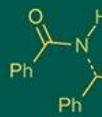


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Effect of sowing windows, moisture conservation practices and drought mitigation strategies on yield and economics of chickpea

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Abstract

A field experiment was conducted during *rabi* of 2024-25 and 2025-26 at Agricultural College Farm, Bapatla to study the effect of sowing windows, moisture conservation practices and drought mitigation strategies on yield and economics of chickpea. The experiment was laid out in split split plot design with four main plots (Second fortnight of November, First fortnight of December, Second fortnight of December and First fortnight of January), three sub plots (Two shallow ploughings, Deep ploughing to a depth of 30 cm with MB plough *fb* two shallow ploughings and Rice husk biochar incorporation @ 5 t ha⁻¹ with rotavator) and three sub-sub plots (Salicylic acid @ 50 ppm spray at flowering and pod development stages, Homobrassinolide @ 0.25 ppm spray at flowering and pod development stages and 1 % KNO₃ spray at flowering and pod development stages). The experimental results revealed that sowing of chickpea during second fortnight of November recorded higher yield, harvest index and economics of chickpea which was comparable with sowing of chickpea during first fortnight of December. Among moisture conservation practices, deep ploughing to a depth of 30 cm *fb* two shallow ploughings recorded significantly higher yield and net returns of chickpea. Foliar spray of homobrassinolide @ 0.25 ppm at flowering and pod development stages recorded numerically higher yield and benefit cost ratio during both the years of study and in pooled data.

Keywords: Chickpea, biochar, yield, economics

Introduction

Chickpea is an important pulse crop cultivated mostly under rainfed conditions, where the productivity is strongly influenced by the weather conditions, availability and distribution of soil moisture during the crop growing period. Long term moisture stress, especially during the flowering and pod formation stages can significantly lower the biomass output, pod formation and grain yield. Unfavourable conditions can lower the farmers' economic returns in addition to yield losses. Time of sowing is one of the key elements influencing the crop's exposure to temperature and moisture conditions at various stages of growth. Chickpea may be subjected to terminal moisture stress and rising temperatures if sowing is delayed, thereby affecting the pod formation and yield. Tillage practices influence soil structure, infiltration, evaporation and rainfall storage within the crop root zone. In a similar way, biochar has the potential to alter the soil physical properties and enhance moisture retention, thereby supporting crop growth during intermittent dry periods. In addition to soil and water management, foliar application of plant growth regulators like salicylic acid, homobrassinolide, and potassium nitrate may help to sustain physiological activity, enhance stress tolerance and boost reproductive development under stress conditions.

With increasing climate change and the frequency of occurrence of stress conditions, we must adopt new strategies to address both productivity and profitability of chickpea. Keeping all these in view, this experiment was conducted to know the effect of sowing windows, moisture conservation practices and drought mitigation strategies on yield and economics of chickpea.

Materials and Methods

The field experiment was carried out during *rabi* of 2024-25, 2025-26 at Agricultural College Farm, Bapatla. The experimental soil was clay in texture with slightly alkaline pH, low levels of nitrogen, medium levels of phosphorus, potassium and organic carbon content. The experiment was laid out in split split plot design and replicated thrice. It consists of three factors: main factor (sowing windows), sub factor (moisture conservation practices) and subsub factor (drought mitigation strategies). Sowing windows include S₁: Second fortnight of November, S₂: First fortnight of December, S₃: Second fortnight of December and S₄: First fortnight of January, moisture conservation practices include M₁: Two shallow ploughings, M₂: Deep ploughing to a depth of 30 cm with MB plough fb two shallow ploughings and M₃: Rice husk biochar incorporation @ 5 t ha⁻¹ with rotavator and drought mitigation strategies include D₁: Salicylic acid @ 50 ppm spray at flowering and pod development stages, D₂: Homobrassinolide @ 0.25 ppm spray at flowering and pod development stages and D₃: 1 % KNO₃ spray at flowering and pod development stages. Chickpea crop was sown with a spacing of 30 cm x 10 cm according to the treatments. Pre emergence herbicide Pendimethalin @ 1L ha⁻¹ was sprayed and later hand weeding was done to remove the weeds. The recommended dose of fertilizers (20 kg Nitrogen, 50 kg Phosphorus) were applied to the field.

Results and Discussion

Seed yield (kg ha⁻¹)

The data regarding the effect of sowing windows, moisture conservation practices and drought mitigation strategies on seed yield of chickpea is presented in table 1.

Among the sowing windows, Significantly higher seed yield was recorded in the chickpea crop which was sown during second fortnight of November (1782, 1892 and 1837 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data) and it was statistically on par with yield of chickpea crop which was sown during first fortnight of December (1688, 1809 and 1749 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data). The lower yield was recorded in chickpea crop which was sown during first fortnight of January (1397, 1482 and 1440 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data) and it was on par with yield obtained when the crop was sown during second fortnight of December (1475, 1546 and 1511 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data) during the two years of experimentation and in the pooled data. This might be due to better crop growth and reproductive development with the prevailing weather conditions, which led to better canopy development, sustained photosynthetic activity, efficient translocation towards reproductive sinks which led to good seed development and higher yield. Similar results were reported by Seth *et al.* (2020) [5].

Moisture conservation practices also had shown significant effect on yield of the crop, where higher seed yield was obtained with deep ploughing to a depth of 30cm with MB plough fb two shallow ploughings (1665, 1771 and 1718 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data) and it was comparable with rice husk biochar incorporation @ 5 t ha⁻¹ with rotavator treatment (1610, 1706 and 1658 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data). This might be due to better storage of moisture and it was made available to the crop during critical period. This helped plants to retain more reproductive structures and continue assimilate

transfer to them. Availability of water during critical stages and their utilization for assimilate production and transfer to the seeds led to better yields. These results were in line with the findings of Basha *et al.* (2020) [1].

Foliar spray of salicylic acid, homobrassinolide and potassium nitrate did not influence the seed yield of chickpea statistically and they might have performed similarly on chickpea yield. However, numerically higher seed yield was noticed with foliar spray of Homobrassinolide @ 0.25 ppm at flowering and pod development stages (1603, 1704 and 1654 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data).

Interaction among the sowing windows, moisture conservation practices and drought mitigation strategies was found to be non significant during both the years of study and in pooled data.

Haulm yield (kg ha⁻¹)

Haulm yield was significantly influenced by both sowing windows and moisture conservation practices but not by the drought mitigation strategies during both the years of study and in pooled analysis and the data regarding haulm yield was presented in table 2.

Significantly higher haulm yield of chickpea was noticed when the crop was sown during second fortnight of November (2894, 3080 and 2987 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data) and it was on par with the haulm yield recorded when sown during first fortnight of December (2747, 3029 and 2888 kg ha⁻¹ during 2024-25, 2025-26 and in pooled data). This might be attributed to the longer duration available for vegetative growth under favourable conditions which led to better development of above ground parts like leaves, branches and stem and maintained them till the harvest of the crop. Similar results were reported by Sikdar *et al.* (2015) [6].

It is also known from the data that higher haulm yield was observed in deep ploughing to a depth of 30cm with MB plough fb two shallow ploughings (2786, 3065 and 2925 kg ha⁻¹ during 2024-25, 2025-26 and pooled data) and it was on par with rice husk biochar incorporation @ 5 t ha⁻¹ with rotavator treatment (2708, 2979 and 2844 kg ha⁻¹ during 2024-25, 2025-26 and pooled data). It might be due to moisture availability during the crop growing period which allowed better vegetative growth and reduced the premature deterioration which led to more haulm yield. Two shallow ploughings treatment recorded significantly lower haulm yield of chickpea. These results were in line with the findings of Khattak *et al.* (2018) [3].

The interaction effect of sowing windows, moisture conservation practices and drought mitigation strategies on haulm yield was found to be non significant.

Harvest index

The data regarding the influence of sowing windows, soil moisture conservation practices and drought mitigation strategies was presented in table 3.

Harvest index was significantly influenced by the sowing windows of chickpea. The data revealed that harvest index was significantly higher in the crop which was sown during second fortnight of November (0.38, 0.38 and 0.38 during two years and in pooled data) and was comparable with crop sown during first fortnight of December (0.38, 0.37 and 0.38 during 2024-25, 2025-26 and pooled data) during the two years of study and in pooled data. This might be due to the

efficient partitioning of assimilates towards the reproductive parts under favourable conditions during flowering, pod development and seed filling. These conditions enhanced the translocation of photosynthates from source tissues to developing seeds, resulting in greater proportion of biomass being converted into economic yield. These results were in accordance with the findings of Sikdar *et al.* (2015)^[6].

The data revealed that the influence of moisture conservation practices and drought mitigation strategies on harvest index of chickpea was found to be non significant.

The interaction among sowing windows, moisture conservation practices and drought mitigation strategies did not influence the harvest index of chickpea during both the years of study and in pooled data.

Economics

The data pertaining to cost of cultivation, gross returns, net returns and benefit cost ratio were presented in the table 4

and 5.

The higher gross returns (₹ 1,10,462 ha⁻¹, ₹ 1,24,770 ha⁻¹ and ₹ 1,17,616 ha⁻¹ during 2024-25, 2025-26 and in pooled data) net returns ((₹ 60,375 ha⁻¹, ₹ 74,484 ha⁻¹ and ₹ 67,428 ha⁻¹ during 2024-25, 2025-26 and pooled data) and benefit cost ratio (1.21, 1.48 and 1.35 during 2024-25, 2025-26 and pooled data respectively) were observed in the treatment where the crop was sown with deep ploughing to a depth of 30cm with MB plough */b* two shallow ploughings during second fortnight of November with foliar spray of homobrassinolide @ 0.25 ppm at flowering and pod development stages during the two years of study and in pooled data. This might be attributed to better vegetative and reproductive growth which aligned with the suitable weather conditions and moisture which led to higher yields and better returns. These findings were in line with the results reported by Kumar and Angadi (2016)^[4] and Dubey *et al.* (2024)^[2].

Table 1: Seed yield (kg ha⁻¹) of chickpea as influenced by sowing windows, moisture conservation practices and drought mitigation strategies

Treatments	Seed yield (kg ha ⁻¹)		
	2024-25	2025-26	Pooled data
Main plots : Sowing windows (S)			
S ₁ : Second fortnight of November	1782	1892	1837
S ₂ : First fortnight of December	1688	1809	1749
S ₃ : Second fortnight of December	1475	1546	1511
S ₄ : First fortnight of January	1397	1482	1440
SEm ±	29.1	30.1	29.2
CD (P = 0.05)	101	104	101
CV (%)	9.5	9.3	9.3
Subplots: Moisture conservation practices (M)			
M ₁ : Two shallow ploughings	1482	1570	1526
M ₂ : Deep ploughing to a depth of 30 cm with MB plough <i>/b</i> two shallow ploughings	1665	1771	1718
M ₃ : Rice husk biochar incorporation @ 5 t ha ⁻¹ with rotavator	1610	1706	1658
SEm ±	19.9	23.6	21.4
CD (P = 0.05)	60	71	64
CV (%)	7.5	8.4	7.8
Sub-sub plots : Drought mitigation strategies (D)			
D ₁ : Salicylic acid @ 50 ppm spray at flowering and pod development stages	1562	1653	1607
D ₂ : Homobrassinolide @ 0.25 ppm spray at flowering and pod development stages	1603	1704	1654
D ₃ : 1 % KNO ₃ spray at flowering and pod development stages	1593	1689	1641
SEm ±	19.7	21.9	20.5
CD (P = 0.05)	NS	NS	NS
CV (%)	7.5	7.8	7.5
Interaction			
S x M	NS	NS	NS
M x D	NS	NS	NS
S x D	NS	NS	NS
S x M x D	NS	NS	NS

Table 2: Haulm yield (kg ha⁻¹) of chickpea as influenced by sowing windows, moisture conservation practices and drought mitigation strategies

Treatments	Haulm yield (kg ha ⁻¹)		
	2024-25	2025-26	Pooled data
Main plots : Sowing windows (S)			
S ₁ : Second fortnight of November	2894	3080	2987
S ₂ : First fortnight of December	2747	3029	2888
S ₃ : Second fortnight of December	2575	2846	2710
S ₄ : First fortnight of January	2543	2805	2674
SEm ±	45.3	50.4	45.3
CD (P = 0.05)	157	174	157
CV (%)	8.8	8.9	8.4
Subplots: Moisture conservation practices (M)			
M ₁ : Two shallow ploughings	2575	2776	2676
M ₂ : Deep ploughing to a depth of 30 cm with MB plough /b two shallow ploughings	2786	3065	2925
M ₃ : Rice husk biochar incorporation @ 5 t ha ⁻¹ with rotavator	2708	2979	2844
SEm ±	36.7	38.4	35.5
CD (P = 0.05)	110	115	106
CV (%)	8.2	7.8	7.6
Sub-sub plots : Drought mitigation strategies (D)			
D ₁ : Salicylic acid @ 50 ppm spray at flowering and pod development stages	2658	2914	2786
D ₂ : Homobrassinolide @ 0.25 ppm spray at flowering and pod development stages	2708	2950	2829
D ₃ : 1 % KNO ₃ spray at flowering and pod development stages	2703	2956	2829
SEm ±	30.8	35.7	31.2
CD (P = 0.05)	NS	NS	NS
CV (%)	6.9	7.3	6.6
Interaction			
S x M	NS	NS	NS
M x D	NS	NS	NS
S x D	NS	NS	NS
S x M x D	NS	NS	NS

Table 3: Harvest index as influenced by sowing windows, moisture conservation practices and drought mitigation strategies in chickpea

Treatments	Harvest index		
	2024-25	2025-26	Pooled data
Main plots : Sowing windows (S)			
S ₁ : Second fortnight of November	0.38	0.38	0.38
S ₂ : First fortnight of December	0.38	0.37	0.38
S ₃ : Second fortnight of December	0.36	0.35	0.36
S ₄ : First fortnight of January	0.35	0.35	0.35
SEm ±	0.004	0.005	0.004
CD (P = 0.05)	0.01	0.02	0.01
CV (%)	5.21	6.68	5.74
Subplots: Moisture conservation practices (M)			
M ₁ : Two shallow ploughings	0.36	0.36	0.36
M ₂ : Deep ploughing to a depth of 30 cm with MB plough /b two shallow ploughings	0.37	0.37	0.37
M ₃ : Rice husk biochar incorporation @ 5 t ha ⁻¹ with rotavator	0.37	0.36	0.37
SEm ±	0.003	0.003	0.003
CD (P = 0.05)	NS	NS	NS
CV (%)	4.69	5.72	4.88
Sub-sub plots : Drought mitigation strategies (D)			
D ₁ : Salicylic acid @ 50 ppm spray at flowering and pod development stages	0.37	0.36	0.37
D ₂ : Homobrassinolide @ 0.25 ppm spray at flowering and pod development stages	0.37	0.37	0.37
D ₃ : 1 % KNO ₃ spray at flowering and pod development stages	0.37	0.36	0.37
SEm ±	0.003	0.004	0.003
CD (P = 0.05)	NS	NS	NS
CV (%)	4.90	6.11	5.32
Interaction			
S x M	NS	NS	NS
M x D	NS	NS	NS
S x D	NS	NS	NS
S x M x D	NS	NS	NS

Table 4: Cost of cultivation and Gross returns (₹ ha⁻¹) as influenced by sowing windows, moisture conservation practices and drought mitigation strategies in chickpea

Treatments	2024-25		2025-26		Pooled data	
	Cost of cultivation	Gross returns (₹ ha ⁻¹)	Cost of cultivation	Gross returns (₹ ha ⁻¹)	Cost of cultivation	Gross returns (₹ ha ⁻¹)
M ₁ S ₁ SS ₁	43774	88998	43976	95861	43875	92430
M ₁ S ₁ SS ₂	45087	92767	45289	101861	45188	97314
M ₁ S ₁ SS ₃	44437	90487	44639	99466	44538	94977
M ₁ S ₂ SS ₁	48774	104703	48976	115187	48875	109945
M ₁ S ₂ SS ₂	50087	110462	50289	124770	50188	117616
M ₁ S ₂ SS ₃	49437	107006	49639	118816	49538	112911
M ₁ S ₃ SS ₁	65274	101535	65476	112243	65375	106889
M ₁ S ₃ SS ₂	66587	106854	66789	117835	66688	112345
M ₁ S ₃ SS ₃	65937	103562	66139	114221	66038	108892
M ₂ S ₁ SS ₁	43774	86447	43976	96632	43875	91540
M ₂ S ₁ SS ₂	45087	88035	45289	98623	45188	93329
M ₂ S ₁ SS ₃	44437	87751	44639	97406	44538	92579
M ₂ S ₂ SS ₁	48774	98607	48976	109745	48875	104176
M ₂ S ₂ SS ₂	50087	102893	50289	115045	50188	108969
M ₂ S ₂ SS ₃	49437	102425	49639	113783	49538	108104
M ₂ S ₃ SS ₁	65274	96285	65476	107234	65375	101760
M ₂ S ₃ SS ₂	66587	97643	66789	108928	66688	103286
M ₂ S ₃ SS ₃	65937	98428	66139	109270	66038	103849
M ₃ S ₁ SS ₁	43774	80633	43976	87635	43875	84134
M ₃ S ₁ SS ₂	45087	80290	45289	87336	45188	83813
M ₃ S ₁ SS ₃	44437	79130	44639	86054	44538	82592
M ₃ S ₂ SS ₁	48774	85208	48976	93398	48875	89303
M ₃ S ₂ SS ₂	50087	89409	50289	97331	50188	93370
M ₃ S ₂ SS ₃	49437	87839	49639	96157	49538	91998
M ₃ S ₃ SS ₁	65274	82055	65476	88839	65375	85447
M ₃ S ₃ SS ₂	66587	83599	66789	90957	66688	87278
M ₃ S ₃ SS ₃	65937	82115	66139	89507	66038	85811
M ₄ S ₁ SS ₁	43774	74013	43976	82408	43875	78211
M ₄ S ₁ SS ₂	45087	75550	45289	83935	45188	79743
M ₄ S ₁ SS ₃	44437	80859	44639	89596	44538	85228
M ₄ S ₂ SS ₁	48774	78352	48976	86113	48875	82233
M ₄ S ₂ SS ₂	50087	82024	50289	89868	50188	85946
M ₄ S ₂ SS ₃	49437	80247	49639	88036	49538	84142
M ₄ S ₃ SS ₁	65274	81960	65476	90227	65375	86094
M ₄ S ₃ SS ₂	66587	77120	66789	85118	66688	81119
M ₄ S ₃ SS ₃	65937	80308	66139	88423	66038	84366

*MSP for chickpea during 2024-25 and 2025-26 are Rs.56.50 kg⁻¹ and Rs. 58.75 kg⁻¹ respectively

Table 5: Net returns (₹ ha⁻¹) and Benefit cost ratio as influenced by sowing windows, moisture conservation practices and drought mitigation strategies in chickpea

Treatments	2024-25		2025-26		Pooled data	
	Net returns (₹ ha ⁻¹)	BCR	Net returns (₹ ha ⁻¹)	BCR	Net returns (₹ ha ⁻¹)	BCR
M ₁ S ₁ SS ₁	45224	1.03	51885	1.18	48555	1.11
M ₁ S ₁ SS ₂	47680	1.06	56572	1.25	52126	1.16
M ₁ S ₁ SS ₃	46050	1.04	54827	1.23	50439	1.14
M ₁ S ₂ SS ₁	55929	1.15	66211	1.35	61070	1.25
M ₁ S ₂ SS ₂	60375	1.21	74481	1.48	67428	1.35
M ₁ S ₂ SS ₃	57569	1.16	69177	1.39	63373	1.28
M ₁ S ₃ SS ₁	36261	0.56	46767	0.71	41514	0.64
M ₁ S ₃ SS ₂	40267	0.6	51046	0.76	45657	0.68
M ₁ S ₃ SS ₃	37625	0.57	48082	0.73	42854	0.65
M ₂ S ₁ SS ₁	42673	0.97	52656	1.2	47665	1.09
M ₂ S ₁ SS ₂	42948	0.95	53334	1.18	48141	1.07
M ₂ S ₁ SS ₃	43314	0.97	52767	1.18	48041	1.08
M ₂ S ₂ SS ₁	49833	1.02	60769	1.24	55301	1.13
M ₂ S ₂ SS ₂	52806	1.05	64756	1.29	58781	1.17
M ₂ S ₂ SS ₃	52988	1.07	64144	1.29	58566	1.18
M ₂ S ₃ SS ₁	31011	0.48	41758	0.64	36385	0.56
M ₂ S ₃ SS ₂	31056	0.47	42139	0.63	36598	0.55
M ₂ S ₃ SS ₃	32491	0.49	43131	0.65	37811	0.57
M ₃ S ₁ SS ₁	36859	0.84	43659	0.99	40259	0.92
M ₃ S ₁ SS ₂	35203	0.78	42047	0.93	38625	0.86
M ₃ S ₁ SS ₃	34693	0.78	41415	0.93	38054	0.86
M ₃ S ₂ SS ₁	36434	0.75	44422	0.91	40428	0.83
M ₃ S ₂ SS ₂	39322	0.79	47042	0.94	43182	0.87
M ₃ S ₂ SS ₃	38402	0.78	46518	0.94	42460	0.86
M ₃ S ₃ SS ₁	16781	0.26	23363	0.36	20072	0.31
M ₃ S ₃ SS ₂	17012	0.26	24168	0.36	20590	0.31
M ₃ S ₃ SS ₃	16178	0.25	23368	0.35	19773	0.30
M ₄ S ₁ SS ₁	30239	0.69	38432	0.87	34336	0.78
M ₄ S ₁ SS ₂	30463	0.68	38646	0.85	34555	0.77
M ₄ S ₁ SS ₃	36422	0.82	44957	1.01	40690	0.92
M ₄ S ₂ SS ₁	29578	0.61	37137	0.76	33358	0.69
M ₄ S ₂ SS ₂	31937	0.64	39579	0.79	35758	0.72
M ₄ S ₂ SS ₃	30810	0.62	38397	0.77	34604	0.70
M ₄ S ₃ SS ₁	16686	0.26	24751	0.38	20719	0.32
M ₄ S ₃ SS ₂	10533	0.16	18329	0.27	14431	0.22
M ₄ S ₃ SS ₃	14371	0.22	22284	0.34	18328	0.28

Conclusion

Among sowing windows, sowing of chickpea during second fortnight of November recorded significantly higher seed yield, haulm yield and harvest index of chickpea and the lowest was recorded in first fortnight of January sowing. Among the moisture conservation practices, deep ploughing to a depth of 30cm with MB plough *fb* two shallow ploughings was found to be superior over two shallow ploughings with regard to seed yield and haulm yield of chickpea. Drought mitigation strategies did not influence the yield of chickpea, however, foliar spray of homobrassinolide @ 0.25 ppm at flowering and pod development stages recorded numerically higher seed yield and haulm yield of chickpea. Higher economic returns were observed in the treatment with deep ploughing to a depth of 30cm with MB plough *fb* two shallow ploughings during second fortnight of November with foliar spray of homobrassinolide @ 0.25 ppm at flowering and pod development stages.

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