) while the lowest was registered with no fertilizers (2802 and 2304 kg ha^{-1}). The per cent was linearly increased with increasing fertilizer levels from 0 per cent NPK to 150 per cent NPK (Table 2).

Among organic manures/*panchagavya* and BF, the maximum dry matter production was noticed with castor cake @ 2.5 t ha^{-1} + BF (4971 and 4089 kg ha^{-1}) followed by vermi-compost @ 1 t ha^{-1} + BF (4171 and 3430 kg ha^{-1}) and *panchagavya* @ 5 per cent foliar spray + BF (3722 and 3054 kg ha^{-1}). The lowest was recorded with no manures + BF (3092 and 2550 kg ha^{-1}).

Among different combinations, application of castor cake @ 2.5 t ha^{-1} + BF with 150 per cent NPK recorded significantly the highest dry matter production (6204 and 5101 kg ha^{-1}, in both the years, respectively). The treatments 100 per cent NPK along with castor cake @ 2.5 t ha^{-1} + BF (5484 and 4510 kg ha^{-1}) and 150 per cent NPK along with vermi-compost @ 1 t ha^{-1} + BF (5428 and 4454 kg ha^{-1}) were at par with each other. The combination of 100 per cent NPK along with vermi-compost @ 1 t ha^{-1} + BF and 100 per cent NPK along with *panchagavya* @ 5 per cent foliar spray + BF did not differ significantly (4322 kg ha^{-1}) in *Rabi* 2007-2008. The lowest dry matter production was noticed with control (2318 and 1900 kg ha^{-1}). Application of castor cake @ 2.5 t ha^{-1} + BF (3255 and 2685 kg ha^{-1}) and vermi-compost @ 1 t ha^{-1} + BF (2974 and 2448 kg ha^{-1}) resulted higher dry matter production than 50 per cent NPK + BF (2820 and 2324 kg ha^{-1}).

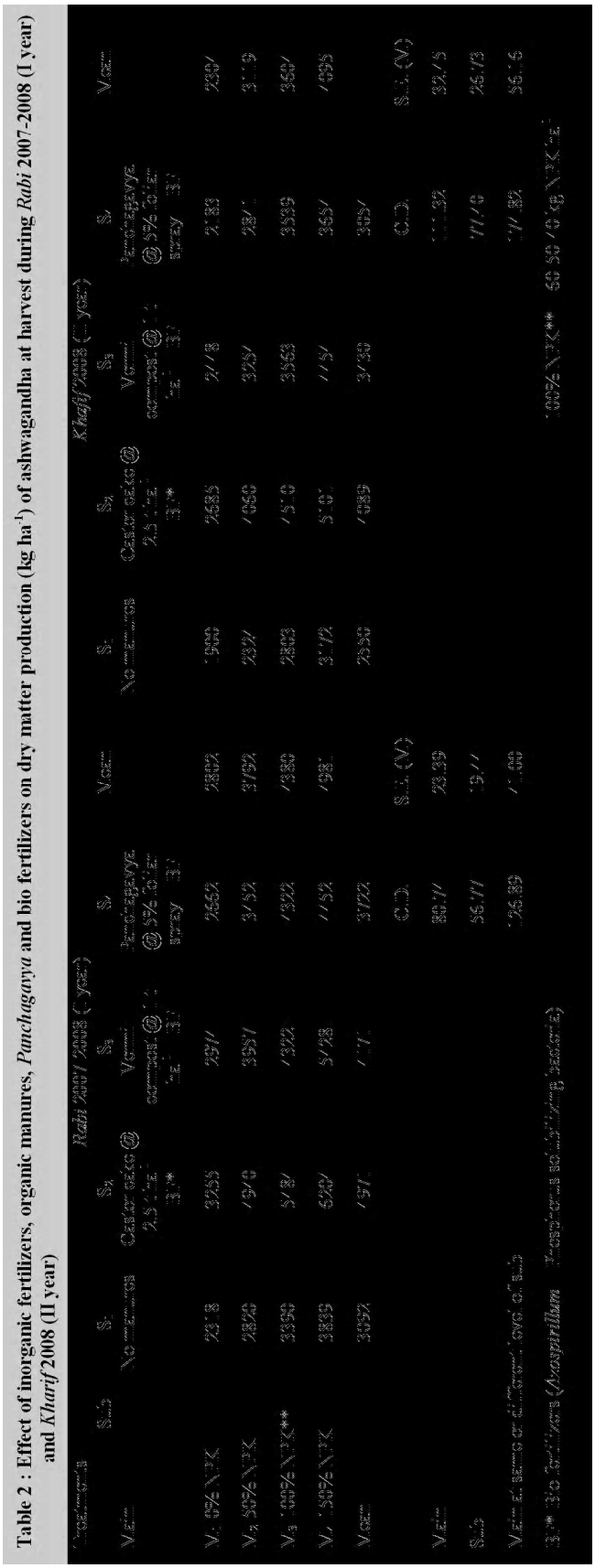
The dry matter production was an important character which indicates the effect of accumulation of photosynthates and is an indirect indication of photosynthetic activity. The increase in dry matter production with increase in NPK levels can be attributed to the favourable effect of these nutrients. The nitrogen is mainly responsible for promoting growth of plants. As vegetative growth of plant is more, the dry weight

Table 1 : Effect of inorganic fertilizers, organic manures, *Panchagavya* and bio fertilizers on dry matter production (kg ha^{-1}) of ashwagandha at flowering during *Rabi* 2007-2008 (I year) and *Kharif* 2008 (II year)

Treatments	*Rabi* 2007-2008 (I year)					*Khafif* 2008 (II year)				
Sub / Main	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 Panchagavya @ 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 Panchagavya @ 5% foliar spray + BF	Mean
M_1 0% NPK	1237	1730	1586	1721	1794	1131	1583	1453	1300	1367
M_2 50% NPK	1506	2637	2115	1847	2026	1382	2413	1937	1694	1857
M_3 100% NPK**	1818	2927	2315	2324	2346	1687	2732	2147	2112	2170
M_4 150% NPK	2054	3314	2901	2384	2664	1916	3083	2689	2199	2472
Mean	1654	2652	2229	1994		1529	2453	2057	1826	
				C.D.	S.E. (M)				C.D.	S.E. (M)
Main				32.23	16.44				62.77	18.18
Sub				30.21	15.41				42.51	14.56
Main at same or different level of sub				63.48	32.39				96.45	31.09

BF* Bio fertilizers (*Azospirillum* + Phosphorus solubilizing bacteria) 100% NPK** = 60:50:40 kg NPK ha^{-1}

Table 2 : Effect of inorganic fertilizers, organic manures, *Panchagavya* and bio fertilizers on dry matter production (kg ha^{-1}) of ashwagandha at harvest during *Rabi* 2007-2008 (I year) and *Kharif* 2008 (II year)



of plant is also more (Venkata Reddy *et al*.,2004; Pakkyanathan *et al*., 2004). Phosphorus plays active role in the formation of high energy phosphates which are unstable in water and act as carrier for many vital reactions like oxidation of sugars and photosynthesis thus contributing directly towards growth and yield (Khandelwal *et al*., 2003). The beneficial effect of organic manures like higher supply of major and micronutrients, provide favourable physical and biological environment in the soil leading to better root growth and nutrient absorption are responsible for higher dry matter production (Yadav *et al*., 2003). Integrated use of organic manures along with inorganic fertilizers not only reduce the dosage of inorganic fertilizers but also helps to improve the inorganic fertilizer efficiency which leads to more translocation of photosynthates to roots due to increase in dry matter production resulting in higher root yield (Sandhya Rani, 2006; Somanath *et al*., 2005).

Root yield

Flowering:

There was significant increase in dry root yield with increasing levels of fertilizers from 0 per cent NPK to 150 per cent NPK (Table 3). Among fertilizers levels the highest dry root yield was observed with 150 per cent NPK (115 and 117 kg ha^{-1}) followed by 100 per cent NPK (112 and 114 kg ha^{-1}). Application of 50 per cent NPK showed 105 and 109 kg ha^{-1} of dry root yield while the lowest was 101and 103 kg ha^{-1} with no fertilizers.

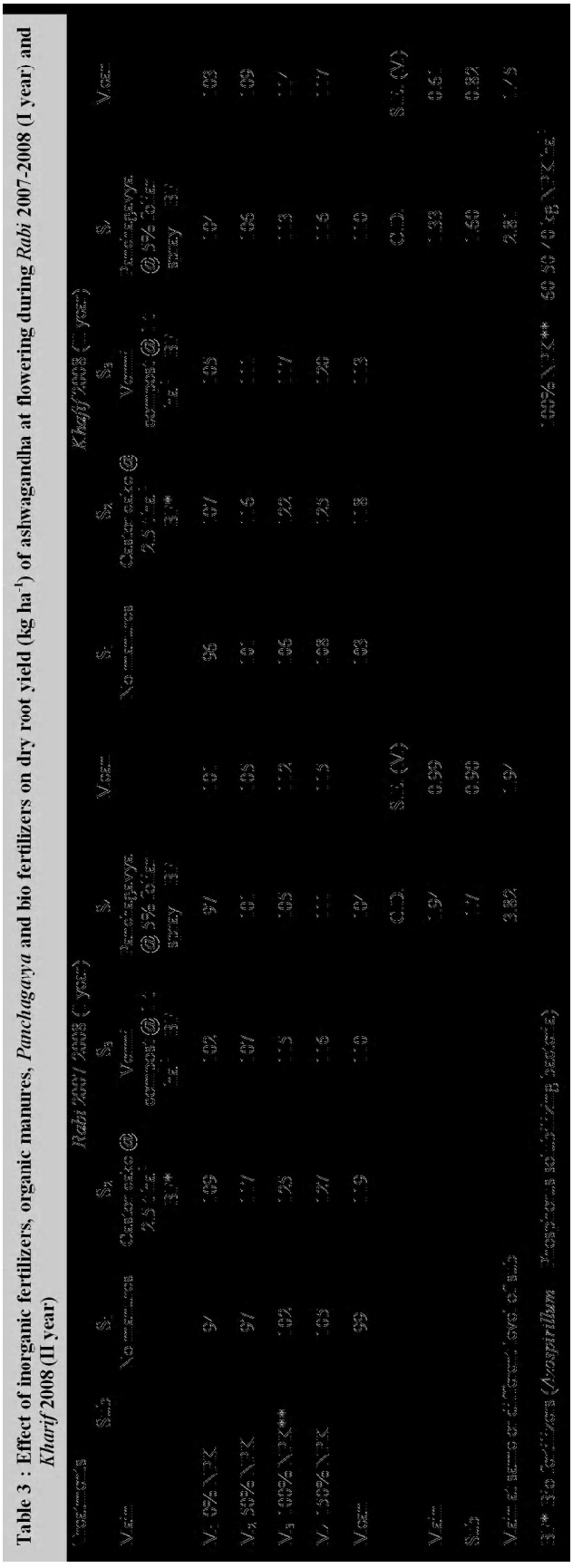
Significantly the highest dry root yield was noticed with application of castor cake @ 2.5 t ha^{-1} + BF (119 and 118 kg ha^{-1}) followed by vermi-compost @ 1 t ha^{-1} + BF (110 and 113 kg ha^{-1}) and *panchagavya* @ 5 per cent foliar spray+ BF (104 and 110 kg ha^{-1}) and lowest was noticed with no manures+ BF (99 and 103 kg ha^{-1}).

Among the interactions, in both the years, integrated use of different levels of fertilizers, organic manures, *panchagavya* and BF showed significant effect on dry root yield. The treatment 150 per cent NPK along with castor cake @ 2.5 t ha^{-1} + BF (127 and 125 kg ha^{-1}) (M_4S_2) showed the highest yield but it was at par with 100 per cent NPK along with castor cake @ 2.5 t ha^{-1} + BF (125 kg ha^{-1}) (M_3S_2) in *Rabi* 2007-2008. The treatments 50 per cent NPK along with castor cake +BF and 150 per cent NPK with *panchagavya* +BF showed similar dry root yield (116 kg ha^{-1}) (M_2S_2 and M_4S_4) during *Kharif* 2008. The lowest dry root yield (94 and 96 kg ha^{-1}) (M_1S_1) was noticed with control, however it was at par with *panchagavya* @ 5 per cent foliar spray + BF (97 kg ha^{-1}) (M_1S_4) and 50 per cent NPK + BF (97 kg ha^{-1}) (M_2S_1) in *Rabi* 2007-2008. During *Kharif* 2008, application of castor cake + BF and 50 per cent NPK with *panchagavya* also recorded one and same value (107 kg ha^{-1}) (M_1S_2), (M_2S_4).

Harvest:

Dry root yield was increased from 273 kg ha^{-1} to 315 kg

Table 3 : Effect of inorganic fertilizers, organic manures, *Panchagavya* and bio fertilizers on dry root yield (kg ha^{-1}) of ashwagandha at flowering during *Rabi* 2007-2008 (I year) and *Kharif* 2008 (II year)



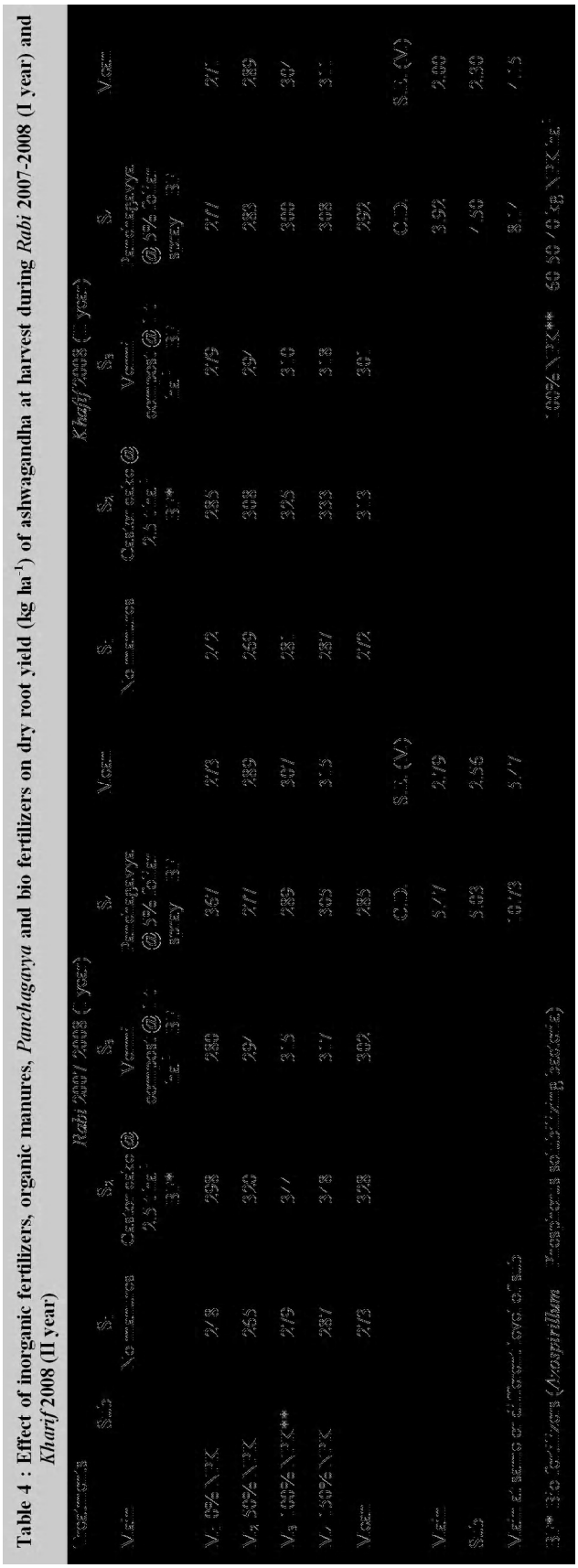
ha^{-1} and 272 to 311 kg ha^{-1} with increased levels of application of fertilizers from 0 per cent to 150 per cent NPK. There was a successive increase in dry root yield observed from 0 per cent NPK to 150 per cent NPK. The highest dry root yield was observed in 150 per cent NPK (315 and 311 kg ha^{-1}) which significantly differed from any fertilizer level followed by 100 per cent NPK (307 and 304 kg ha^{-1}) and 50 per cent NPK (289 kg ha^{-1}). The lowest was noticed with no fertilizers (273 and 271 kg ha^{-1}).

Among organic manures / *panchagavya* and BF, application of castor cake @ 2.5 t ha^{-1} + BF recorded significantly the highest dry root yield (328 and 313 kg ha^{-1}) followed by vermi-compost @ 1 t ha^{-1} + BF (302 and 301 kg ha^{-1}) and *panchagavya* @ 5 per cent foliar spray+ BF (285 and 292 kg ha^{-1}). The lowest value was noticed with no manures+ BF (273 and 272 kg ha^{-1}).

There was significant difference observed with fertilizer levels, organic manures, *panchagavya* and BF on dry root yield. The highest dry root yield was observed with 150 per cent NPK along with castor cake @ 2.5 t ha^{-1} + BF (348 and 333 kg ha^{-1}) (M_4S_2) which was at par with 100 per cent NPK + castor cake @ 2.5 t ha^{-1} + BF (344 and 325 kg ha^{-1}) (M_3S_2). The treatments 50 per cent NPK along with *panchagavya* @ 5 per cent foliar spray (277 kg ha^{-1}) (M_2S_4), 100 per cent NPK + BF (279 kg ha^{-1}) (M_3S_1), vermi-compost + BF (280 kg ha^{-1}) (M_1S_3) and1150 per cent NPK + BF (287 kg ha^{-1}) (M_4S_1) were at par with each other during *Rabi* 2007-2008. The treatments 150 per cent NPK along with *panchagavya* @ 5 per cent foliar spray (M_4S_4) and 50 per cent NPK + castor cake @ 2.5 t ha^{-1} + BF (M_2S_2) did not differ significantly (308 kg ha^{-1}) in *Kharif* 2008. The lowest was noticed with control (248 and 242 kg ha^{-1}) (M_1S_1).

Higher yields with 150 per cent NPK might be due to high nitrogen, phosphorus and potassium supply leads to increased number of branches, leaves and leaf area which might have helped in the efficient synthesis and translocation of photosynthates from the source to sink (Nigam *et al*., 1984; Praveen, 2000). The C:N ratio of castor cake is lower indicates rapid mineralisation of nitrogen from castor cake. The higher yield due to integration of inorganic fertilizers and organic manures could be due to the higher yield attributing characters like root length and girth, higher dry matter production, higher supply of nutrients, favourable physical and biological environment in the soil leading to better root activity and nutrient absorption (Chauhan *et al*., 2005; Joy *et al*.,2005; Mazumdar *et al*., 2002). As ashwagandha is a root crop, improvement of soil physical environment might be helped in better development of roots. The increase in yield due to inoculation of bio fertilizers could be attributed to the factors like N contribution either by inoculated strain, the positive effect of inoculation in contribution with organic matter and increased P uptake due to solubilization effect of phosphate solubilizing bacteria (Rao, 1998).

Table 4 : Effect of inorganic fertilizers, organic manures, *Panchagavya* and bio fertilizers on dry root yield (kg ha^{-1}) of ashwagandha at harvest during *Rabi* 2007-2008 (I year) and *Kharif* 2008 (II year)



The investigations indicated that integrated use of 150 per cent NPK (90-75-60 kg ha^{-1}) along with castor cake @ 2.5 t ha^{-1} + BF recorded the highest dry matter production and dry root yield of ashwagandha in sandy clay loam soils.

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