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RESEARCH ARTICLE

Effect of sowing dates and seed rates on growth, yield and economics of ashwagandha

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SUMMARY

The present investigation entitled effect of sowing dates and seed rates on yield of ashwagandha during *Kharif* season of 2009-2010 on the Farm of Nagarjun Medicinal Plant Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The soil of experimental site was medium black in colour, clayey in texture, medium in organic carbon, low in available nitrogen, phosphorus and medium to high in potash content. The soil was slightly alkaline in reaction. The experiment was laid out in Factorial Randomized Block Design with three replications and twelve treatment combinations comprised with factor A *viz.*, four sowing dates as 28th MW (D_1), 31st MW (D_2), 33rd MW (D_3) and 35th MW (D_4) and factor B *viz.*, three seed rates as 8 kg ha^{-1} (S_1), 10 kg ha^{-1} (S_2) and 12 kg ha^{-1} (S_3). The results of the study showed that significantly maximum plant height and root shoot ratio, were recorded with sowing at 28th MW. Same characters were proved significantly better with 12 kg ha^{-1} seed rate. There was no any significant effect of sowing dates on plant stand. Sowing on 28th MW week with seed rate 12 kg ha^{-1} produced significantly maximum plant height, root shoot ratio, root and seed yield. The same treatment combinations recorded ultimately significantly maximum gross monetary returns, net monetary returns and B:C ratio.

Key Words : Ashwagandha, Sowing date, Seed rate, Growth, Yield, Economics

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Now-a-days use of ayurvedic medicine is increasing due to its less side effects. Asgandh roots and occasionally its leaf and seeds are used in ayurvedic and unani medicines. The pharmacological activity of the roots is attributed to the presence of several alkaloids and withaniols. The total alkaloidal content of the Indian roots is reported to vary between 0.13 and 0.31 per cent. Roots are prescribed in medicines for hiccup, several female disorders, bronchitis, rheumatism, dropsy, stomach and lung information and skin diseases. Fruits considered as a diuretic, which are used in chest complaints (Chopra *et al.*, 2006). Out of several factors of production technology affecting yield of Asgandh, time of sowing, seed rate and their interaction are the important factor in producing high yield. Kahar *et al.* (1991) reported that crop sown on 7th August at Mandsaur gave significantly higher root yield. Earlier and latter sown fields showed gradual reduction in root yield.

Ashwagandha is an important cash crop for greening the arid and dry land zones and profit making crop for the wasteland (Nigam and Kandalker, 1995) but very less information is available regarding agro-techniques such as sowing dates and seed rates effect to optimize yield and quality of root hence, present investigation entitled effect of sowing dates and seed rates on yield of ashwagandha was planned with objectives to find out suitable time of sowing and seed rates for optimising yield and to find out best

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combination of seed rate and time of sowing.

MATERIAL AND METHODS

A field experiment was conducted to study the effect of sowing dates and seed rates on yield of ashwagandha (*Withania somnifera* Dunal) on the farm of Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* season of 2009-2010. The experiment was laid out in a Factorial Randomized Block Design with three replications and twelve treatment combinations comprised with factor A *viz.*, four sowing dates as 28th MW (D_1), 31st MW(D_2), 33rd MW (D_3) and 35th MW (D_4) and factor B *viz.*, three seed rates as 8 kg/ha (S_1), 10 kg/ha (S_2) and 12 kg/ha (S_3).

Soil status:

The soil site selected for the experiment was medium black in colour and clayey in texture. The soil samples to a depth of 30 cm were collected from randomly selected spots spread over the experimental area, prior to land preparation. Then composite site sample was prepared and analysed for important physico-chemical properties and presented in Table A.

The data on the mechanical analysis showed in Table A, indicated that the soil of the experimental site was clayey in texture, medium in organic carbon content low in total nitrogen and available phosphorus content and medium to high in potash content with pH slight alkaline in reaction.

Growth observations:

Data pertaining to growth of ashwagandha (JAS-20) given in Table indicated favourable effect of sowing dates and seed rates on root shoot ratio.

Root shoot ratio:

The dry weight of root and shoot was used in calculating root shoot ratio of the crop. Root shoot ratio is obtained by dividing dry weight of root to dry weight of shoot expressed in same units:

$$\text{Root} - \text{shoot ratio} = \frac{\text{Dry weight of root(g)}}{\text{Dry weight of shoot (g)}}$$

Yield observation:

Seed yield per hectare (kg):

Treatment wise seed yield obtained from net plot was multiplied with hectare factor and thus, seed yield per hectare was calculated and recorded in kilogram.

Dry root yield per ha (kg):

The dry weight of root per plot so obtained in kilogram was converted in kilogram per hectare by multiplying with hector factor.

Economics:

Economics was calculated considering standard market price of ashwagandha for root Rs. 60 kg^{-1} and seed Rs. 60 kg^{-1}. Gross and net monetary returns were calculated and presented in terms of benefit cost ratio.

Gross monetary returns (*Rs. ha^{-1}*):

The total value of produce *i.e.* seed and root yield of ashwagandha was estimated treatment wise as per prevailing market price and treated as gross monetary returns. From this gross monetary returns $hectare^{-1}$ were calculated.

Cost of cultivation:

The total cost of cultivation was calculated considering the inputs used in each treatment with prevailing market prices.

Net monetary returns (*Rs. ha^{-1}*):

Net monetary returns were calculated by subtracting cost of cultivation from gross returns treatment wise. That

Table A: Physico-chemical characteristics of experimental site

Sr. No.	Soil characteristics	Content	Methods
Mechanical analysis on oven dry basis (Bouyoucos hydrometer method)			
1.	Sand (%)	29.0	Bouyoucos hydrometer
2.	Silt (%)	21.0	method (Bouyoucos, 1928)
3.	Clay (%)	50.0	
4.	Textural class	Clayey	
Ph.ysico chemical properties			
1.	pH (1:2.5)	7.6	Glass electrode method (Jackson, 1967)
2.	EC (dSm^{-1})	0.36	Direct reading EC meter (Jackson, 1967)
3.	Organic carbon (g kg^{-1})	5.3	Walkley and Black method (Jackson, 1967)
4.	Available nitrogen (kg ha^{-1})	175.85	Alkaline permanganate method (Subbiah and Asija, 1967)
5.	Available phosphorus (kg ha^{-1})	15.80	Olsens method (Jackson, 1967)
6.	Available potassium (kg ha^{-1})	290.05	Flame photometer (Jackson, 1967)

provided a firm basis for comparison and intercropping system as this represented the actual income to the farmers.

Benefit cost ratio:

The benefit cost ratio was worked out by dividing the net returns with total cost of cultivation by using the formula given below :

$$\textbf{B : C ratio} = \frac{\textbf{Net monetary returns}}{\textbf{Cost of cultivation}}$$

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Growth observations:

Data pertaining to growth of ashwagandha (JAS-20) given in Table 1 indicated favourable effect of sowing dates and seed rates on plant height and root shoot ratio.

Plant stand:

The number of plants per plot was counted at 30 DAS and again at harvest and the counts recorded in different treatments are given in Table 1.

Effect of sowing date:

The data presented in Table 1, showed that sowing dates had no significant effect on plant stand at 30 DAS and at harvest. The data clearly indicated that plant population of ashwagandha did not change due to the change in treatment *i.e.* sowing dates showing thereby that plant population remain uninfluenced by treatments. Similar results were observed by Anonymous (2008).

Plants survival at harvest was satisfactory. The reduction in the plant population at harvest is because of mortality or due to plant removal for observations or other reasons.

Effect of seed rate:

The data presented in Table 1 in respect of plant stand as influenced by seed rate showed that the treatment S_3 recorded maximum plant stand (753.50 and 731.00) at 30 DAS and at harvest, respectively followed by S_2 and S_1. These results in present study are in agreement with the findings of Anonymous (2008). This indicated that as the seed rate increased there will be increase in plant population.

Interaction effect:

The interaction effect due to sowing date and seed rate on plant stand was found to be non-significant indicating that both the factors were independent unaffecting plant stand. Same result was observed by Anonymous (2008).

Plant height:

The data regarding the mean plant height (cm) at 45, 90, 135 DAS and at harvest are presented in Table 2. The ashwagandha plant height increased till harvest while maximum increased was noticed during the period from 45 to 90 DAS whereas increase in plant height, thereafter, was very slow and negligible.

Effect of sowing dates:

Significant differences were noted among the different

Table 1: Plant stand as influenced by sowing dates and seed rates

	Plant stand	
	Initial plant stand at 30 DAS	Final plant stand at harvest
Sowing dates (D)		
D_1 (15th July)	665.000	621.22
D_2 (1st August)	646.880	616.33
D_3 (15th August)	639.660	609.44
D_4 (1st September)	627.110	613.33
'f' test	NS	NS
S.E.±	18.1980	19.99
C.D. at 5%	-	-
Seed rates (S)		
S_1 (8 kg ha^{-1})	527.50	491.91
S_2 (10 kg ha^{-1})	653.00	622.33
S_3 (12 kg ha^{-1})	753.50	731.00
'f' test	Sig.	Sig.
S.E.±	15.759	17.310
C.D. at 5%	46.225	50.790
Interaction (D x S)		
'f' test	NS	NS
S.E.±	31.510	34.630
C.D. at 5%	-	-
C.V. (%)	8.46	9.75

NS= Non-significant Sig. = Significant at 5 %

Table 2: Plant height as influenced by sowing dates and seed rates

	Plant height			
	45 DAS	90 DAS	135 DAS	At harvest
Sowing date (D)				
D_1 (15th July)	15.22	46.75	50.71	51.05
D_2 (1st August)	14.11	43.65	48.47	48.81
D_3 (15th August)	10.30	41.28	47.25	48.24
D_4 (1st September)	9.26	40.25	43.27	44.71
'f' test	Sig.	Sig.	Sig.	Sig.
S.E.±	0.689	1.570	1.501	1.502
C.D. at 5%	2.022	4.605	4.404	4.407
Seed rate (S)				
S_1 (8 kg ha^{-1})	10.24	39.77	4.18	45.63
S_2 (10 kg ha^{-1})	12.03	43.41	47.03	47.52
S_3 (12 kg ha^{-1})	14.40	45.77	51.06	51.45
'f' test	Sig.	Sig.	Sig.	Sig.
S.E.±	0.597	1.359	1.300	1.3012
C.D. at 5%	1.751	3.988	3.814	3.816
Interaction (D x S)				
'f' test	NS	NS	NS	NS
S.E.±	1.194	2.7194	2.600	2.602
C.D. at 5%	3.502	7.976	7.628	7.633
C.V. (%)	16.91	10.95	9.49	9.35

NS=Non-significant Sig. = Significant at 5 %

Table 3 : Root shoot ratio as influenced by sowing date and seed rate

	Mean root shoot ratio			
	45 DAS	90 DAS	135 DAS	At harvest
Sowing date (D)				
D_1 (15th July)	0.153	0.155	0.202	0.233
D_2 (1st August)	0.146	0.147	0.149	0.183
D_3 (15th August)	0.129	0.131	0.136	0.166
D_4 (1st September)	0.102	0.105	0.106	0.141
'f' test	Sig.	Sig.	Sig.	Sig.
S.E.±	0.007	0.007	0.007	0.006
C.D. at 5%	0.020	0.020	0.021	0.019
Seed rate (S)				
S_1 (8 kg ha^{-1})	0.118	0.118	0.134	0.169
S_2 (10 kg ha^{-1})	0.131	0.131	0.146	0.176
S_3 (12 kg ha^{-1})	0.148	0.156	0.165	0.197
'f' test	Sig.	Sig.	Sig.	Sig.
S.E.±	0.006	0.006	0.006	0.006
C.D. at 5%	0.017	0.017	0.018	0.017
Interaction (D x S)				
'f' test	NS	NS	Sig.	Sig.
S.E.±	0.012	0.012	0.012	0.011
C.D. at 5%	-	-	0.036	0.033
C.V. (%)	15.48	15.29	14.51	11.03

NS=Non-significant Sig. = Significant at 5 %

sowing date treatments at all stages of crop growth. This indicated that the plant growth was highly influenced by sowing dates. The growth indicated in term of plant height was observed to be maximum under D_1 (15thJuly) (51.05 cm) while minimum D_4 (1stSept.) (44.71 cm). Earlier seed sowing experienced optimum day length, favourable maximum and minimum temperature, relative humidity and rainfall which favoured more vegetative growth. The higher temperature and lower relative humidity provided during September month would have reduced the vegetative growth of plant. The higher growth of plants under optimum sowing dates has already been noticed by Agarwal *et al.* (2003).

Effect of seed rates:

This may observed that seed rate significantly affected plant height. As seed rate increased, plant population also increased which led into increase in plant height due to competition for light. Such same results were obtained by Tiwari *et al.* (2002).

Interaction effect:

The interaction effect between sowing date and seed rate on plant height was found to be non-significant.

Root shoot ratio:

The data pertaining to root shoot ratio as influenced by various treatments at 45, 90, 135 DAS and at harvest are presented in Table 2. It was evident from the general mean that the root shoot ratio increased till harvest.

Effect of sowing dates:

Sowing dates influenced significantly root shoot ratio from 45 DAS upto harvest. Significantly maximum root shoot ratio recorded in D_1 (0.233) followed by D_2 than rest of the treatment. Data in respect of sowing dates indicated that root shoot ratio increased remarkably with advancement in plant age and also increased with increased in dry root yield. These results are in agreement with results observed by Anonymous (2008).

Effect of seed rates:

The different seed rates treatments significantly influenced the root shoot ratio at all stages of observations. This increase in root shoot ratio from 45 to harvest was observed in S_3 (0.197) due to more vegetative growth provided by favourable environmental condition and also due to more root length and dry weight of root per plant. Same

Table 4 : Seed yield kg per hectare as influenced by sowing date and seed rate

Sowing date	Seed rate (kg ha^{-1})			Mean
	S_1 (8 kg)	S_2 (10 kg)	S_3 (12 kg)	
D_1 (15th July)	470.67	510.02	745.36	575.35
D_2 (1st August)	313.65	446.37	684.02	481.34
D_3 (15th August)	314.427	325.229	594.13	411.26
D_4 (1st September)	305.16	347.60	381.94	344.90
Mean	350.98	407.30	601.36	
	Sowing date (D)	Seed rate (S)	Interaction (D x S)	
'f' test	Sig.	Sig.	Sig.	
S.E.±	24.427	21.154	42.309	
C.D. at 5%	71.648	62.049	124.098	

Sig. = Significant at 5 %

Table 5 : Root yield per hectare as influenced by sowing date and seed rate

Sowing date	Seed rate (kg ha^{-1})			Mean
	S_1 (8 kg)	S_2 (10 kg)	S_3 (12 kg)	
D_1 (15th July)	631.55	890.42	1109.17	877.05
D_2 (1st August)	608.79	697.526	707.17	671.16
D_3 (15th August)	464.88	551.30	883.86	633.35
D_4 (1st September)	437.49	603.77	614.5749	551.95
Mean	535.68	683.75	828.69	
	Sowing date (D)	Seed rate (S)	Interaction (D x S)	
'f' test	Sig.	Sig.	Sig.	
S.E.±	19.009	16.462	32.925	
C.D. at 5%	55.755	48.285	96.571	

Sig. = Significant at 5 %

results were observed by Anonymous (2006).

Interaction effect:

Interaction effect of sowing date and seed rate were found to be non-significant significant and data are presented in Table 3. The combine effect of sowing dates and seed rates *i.e.* D_1S_3 recorded significantly highest root shoot ratio (0.277) than other all treatments while the treatments D_1S_1, D_2S_1, D_3S_3 and D_3S_2 were at par with each other and found significantly superior over the rest of the treatment combinations.

Yield observation:

The data on yield per plot and per hectare (kg) recorded in different treatments have been tabulated and given below.

Seed yield kg per hectare:

The data in respect of seed yield per hectare (kg) as influenced by sowing date and seed rate are presented in Table 4.

Effect of sowing dates:

The data presented in Table 4 showed that the treatment D_1 produced significantly highest seed yield (575.35 kg) which found at par with D_2 (481.34 kg) and the minimum yield was recorded in the treatment D_4 (344.90 kg).

It is revealed that seed yield per hectare was significantly affected by sowing dates. The maximum seed yield per hectare was recorded in sowing date 15th July which might be due to favourable environmental conditions during the crop growth period.

Effect of seed rates:

The data presented in Table 4, showed the significant effect of seed rates on seed yield per hectare of ashwagandha. Maximum seed yield per hectare was recorded in treatment S_3 (601.36 kg) while treatment S_2 (407.30 kg) and S_1 (350.98 kg) were found to be at par with each other. This might be due to increase in seed rate as seed rate increases more number of plants per unit area produced more seed yield and also due to more vegetative growth provided by favourable environmental condition. Same results were observed by Maheshwari and Sharma (2002).

Interaction effect:

Interaction effect due to sowing date and seed rate on seed yield per hectare was found to be significant. The significantly maximum seed yield per hectare was recorded in treatment D_1S_3 (745.36 kg) which found to be at par with the treatment D_2S_3 (684.02 kg) followed by treatment D_3S_3 (594.13 kg) while minimum seed yield per hectare was observed in treatment D_4S_1 (305.16 kg) which was at par with D_2S_1 and D_3S_1.

Root yield per hectare (kg):

The data in respect of root yield per hectare (kg) as influenced by sowing date and seed rate are presented in Table 5.

Effect sowing dates:

The data presented in Table 5, showed the significant effect of sowing date on root yield per hectare. The maximum root yield per hectare was recorded in treatment D_1 (877.05 kg) while treatment D_2 (671.16 kg) and D_3 (633.35 kg) were

Table 6: Cost of cultivation, gross monetary return, net monetary return and benefit cost ratio as influenced by sowing dates and seed rates

	COC (Rs ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C
Sowing date (D)				
D_1 (28th MW)	22925	73988	51063	3.22
D_2 (31st MW)	21175	59083	37908	2.78
D_3 (33rd MW)	21175	53176	32001	2.50
D_4 (35th MW)	21175	45531	24356	2.14
S.E.±	764.177	1739.064	1739.064	0.078
C.D. at 5%	-	5100.811	5100.811	0.229
Seed rate (S)				
S_1 (8 kg ha^{-1})	21492	45164	23672	2.09
S_2 (10 kg ha^{-1})	21612	55297	33685	2.54
S_3 (12 kg ha^{-1})	21732	73373	51640	3.36
S.E.±	661.796	1506.073	1506.073	0.067
C.D. at 5%	-	4417.432	4417.432	0.198
Interaction (D x S)				
S.E.±	1323.593	3012.146	3012.146	0.135
C.D. at 5%	-	8834.863	8834.863	0.397

found to be at par with each other. The minimum root yield per hectare was observed to be under treatment D_4 (551.95 kg).

Maximum dry weight of root per hectare obtained in earlier sowing date which was as a result of more growth of root, more length of root and more dry weight of root per plot. Sowing time significantly affected dry root yield per hectare was also recorded by Agarwal *et al.* (2004).

Effect of seed rates:

The data presented in Table 5, showed the significant effect of seed rate on root yield per hectare. The significantly maximum root yield per hectare was obtained in treatment S_3 (828.69 kg) and minimum in S_1 (535.68 kg). As regard seed rate, higher seed rates resulted in more growth of root and dry root yield, as increasing plant population received proper soil conditions and environmental condition for their completion of life cycle. These results are in line with the results obtained by Tiwari *et al.* (2002).

Interaction effect:

Interaction effects due to sowing date and seed rate on dry root yield per hectare was significant. The maximum dry root yield per hectare recorded in treatment D_1S_3 (1109.17 kg) over the rest of the treatment while treatment D_1S_2 (890.42 kg) was found to be at par with D_3S_3 (883.86 kg) and treatment D_2S_3 (707.17 kg), D_2S_2 (697.52 kg), D_1S_1 (631.55 kg) and D_4S_3 (614.57) were found to be at par with each other. The minimum dry root yield per hectare was observed in treatment D_4S_1 (437.49) which was found at par with D_3S_1 (464.88 kg) and D_3S_2 (551.30 kg).

Optimum sowing time and seed rate combined together and received proper congenial environmental conditions resulted in more growth of root, dry root yield per plot and root length due to complementary and supplementary interaction effect. Same results obtained by Anonymous (2008) in ashwagandha.

Economics of treatments:

Data pertaining economics of treatment *viz.*, cost of cultivation, gross monetary returns (Rs. ha^{-1}), net monetary returns (Rs. ha^{-1}) and benefit cost ratio are presented in Table 6.

Effect of sowing dates:

Among all sowing dates, significantly maximum gross monetary returns (73988 Rs. ha^{-1}), net monetary returns (51063 Rs. ha^{-1}) and benefit cost ratio (3.22) was observed when crop sown on 28th MW (D_1).

Effect of seed rates:

As regard seed rates, 12 kg ha^{-1} (S_3) significantly gave more gross monetary returns (73373 Rs. ha^{-1}), net monetary returns (51640 Rs. ha^{-1}) and B:C ratio (3.36).

Interaction effect:

When crop was sown on 28th MW with 12 kg ha^{-1} seed rate (D_1S_3) significantly gave maximum gross monetary returns (94634 Rs. ha^{-1}), net monetary returns (71589 Rs. ha^{-1}) and B:C ratio (4.10).

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