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# Effect of sowing time, seed rate and harvesting duration on quality of Ashwagandha *Withania somnifera*

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### Abstract

The experiment was carried out at Herbal garden, Rajendranagar, Hyderabad during the 2009-10. The experiment was laid out in Completely Randomized Block Design with factorial concept comprising a total of 18 treatments replicated thrice with two sowing dates (August 15<sup>th</sup> and August 30<sup>th</sup>), three seed rates (10 kg/ha, 12 kg/ha and 14 kg/ha) and three harvesting durations (150 DAS, 180 DAS and 210 DAS). The data indicated that fresh root yield (13.91 q/ha) and dry root yield (3.38 q/ha) were maximum in August 15<sup>th</sup> sown crop when compared to August 30<sup>th</sup> crop. Among the harvesting durations, H<sub>3</sub> (210 DAS) recorded maximum fresh root yield (13.48 q/ha) and dry root yield (3.12 q/ha). Among the three way interactions, maximum fresh root yield (15.63 q/ha) and dry root yield (4.40 q/ha) were recorded with August 15<sup>th</sup> sown crop with a seed rate of 12 kg/ha and harvesting duration of 210 DAS (D<sub>1</sub>S<sub>2</sub>H<sub>3</sub>). There was significant difference in starch content due to dates of sowing. Significantly maximum starch content (11.81%) was recorded in D<sub>2</sub> (August 30<sup>th</sup>) followed by D<sub>1</sub> (August 15<sup>th</sup>) recording 11.64%. Reducing sugars were reported to be maximum (2.89%) in August 30<sup>th</sup> sown crop when compared to August 15<sup>th</sup> crop. Among the seed rates, S<sub>1</sub> (10 kg/ha) recorded maximum reducing sugars (3.26%). Among the harvesting durations, H<sub>3</sub> (210 DAS) recorded maximum reducing sugars (3.25%). Maximum non-reducing sugars (7.70%) was recorded in August 30<sup>th</sup> sown crop when compared to August 15<sup>th</sup> crop. Among the harvesting durations, H<sub>3</sub> (210 DAS) recorded maximum non-reducing sugars (7.70%). Among the three way interactions, maximum non-reducing sugars (7.78%) was recorded with August 30<sup>th</sup> sown crop with a seed rate of 12 kg/ha and harvesting duration of 210 DAS (D<sub>2</sub>S<sub>2</sub>H<sub>3</sub>).

**Keywords:** Ashwagandha, seed rate, harvesting duration, sowing time, yield, starch reducing sugars, non-reducing sugars and quality

### Introduction

Ashwagandha is an important cash crop for greening the arid and dry zone having medicinal properties belonging to solanaceae. Ashwagandha is late sown kharif crop and harvested between 150-170 days after sowing. It is mainly cultivated in the drier parts of Madhya Pradesh, Punjab, Rajasthan and South India. In Madhya Pradesh, it is cultivated in about 4000 hectares area (Nigam *et al.*)<sup>[1]</sup>. Ashwagandha is an important drug used in ayurvedic medicines. The pharmacological activity of the roots is attributed to the presence of alkaloids withanine and somniferine. The roots also contain starch, reducing sugars and glycosides. The plant is a rich source of crude protein, calcium and phosphorous (Nigam *et al.*)<sup>[2]</sup>. The leaf paste and decoction are used both externally and internally for many ailments like sore eyes, boils hand and foot swellings, wounds etc. An infusion of bark is used for control of asthma. The fruits and seeds are used in chest complaints.

Ashwagandha is commercially grown for its roots. Now-a-days, use of ayurvedic medicines is increasing due to fewer side effects. The drug is mainly used in ayurvedic and unani preparations. The alkaloid withaferine-A which is present in roots having antibiotic and anti-tumour properties (Farooqui *et al.*)<sup>[2]</sup>. Plant extract of ashwagandha on stored pulses and products showed 100 per cent mortality of callosobruchus pest (Anuradha *et al.*)<sup>[3]</sup>. Crude leaf extract of ashwagandha gave 90-100 per cent inhibition of Tobacco Mosaic Virus in chillies (Peshney and Moghe.)<sup>[4]</sup>.

## Materials and Methods

The experiment was carried out during August 2009-March 2010 in Herbal garden, Rajendranagar, Hyderabad. The experiment was laid out with two sowing dates (August 15<sup>th</sup> and August 30<sup>th</sup>), three seed rates (10 kg/ha, 12 kg/ha and 14 kg/ha) and three harvesting durations (150 DAS, 180 DAS and 210 DAS) in Completely Randomized Block Design with factorial concept comprising a total of 18 treatments replicated thrice. The land was brought to fine tilth by ploughing and harrowing. The experimental area was divided into plots of 2m x 3m size. Irrigation channels of 0.5m size were provided. The cleaned seeds mixed with sand at the ratio of 1:1 and sown directly in the field by broadcasting method. Uniformly growing five plants were randomly selected and tagged from the net plot area in each treatment and replication for the purpose of recording the biometric observations. The data recorded on yield and quality parameters were subjected to statistical analysis. The data were analyzed using computer software programmed by the method of variance (Panse and Sukhatme, 5).

## Results and Discussion

### Effect of sowing time on yield

The August 15<sup>th</sup> crop performed better in yield characters compared to sowing on August 30<sup>th</sup>. Yield like fresh root yield (13.91 q/ha) and dry root yield (3.38 q/ha) were recorded maximum in August 15<sup>th</sup> sowing (Table 1&2). The root yield of Ashwagandha was significantly influenced by dates of sowing.

The results indicated that the crop sown on August 15<sup>th</sup> recorded significantly higher root yield (3.38 q/ha) over the August 30<sup>th</sup> sowing (2.26 q/ha). This clearly indicated that the optimum date of sowing for Ashwagandha crop would be August 15<sup>th</sup>. The higher root yield due to sowing on August 15<sup>th</sup> could be attributed to better performance of crop with respect to yield contributing characters at harvest. Similar results at Rahuri (Maharashtra) were reported having significant effect of dates of sowing on root yield of Ashwagandha (Desai *et al.*)<sup>[6]</sup> and on root length of Ashwagandha (Manish Agarwal *et al.*)<sup>[7]</sup>.

**Table 1:** Effect of sowing time, seed rate and harvesting duration on fresh root yield (q/ha) at 210 DAS in Ashwagandha

Seed rate(S)				
Sowing date(D)	S <sub>1</sub> (10kg/ha)	S <sub>2</sub> (12 kg/ha)	S <sub>3</sub> (14 kg/ha)	Mean
D <sub>1</sub> (August 15 <sup>th</sup> )	14.02	13.64	14.06	13.91
D <sub>2</sub> (August 30 <sup>th</sup> )	12.20	11.99	11.96	12.05
Mean	13.00	12.82	13.00	
Harvesting duration(H)				
H <sub>1</sub> (150 DAS)	13.58	12.15	12.63	12.79
H <sub>2</sub> (180DAS)	12.73	12.17	13.08	12.66
H <sub>3</sub> (210DAS)	13.02	14.13	13.30	13.48
Mean	13.00	12.82	13.00	

Seed rates (S)							
Harvesting duration (H)	S <sub>1</sub> (10 kg/ha)			S <sub>2</sub> (12 kg/ha)		S <sub>3</sub> (14 kg/ha)	
	Sowing dates (D)	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug30 <sup>th</sup> )	D <sub>1</sub> (Aug15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )	D <sub>1</sub> (Aug15 <sup>th</sup> )	D <sub>2</sub> (Aug30 <sup>th</sup> )
H <sub>1</sub> (150DAS)	15.23		11.93	12.77	11.53	14.20	11.07
H <sub>2</sub> (180DAS)	13.57		11.90	12.53	11.80	14.53	11.63
H <sub>3</sub> (210DAS)	13.27		12.77	15.63	12.63	13.43	13.17

Factors	S.E m ±	CD (5%)	Interactions	S.E m ±	CD (5%)
Sowing date (D)	0.31	0.89	DXS	0.54	NS
Seed rate (S)	0.38	NS	DXH	0.54	NS
Harvesting duration (H)	0.38	NS	SXH	0.66	NS
			DXSXH	0.93	NS

**Table 2:** Effect of sowing time, seed rate and harvesting duration on dry root yield (q/ha) at 210 DAS in Ashwagandha

Seed rate(S)				
Sowing date(D)	S <sub>1</sub> (10kg/ha)	S <sub>2</sub> (12 kg/ha)	S <sub>3</sub> (14 kg/ha)	Mean
D <sub>1</sub> (August 15 <sup>th</sup> )	3.42	3.31	3.40	3.38
D <sub>2</sub> (August 30 <sup>th</sup> )	2.33	2.13	2.32	2.26
Mean	2.88	2.72	2.86	
Harvesting duration(H)				
H <sub>1</sub> (150 DAS)	3.13	2.25	2.50	2.63
H <sub>2</sub> (180DAS)	2.72	2.50	2.93	2.72
H <sub>3</sub> (210DAS)	2.78	3.42	3.15	3.12
Mean	2.88	2.72	2.86	

Seed rates (S)							
Harvesting duration (H)	S <sub>1</sub> (10 kg/ha)			S <sub>2</sub> (12 kg/ha)		S <sub>3</sub> (14 kg/ha)	
	Sowing dates (D)	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug30 <sup>th</sup> )	D <sub>1</sub> (Aug15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )	D <sub>1</sub> (Aug15 <sup>th</sup> )	D <sub>2</sub> (Aug30 <sup>th</sup> )
H <sub>1</sub> (150DAS)	3.83		2.43	2.63	1.87	3.20	1.80
H <sub>2</sub> (180DAS)	3.47		1.97	2.90	2.10	3.83	2.03
H <sub>3</sub> (210DAS)	2.97		2.60	4.40	2.43	3.17	3.13

Factors	S.E m ±	CD (5%)	Interactions	S.E m ±	CD (5%)
Sowing date (D)	0.17	0.50	DXS	0.30	NS
Seed rate (S)	0.21	NS	DXH	0.30	NS
Harvesting duration (H)	0.21	NS	SXH	0.37	NS
		DXSXH	0.52	NS	

**Effect of seed rate on yield**

The seed rate of 10 kg/ha (S<sub>1</sub>) recorded maximum dry root yield (2.88 q/ha), when compared to S<sub>2</sub> (12 kg/ha) and S<sub>3</sub> (14 kg/ha). Highest dry root yield with thick roots and good quality roots were reported with seed rate of 10 kg/ha on yield of Ashwagandha and safed musli (Patel *et al.*, 8 and Gholap *et al.*)<sup>[9]</sup>

**Effect of harvesting duration on yield**

Yield characters like fresh root yield (13.48 q/ha), dry root yield (3.12 q/ha) recorded to be maximum in 210 days of harvesting duration. The root yield of Ashwagandha increased with increased period of harvesting. This indicated that the higher root yield of Ashwagandha crop harvested at 210 DAS can be attributed to higher values of yield parameters at harvest. The fresh root weight and dry root weight were significantly higher with the crop harvested at 210 DAS compared to other harvesting stages. The yield parameters of Ashwagandha increased with increased period of harvesting. The higher values of yield were mainly attributed to better growth of the plant, which can be related to higher values of growth parameters like plant height, primary branches etc (Manish Agarwal *et al.*, and Patel *et al.*)<sup>[7,8]</sup>.

**Interactions**

Though interaction treatments were not significant, a combination of August 15<sup>th</sup> sown crop with a seed rate of 12 kg/ha and harvesting duration of 210 DAS (D<sub>1</sub>S<sub>2</sub>H<sub>3</sub>) recorded maximum fresh root yield (15.63 q/ha) and dry root yield (4.40 q/ha). Though interaction treatments were not significant, a combination of August 15<sup>th</sup> sown crop with a seed rate of 12 kg/ha and harvesting duration of 180 DAS (D<sub>1</sub>S<sub>2</sub>H<sub>2</sub>) recorded early harvesting of seed (150.00 days) and highest total biomass production (1304.18 g/plant).

**Effect of sowing time on Quality****Starch content at 210 days after sowing (%)**

The data pertaining to starch content of Ashwagandha at 210 DAS as influenced by sowing time, seed rate and harvesting duration are presented in Table 3.

There was significant difference in starch content due to dates of sowing. Significantly maximum starch content (11.81%) was recorded in D<sub>2</sub> (August 30<sup>th</sup>) followed by D<sub>1</sub> (August 15<sup>th</sup>) recording 11.64%.

Starch content at 210 DAS was significant due to seed rates. Significantly higher starch content (11.84%) was recorded with S<sub>3</sub> (14 kg/ha) which was followed by S<sub>2</sub> (12 kg/ha) recording 11.73% and S<sub>1</sub> (10 kg/ha) recording 11.61%.

Starch content was not significant at 210 DAS due to harvesting durations. Higher starch content (11.74%) was recorded with H<sub>1</sub> (150 DAS) which was on par with H<sub>3</sub> (210 DAS) recording 11.73%. Low starch content was recorded in H<sub>2</sub> (180DAS) recording 11.72%.

The data on interaction between dates of sowing and seed rates (DXS) were non-significant. Seed rates and harvesting durations (SXH), dates of sowing and harvesting durations (DXH) as well as the three way interaction between sowing times, seed rates and harvesting durations (DXSXH) on starch content at 210 DAS were found to be significant, where a combination of August 30<sup>th</sup> sowing and 210 DAS (D<sub>2</sub>H<sub>3</sub>) recorded maximum starch content (11.91%) followed by D<sub>2</sub>H<sub>2</sub> (11.86%) and D<sub>1</sub>H<sub>1</sub> (11.81%). A treatment combination of 14 kg/ha and 150 DAS (S<sub>3</sub>H<sub>1</sub>) recorded maximum starch content (11.95%) followed by S<sub>3</sub>H<sub>2</sub> (11.83) and S<sub>2</sub>H<sub>3</sub> (11.80). A treatment combination of August 30<sup>th</sup> sowing, 14 kg/ha and 180 DAS (D<sub>2</sub>S<sub>3</sub>H<sub>2</sub>) followed by D<sub>2</sub>S<sub>2</sub>H<sub>3</sub> (12.03%) and D<sub>2</sub>S<sub>3</sub>H<sub>1</sub> (11.97%).

**Table 3:** Effect of sowing time, seed rate and harvesting duration on starch content (%) at 210 DAS in Ashwagandha

Seed rate(S)				
Sowing date(D)	S <sub>1</sub> (10kg/ha)	S <sub>2</sub> (12 kg/ha)	S <sub>3</sub> (14 kg/ha)	Mean
D <sub>1</sub> (August 15 <sup>th</sup> )	11.52	11.67	11.74	11.64
D <sub>2</sub> (August 30 <sup>th</sup> )	11.70	11.80	11.93	11.81
Mean	11.61	11.73	11.84	
Harvesting duration(H)				
H <sub>1</sub> (150 DAS)	11.58	11.68	11.95	11.74
H <sub>2</sub> (180DAS)	11.60	11.72	11.83	11.72
H <sub>3</sub> (210DAS)	11.65	11.80	11.73	11.73
Mean	11.61	11.73	11.84	

Seed rates (S)							
Harvesting duration (H)	S <sub>1</sub> (10 kg/ha)			S <sub>2</sub> (12 kg/ha)		S <sub>3</sub> (14 kg/ha)	
	Sowing dates (D)	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )
H <sub>1</sub> (150DAS)	11.67		11.50	11.83	11.53	11.93	11.97
H <sub>2</sub> (180DAS)	11.53		11.67	11.60	11.83	11.60	12.07
H <sub>3</sub> (210DAS)	11.3		11.3	11.57	12.03	11.70	11.77

Factors	S.E m ±	CD (5%)
Sowing date (D)	0.03	0.07
Seed rate (S)	0.03	0.09
Harvesting duration (H)	0.03	NS

**Interactions**

DXS	0.04	NS
DXH	0.04	0.13
SXH	0.05	0.16
DXSXH	0.08	0.12

**Reducing sugars at 210 days after sowing (%)**

The data pertaining to reducing sugars of Ashwagandha at 180 DAS as influenced by sowing time, seed rate and harvesting duration are presented in Table 4.

Reducing sugars did not differ significantly due to sowing dates. High reducing sugars was recorded in D<sub>2</sub> (August 30<sup>th</sup>) recording 2.89% followed by D<sub>1</sub> (August 15<sup>th</sup>) recording 2.16%. Reducing sugars at 210 DAS due seed rates did not differ significantly. However, higher reducing sugars (3.26%) was recorded with S<sub>1</sub> (10 kg/ha) which was followed by S<sub>3</sub> (14 kg/ha) and S<sub>2</sub> (12 kg/ha) recording 2.16% each.

There was no significant difference in reducing sugars at 210 DAS due to harvesting durations. Higher reducing sugars (3.25%) was recorded with H<sub>3</sub> (210 DAS), which was on par with H<sub>1</sub> (150DAS) recording 2.17% and H<sub>2</sub> (180 DAS) recording 2.16%.

The data on interaction between dates of sowing and seed rates (DXS), seed rates and harvesting durations (SXH), dates of sowing and harvesting durations (DXH) as well as the three way interaction between sowing times, seed rates and harvesting durations (DXSXH) on reducing sugars at 210 DAS were found to be non-significant.

**Table 4:** Effect of sowing time, seed rate and harvesting duration on reducing Sugars (%) at 210 DAS in Ashwagandha

Seed rate(S)				
Sowing date(D)	S <sub>1</sub> (10kg/ha)	S <sub>2</sub> (12 kg/ha)	S <sub>3</sub> (14 kg/ha)	Mean
D <sub>1</sub> (August 15 <sup>th</sup> )	2.16	2.15	2.17	2.16
D <sub>2</sub> (August 30 <sup>th</sup> )	4.35	2.16	2.16	2.89
Mean	3.26	2.16	2.16	
Harvesting duration(H)				
H <sub>1</sub> (150 DAS)	2.17	2.16	2.16	2.17
H <sub>2</sub> (180DAS)	2.16	2.16	2.16	2.16
H <sub>3</sub> (210DAS)	5.43	2.15	2.16	3.25
Mean	3.26	2.16	2.16	

Seed rates (S)							
Harvesting duration (H)	S <sub>1</sub> (10 kg/ha)			S <sub>2</sub> (12 kg/ha)		S <sub>3</sub> (14 kg/ha)	
	Sowing dates (D)	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )
H <sub>1</sub> (150DAS)	2.17		2.17	2.16	2.17	2.17	2.16
H <sub>2</sub> (180DAS)	2.16		2.17	2.15	2.16	2.17	2.15
H <sub>3</sub> (210DAS)	2.16		2.17	2.15	2.16	2.17	2.16

Factors	S.E m ±	CD (5%)
Sowing date (D)	0.51	NS
Seed rate (S)	0.63	NS
Harvesting duration (H)	0.63	NS

**Interactions**

DXS	0.89	NS
DXH	0.89	NS
SXH	1.09	NS
DXSXH	1.54	NS

**Non reducing sugars at 210 days after sowing (DAS)**

The data pertaining to non-reducing sugars of Ashwagandha at 210 DAS as influenced by sowing time, seed rate and harvesting duration are presented in Table 5.

There was significant difference in non-reducing sugars due to dates of sowing. Significantly higher non reducing sugars (7.70%) was recorded in D<sub>2</sub> (August 30<sup>th</sup>) followed by D<sub>1</sub> (August 15<sup>th</sup>) recording 7.65%.

Non reducing sugars at 210 DAS due to seed rates differ significantly. Significantly higher non reducing sugars (7.69%) was recorded with S<sub>3</sub> (14 kg/ha) which was followed by S<sub>2</sub>(12 kg/ha) recording 7.68% and S<sub>1</sub>(10 kg/ha) recording 7.66%.

Significant difference was noticed in non-reducing sugars at 210 DAS due to harvesting durations. Higher non reducing sugars (7.70%) was recorded with H<sub>3</sub> (210 DAS) which was on par with H<sub>2</sub> (180 DAS) recording 7.67% and H<sub>1</sub> (150DAS) recording 7.66%.

The data on interaction between dates of sowing and seed rates (DXS), seed rates and harvesting durations (SXH), dates of sowing and harvesting durations (DXH) as well as three way interaction between sowing times, seed rates and

harvesting durations (DXSXH) on non-reducing sugars at 210 DAS were found to be significant, where a combination of August 30<sup>th</sup> and 12 kg/ha (D<sub>2</sub>S<sub>2</sub>) recorded maximum non reducing sugars (7.72%) followed by D<sub>2</sub>S<sub>3</sub> (7.70%) and D<sub>2</sub>S<sub>1</sub> (7.69%). A combination of August 30<sup>th</sup> and 210 DAS (D<sub>2</sub>H<sub>3</sub>) recorded maximum non reducing sugars (7.73%) followed by D<sub>2</sub>H<sub>2</sub> (7.70%) and D<sub>2</sub>H<sub>1</sub> (7.68%). A combination of 12 kg/ha and 210 DAS (S<sub>2</sub>H<sub>3</sub>) recorded maximum non reducing sugars (7.71%) followed by S<sub>3</sub>H<sub>2</sub> (7.69%) and S<sub>3</sub>H<sub>3</sub> (7.69%). A combination of August 30<sup>th</sup>, 12 kg/ha and 210 DAS (D<sub>2</sub>S<sub>2</sub>H<sub>3</sub>) recorded maximum non reducing sugars (7.78%) followed by D<sub>2</sub>S<sub>1</sub>H<sub>3</sub> (7.72%) and D<sub>2</sub>S<sub>3</sub>H<sub>2</sub> (7.71%).

The quality characters like starch content (16.74%), reducing sugars (2.89%) and non-reducing sugars (7.70%) recorded were higher with lower yield in the crop sown on August 30<sup>th</sup> when compared to August 15<sup>th</sup>. Starch content, reducing sugars and non-reducing sugars had inverse relationship with dry root yield per ha. Similar reports were recorded which showed significantly negative correlation between alkaloid and starch content in roots of Ashwagandha at Anand in Gujarat (Patel *et al.*,) [8].

**Table 5:** Effect of sowing time, seed rate and harvesting duration on non-reducing Sugars (%) at 210 DAS in Ashwagandha

Seed rate(S)				
Sowing date(D)	S <sub>1</sub> (10kg/ha)	S <sub>2</sub> (12 kg/ha)	S <sub>3</sub> (14 kg/ha)	Mean
D <sub>1</sub> (August 15 <sup>th</sup> )	7.64	7.64	7.67	7.65
D <sub>2</sub> (August 30 <sup>th</sup> )	7.69	7.72	7.70	7.70
Mean	7.66	7.68	7.69	
Harvesting duration(H)				
H <sub>1</sub> (150 DAS)	7.64	7.65	7.68	7.66
H <sub>2</sub> (180DAS)	7.66	7.68	7.69	7.67
H <sub>3</sub> (210DAS)	7.68	7.71	7.69	7.70
Mean	7.66	7.68	7.69	

Seed rates (S)							
Harvesting duration (H)	S <sub>1</sub> (10 kg/ha)			S <sub>2</sub> (12 kg/ha)		S <sub>3</sub> (14 kg/ha)	
	Sowing dates (D)	D <sub>1</sub> (Aug 15 <sup>th</sup> )	D <sub>2</sub> (Aug30 <sup>th</sup> )	D <sub>1</sub> (Aug15 <sup>th</sup> )	D <sub>2</sub> (Aug 30 <sup>th</sup> )	D <sub>1</sub> (Aug15 <sup>th</sup> )	D <sub>2</sub> (Aug30 <sup>th</sup> )
H <sub>1</sub> (150DAS)	7.64		7.65	7.62	7.67	7.65	7.70
H <sub>2</sub> (180DAS)	7.62		7.69	7.65	7.70	7.66	7.71
H <sub>3</sub> (210DAS)	7.65		7.72	7.65	7.78	7.69	7.70

Factors	S.E m ±	CD (5%)
Sowing date (D)	0.003	0.01
Seed rate (S)	0.004	0.01
Harvesting duration (H)	0.004	0.01

**Interactions**

DXS	0.006	0.02
DXH	0.006	0.02
SXH	0.007	0.02
DXSXH	0.01	0.01

**Interaction**

In quality parameters, significantly maximum starch content (16.93%) was recorded by a combination of August 30<sup>th</sup> sowing and seed rate of 12 kg/ha (D<sub>2</sub>S<sub>2</sub>). Though interaction treatments were not significant, highest starch content (17.27%) was recorded with August 30<sup>th</sup> sown crop with a seed rate of 10 kg/ha and harvesting duration of 180 DAS (D<sub>2</sub>S<sub>1</sub>H<sub>2</sub>) and August 30<sup>th</sup> sown with a seed rate of 12 kg/ha and harvesting duration of 180DAS (D<sub>2</sub>S<sub>2</sub>H<sub>2</sub>).

Reducing sugars at 120 DAS recorded to be significantly higher with August 30<sup>th</sup> sowing and seed rate of 12 kg/ha (D<sub>2</sub>S<sub>2</sub>), August 15<sup>th</sup> sowing and seed rate of 14 kg/ha (D<sub>1</sub>S<sub>3</sub>) and August 30<sup>th</sup> sowing and seed rate of 10 kg/ha (D<sub>2</sub>S<sub>1</sub>) recorded 1.18%. Though interaction treatments were not significant, highest reducing sugars (2.17%) was recorded with August 30<sup>th</sup> sown crop with a seed rate of 10 kg/ha and harvesting duration of 150 DAS (D<sub>2</sub>S<sub>1</sub>H<sub>1</sub>) and August 30<sup>th</sup> sown with a seed rate of 10 kg/ha and harvesting duration of 180DAS (D<sub>2</sub>S<sub>1</sub>H<sub>2</sub>).

In non-reducing sugars, significantly maximum (7.72%) was recorded by a combination of August 30<sup>th</sup> sowing and seed rate of 12 kg/ha (D<sub>2</sub>S<sub>2</sub>). In three way interaction a combination of August 30<sup>th</sup> sowing, 12 kg/ha seed rate and harvesting duration of 210 DAS (D<sub>2</sub>S<sub>2</sub>H<sub>3</sub>) recorded significantly maximum non reducing sugars (7.78%).

August 15<sup>th</sup> sown crop with seed rate of 12 kg/ha recorded the highest yields which Inturn recorded low starch content, reducing and non-reducing sugars. Starch content, reducing and non-reducing sugars which were produced by plant might have diverted towards the production of thicker and longer roots leading to higher yields. Similar studies were reported in Ashwagandha (Kahar *et al.*)<sup>[10]</sup>.

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