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Amol S Rathod
Department of Agricultural Meteorology, College of Agriculture, Pune, Maharashtra, India

JD Jadhav
Department of Agricultural Meteorology, College of Agriculture, Pune, Maharashtra, India

VM Londhe
Zonal Agricultural Research Station, Solapur, Maharashtra, India

VT Jadhav
Zonal Agricultural Research Station, Solapur, Maharashtra, India

SV Bagade
Department of Agricultural Meteorology, College of Agriculture, Pune, Maharashtra, India

VA Sthool
Department of Agricultural Meteorology, College of Agriculture, Pune, Maharashtra, India

AM Khobragade
Department of Agricultural Meteorology, College of Agriculture, Parbhani, Maharashtra, India

YE Kadam
Department of Agricultural Meteorology, College of Agriculture, Parbhani, Maharashtra, India

Corresponding Author:
Amol S Rathod
Department of Agricultural Meteorology, College of Agriculture, Pune, Maharashtra, India

Performance of chickpea (*Cicer arietinum* L.) cultivars under different sowing window over scarcity zone of Maharashtra

Amol S Rathod, JD Jadhav, VM Londhe, VT Jadhav, SV Bagade, VA Sthool, AM Khobragade and YE Kadam

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Abstract
Field experiment was conducted to study the effect of weather parameters on growth and yield of chickpea crop under different sowing windows during *rabi* seasons of 2020-21 and 2021-22 at Zonal Agricultural Research station, (ZARS) Solapur. An experiment was laid out in split plot design with four replications. The treatments comprised of four sowing windows i.e. S1 - 38 MW (17-23 Sept.), S2 – 40 MW (01-07 Oct.), S3 – 42 MW (15-21 Oct) and S4 (28 Oct- 04 Nov) as a main plot and two chickpea varieties *viz*. V1– Vijay, and V2 – Digvijay as a sub plot. Results revealed that Plant height, dry matter, number of pods, weight of pods, 100 seed weight, seed rain yield, Straw yield decreased with successive delay in sowing. Among all the sowing dates, S1 (38 MW) sowing window in the experimental trial of 2020-21 and S2 (40 MW) sowing window during experimental trial of 2021-22, recorded the higher growth attributes *viz.*, plant height (45.50 and 48.79 cm), mean dry matter per plant (19.30 g and 21.86 g), Number of pods plant^{-1} (37.00 and 40.0), Weight of pods plant^{-1} (g) (9.64 and 10.38), and 100-seed weight (g) (23.9 and 24.36 g), Grain yield (kg ha^{-1}) (1061.2 and 1164.2 kg ha^{-1}) and straw yield (1491.2 and 1622.2 kg ha^{-1}) was maximum in (S1) 38th MW sowing window for 2020-21 and (S2) 40th MW sowing window for the 2021-22 respectively. Among the two screening varieties, at harvest (V2) Digvijay recorded the highest growth attributes *viz.*, mean plant height (44.73 and 47.88 cm) and dry matter plant^{-1} (16.67 and 16.97g), Whereas, yield contributing characters, Number of pods plant^{-1} (33.06& 36.06) Weight of pods plant^{-1} (g) (8.68 and 9.50 g), and 100-seed weight (g) (9.31 & 21.17) were highest in Digvijay over Vijay during both the experimental trials of 2020-21 and 2021-22, respectively.

Keywords: Chickpea, growth, yield

Introduction
Chickpea is a pulse crop first grown in Turkey about 7000 B.C. It is traditionally grown in the semi-arid zones of India and Middle Eastern countries. A member of the family *fabaceae* chickpea has the ability to fix a portion of its nitrogen requirements from air in the soil. The growth habit is erect, with most of the pods formed in the top part of the plant. Chickpea is one of the major pulse crops cultivated and consumed in India, also known as bengal gram. Chickpea is a good and cheap source of protein compared to animal protein. In India, chickpea accounts for about 45% of total pulses produced in the country and contributing for over 75% of total production in the world. During last one decade, additional area of 5.63 Mha was covered pulses of which nearly 2/3rd was contributed by chickpea and black gram (1.9 Mha each). If we see the future pulse outlook there is enormous opportunities at global, regional and national level. In Maharashtra the chickpea crop is mainly sown in *rainfed* zone area. In Maharashtra, area under chickpea is 23.21 Lha with production of 25.97 Lt having productivity of 1118 kg ha^{-1} (4th Advance estimates of MS, 2019-20). Chickpea crop is mainly concentrated in region like Marathwada, vidhbhra and western Maharashtra. The *rainfed* area of western Maharashtra is mainly sowing the gram crop in cool winter season. Pune, Ahmednagar and solapur are the important gram cultivating district of western Maharashtra. The area under gram crop in solapur district is 506.9 ha, and total production is 281 tons. The productivity of gram crop in solapur district is 554 kg ha^{-1}. (Anonymous 2019) [1].

In India Madhya Pradesh ranks first among all state in both area and production of chickpea. India ranks first in acreage and production of chickpea in the world.

Even though, India ranks first in acreage and production of chickpea in the world. Chickpea faces various abiotic stresses during its life cycle such as drought, cold, thermal heat and salinity (Ryan, 1997, Millan *et al*., 2006) [6, 5]. The yield looses due to abiotic stresses may exceed those caused by biotic stresses (Ryan, 1997) [6]. Drought stress and high temperature during the spring season especially at the time of pollination or among the environmental parameters adversely influenced chickpea growth and yield (Krishnamurthy *et al.,* 2011) [4]. By selecting suitable planting times it is likely to avoid the adverse effects of high temperatures on cool adapted legumes (Upadhyaya *et al*., 2012) [10]. Optimum sowing time and selection of improved chickpea types play a remarkable role in exploiting the yield potential of the crop under particular agro climatic conditions. The optimum sowing time is important to exploit the environmental conditions during the growth of chickpea for maximum production. Keeping view in mind, the present experiment had been conducted to find out optimum sowing window and suitable variety of chickpea under scarcity zone of Maharashtra.

Materials and Methods

The field experiment was conducted at Mulegaon Agricultural Farm, Zonal Agricultural Research Station, Solapur during *rabi* season 2020-21 & 2021-22. The geographical location of the site (Solapur) was 17°41'N, latitude; 75°56'E, longitude and 483.6 m above mean sea level (MSL). The soil is medium black calcareous having depth of about 90 cm. The soil was moderately acidic in reaction (pH 7.6) and electrical conductivity was 0.17 dSm^{-1}. The field capacity and permanent wilting point was 310 and 150 mm, respectively with bulk density of 1.2 Mg m^{-3} the annual rainfall received was 500-700 mm. The received rainfall was highly erratic and unpredictable in nature. The coefficient of variation was 29 to 45% for the amount of rainfall received. The monsoon last from June to the end of September, with moderate rainfall. The Solapur city receives an average rainfall of 545 mm per year. Winter begins in November and last until end of February, with the temperature occasionally dropping below 10 °C. The total amount of rainfall received, 368.3 mm during *rabi* 2020-21 and 312.3 mm during *rabi* 2021-22 respectively. Maximum amount of rainfall was 110.0 mm in one week during 42 MW of 2020-21 and maximum amount of rainfall received was 121.7 mm in a week in 39 MW During 2021-22 respectively. An experiment was laid out in split plot design with four replications. The treatments comprised of four sowing windows i.e. S1 - 38 MW (17-23 Sept.), S2 – 40 MW (01-07 Oct.), S3 – 42 MW (15-21 Oct) and S4 (28 Oct- 04 Nov) as a main plot and two chickpea varieties *viz*. V1 – Vijay, and V2 –Digvijay as a sub plot. The crop was grown with all recommended package of practices of the region the whole crop taken as *rainfed* crop, as irrigation is not given to the crop. Immediately after crop establishment, five plants were randomly selected from each plot for recording periodical observations on yield attributing parameters. The data collected were statistically analysed properly with Split-split plot design and results were interpreted thoroughly.

The following parameters are calculated as.

Harvest index (%)

Harvest index is ratio of economic yield to the biological yield per plot. It was calculated by using following formula (Donald and Hamblin, 1976).

Harvest index (%) = (Economic yield (kg ha^{-1})/ Biological yield (kg ha^{-1})) *100

Growing Degree Days (GDD)

The growing degree days (GDD) were calculated during the crop period and attempted to relate the same with crop duration as well as grain yield. The GDD were calculated using the following formula.

$$GDD = \sum_{i=1}^{n} \frac{Tmax+Tmin}{2} - Tbase$$

(Ghadekar, 2004) [12]

$$where \sum_{i=1}^{n} =$$

Period in days from sowing date till the last date of harvesting

Tmax = maximum temperature in °C Tmin = minimum temperature in °C

Tbase = minimum threshold temperature or base temperature in °C The base temperature for sorghum crop is 5 °C.

Helio Thermal Units (HTU)

Heliothermal units for various growth stages were calculated by the formula given by Ritchie and Nesmith, (1991) [13].

HTU = GDD x Bright sunshine hours

Photo Thermal Units (PTU):

Photo thermal units were determined by GDD multiplying with maximum possible sunshine hours (N).

Result and discussion Effect of date of sowing

Results of analysis of mean data indicated that yield, yield attributes of chickpea types differ significantly under crop grown at different dates.

Plant height

During 2020-21, the highest plant height 45.50 cm was recorded under 38 MW (S1) sowing window, which was followed by 40 MW (S2) (43.43 cm) and 42 MW (S3) sowing window (42.13 cm). Whereas lowest plant height (37.85) recorded by the 44 MW (S4). During the experimental trail of *rabi* 2021-22, the 40 MW (S2) sowing window recorded highest plant height (48.79 cm) followed by 38 MW (S1) (46.93 cm) and 42 MW (S2) sowing window (45.59 cm). The 44 MW (S4) sowing produced lowest plant height (40.63 cm) In pooled results, the higher plant height was recorded in S2 (46.21 cm) (40 MW) sowing window which was at par with the S1 (46.13 cm) sowing window. (Table 1).

Dry matter

During 2020-21, significantly higher dry matter accumulation $plant^{-1}$ (g) was recorded with sowing of Chickpea during 38 MW (19.30 g) (S1) than rest of the sowing windows. During 2021-22, the 40 MW recorded highest dry matter accumulation than rest of the sowing window. During both the years 44 MW recorded lowest dry matter accumulation (13.44 & 12.11 g) respectively. The pooled dry matter Accumulation $plant^{-1}$ (g) the higher 19.49 g was recorded with 40 MW (S2) sowing window which was at par with S1 sowing window. (Table 1).

Number of pods: During2020-21 (S1) 38 MW recorded significantly higher number of pods plant^{-1} (37.00) compared to later sowing of S2 (40 MW) (35.38), S3 (42 MW) (31.00) & S4 (44 MW) (20.13) and during the2021-22, the S2 (40 MW) show higher number of pods (40.00) as compared to remaining sowing windows S1 (38 MW), (38.38), S2 (42 MW) (34.00), while it & 44 (MW) (23.13). In pooled analysis, the S2 (40 MW) recorded higher number of Pods (38.75) which was at Par with the S1 sowing windows and S4 (44 MW) recorded lowest (21.88) number of pods plant^{-1}. (Table 1).

Table 1: Mean plant height (cm), Dry matter (g) and Number of pods plant-1 of *rabi* chickpea as influence by different sowing dates and varieties

Treatment	plant height (cm)			dry matter			Number of pods plant-1		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Main	Sowing Dates (S)								
S1: (38 MW) (Sep 17- 23)	45.50	46.93	46.13	19.30	16.36	17.83	37	38.38	36.88
S2: (40 MW) (Oct01-07)	43.43	48.79	46.21	17.14	21.86	19.49	35.38	40	38.75
S3: (42 MW) (Oct15-21)	42.13	45.59	43.86	15.16	14.96	15.06	31	34	32.38
S4: (44 MW) (Oct29-Nov04)	37.85	40.63	39.26	13.44	12.11	12.77	20.13	23.13	21.88
S.E. (m)±	0.97	0.97	0.74	0.11	0.38	0.19	2.35	2.35	2.38
C.D. at 5%	3.15	3.16	2.41	0.37	1.25	0.61	7.64	7.64	7.73
Sub treatment	Varieties (V)								
V1: Vijay	39.72	43.08	41.41	15.85	15.68	15.76	28.69	31.69	30.5
V2: Digvijay	44.73	47.88	46.32	16.67	16.97	16.82	33.06	36.06	34.44
S.E. (m)±	1.11	3.16	1.04	0.26	0.26	0.18	1.01	1.01	0.97
C.D. at 5%	3.47	3.57	3.24	0.8	1.25	0.57	3.16	3.16	3.03
	Interaction (S x V)								
S.E. (m)±	1.85	1.89	1.65	0.38	0.53	0.32	2.76	2.76	2.75
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	42.23	45.48	43.87	16.25	16.33	16.29	30.88	33.88	32.47

Weight of pods plant^{-1} (g)

Maximum weight of pods plant^{-1} was observed from the S1 (38 MW) sowing window 9.64 g for the first experimental trial of 2020-21 and 10.38 g in S2 (40 MW) sowing window for the experimental trials of 2021-22 respectively. The lowest weight of pods plant^{-1} (5.29 g) was recorded by S4 (44 MW) sowing window during 2020 and 6.13 g during 2021 respectively. In pooled analysis, the S2 (40 MW) sowing window recorded higher weight of pods plant^{-1} (10.25) which was at par with S1 sowing window (9.63). (Table 2)

100-seed weight (g)

The maximum hundred seed weight 23.90 g by S1 (38 MW) during 2020 and 24.36 g by S2 (40 MW) in 2021 was recorded respectively and the minimum hundred seed weight 13.04 g &14.94 g was recorded by S4 (44 MW) sowing during both the years of experimental trials. In pooled analysis, the S2 (40 MW) sowing window recorded higher hundred seed weight (24.50 g)) which was at par with S1 sowing window (22.63 g). (Table 2)

Grain Yield (Kg ha^{-1})

During 2020-21, the grain yield of chickpea sowing in the S1 (38 MW) recorded significantly highest grain yield (1061.20kg ha^{-1}) and it was at par with S2 (40 MW) (880.30kg ha^{-1}). The lowest grain yield was recorded sowing window S4 (44 MW) (465.90 kg ha^{-1}). During 2021-22, S2 (40 MW) recorded highest yield (1164.20 kg ha^{-1}) followed by S3 (42 MW) (881.20 kg ha^{-1}) and S1 (38 MW) (832.40 kg ha^{-1}). The pooled analysis show the second sowing window (S2) (40 MW) recorded the significantly highest yield (1022.25 kg ha^{-1}) followed by first sowing window (S1) 38 MW (946.81 kg ha^{-1}) and S3 (42 MW) (825.13 kg ha^{-1}) the lowest yield was produced by S4 (44 MW) (574.51 kg ha-^{1}). (Table 2).

Table 2: Mean Weight of pods plant-1 (g), 100-seed weight (g) and Grain Yield (kg ha^{-1}) of *rabi* chickpea as influence by different sowing dates and varieties

Treatment	Weight of pods plant-1 (g)			100-seed weight (g)			Grain Yield (Kg ha-1)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Main	Sowing dates (S)								
S1: (38 MW) (Sep 17- 23)	9.64	9.75	9.63	23.9	23.48	22.63	1061.2	832.4	946.8
S2: (40 MW) (Oct01-07)	8.95	10.38	10.25	21.88	24.36	24.5	880.3	1164.2	1022.2
S3: (42 MW) (Oct15-21)	7.3	8.13	7.88	17.88	19.78	18.63	769.1	881.2	825.1
S4: (44 MW) (Oct29-Nov04)	5.29	6.13	5.88	13.04	14.94	13.75	465.9	683.1	574.51
S.E. (m)±	0.61	0.59	0.65	1.35	1.73	1.38	41.4	32.1	24.9
C.D. at 5%	1.99	1.9	2.1	4.37	5.61	4.48	132.3	102.8	80.9
Sub treatment	variety (V)								
V1: Vijay	6.91	7.69	7.5	17.18	19.08	17.88	751.6	839.1	795.4
V2: Digvijay	8.68	9.5	9.31	21.17	22.2	21.88	836.6	941.3	888.9
S.E. (m)±	0.39	0.38	0.42	0.89	0.91	0.92	27.5	25.4	19.7
C.D. at 5%	1.22	1.19	1.31	2.79	2.84	2.85	84.8	78.1	61.5
	Interaction (S x V)								
S.E. (m)±	0.83	0.8	0.88	1.85	2.16	1.89	55	50.7	37.4
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	7.79	8.54	8.41	19.17	20.64	19.88	794.1	890.2	842.18

Straw yield (Kg ha^{-1})

During 2020, the first sowing window (S1) (38 MW) (1491.20 kg ha^{-1}) show significantly superior straw yield as compared to other sowing windows, and during 2021, the second sowing windows (S2) (1622.20 kg ha^{-1}) recorded higher straw yield than rest other sowing windows. In pooled analysis, it was observed that the straw yield in S2 (40 MW) sown crop recorded higher straw yield (1466.25 kg ha^{-1}) which was at Par with S1 (1390.80 kg ha^{-1}) (38 MW) sowing window. (Table 3).

Biological yield

During 2020, the S1 38 MW (2525.40 kg ha^{-1}) was recorded significantly higher biological yield than rest other sowing windows. During 2021, S2 40 MW (2786.40 kg ha^{-1}) recorded significantly superior biological yield (3857 kg ha^{-1}) over rest of the sowing windows. In pooled analysis, it was observed that the straw yield in S2 (40 MW) sown crop recorded higher straw yield (2488.5 kg ha^{-1}) which was at Par with S1 (2337.6 kg ha^{-1}). (Table 3)

Harvest index (%)

The S1 (38 MW) & S2 (40 MW) sowing window recorded significantly higher harvest index 41.5% and 41.8% whereas, sowing date of S4 (44 MW) recorded the lowest harvest index (37.3% &35.7%) during the experimental trials of 2020-21 and 2021-22 respectively. In pooled analysis, it was observed that the harvest index in S2 (40 MW) sown crop recorded higher harvest index (40.9%) which was at Par with S1 (40.3%) (38 MW) sowing window. (Table 3).

Table 3: Mean Straw yield (Kg ha-1), Biological yield (Kg ha-1) and Harvest index (%) of *rabi* chickpea as influence by different sowing dates and varieties

Treatment	Straw yield (Kg ha-1)			Biological yield (Kg ha-1)			Harvest index (%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	pooled
Main	Sowing dates (S)								
S1: (38 MW) (Sep 17- 23)	1491.2	1290.4	1390.8	2525.4	2122.9	2337.6	41.5	39.1	40.3
S2: (40 MW) (Oct01-07)	1310.3	1622.2	1466.3	2190.6	2786.4	2488.5	40	41.8	40.9
S3: (42 MW) (Oct15-21)	1199.1	1339.2	1269.1	1968.2	2220.4	2094.3	38.9	39.5	39.2
S4: (44 MW) (Oct29-Nov04)	895.9	1141.1	1018.5	1361.9	1824.2	1593	34	37.3	35.7
S.E. (m)±	41.3	32.1	24.9	82.7	64.3	49.9	0.4	0.4	0.3
C.D. at 5%	134.1	104.3	80.9	268.3	208.5	161.8	1.4	1.2	0.9
Sub treatment	variety (V)								
V1:Vijay	1181.6	1297.1	1239.4	1933.2	2136.2	2034.7	38	38.9	38
V2: Digvijay	1266.6	1399.4	1333	2103.2	2340.7	2222	39.2	40	39.2
S.E. (m)±	27.5	25.4	19.7	55	50.7	39.5	0.3	0.3	0.3
C.D. at 5%	85.7	78.9	61.5	171.4	157.9	123	1	0.9	1
	Interaction (S x V)								
S.E. (m)±	56.8	48.1	37.4	113.5	96.3	74.9	0.6	0.5	0.6
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	1224.1	1348.2	1286.2	2018.2	2238.4	2128.4	38.6	39.4	38.6

GDD, HTU and PTU

The highest growing degree days are recorded 1811.40 and 1863.45 (°C days), the highest HTU 9394.00 and 11474.00 (°C days) and the highest PTU 22738.00 and 23254.50 (°C days) recorded by S1 sowing window and S2 sowing windows respectively during 2020-21 and 2021-22 respectively. (Table 4) The decrease in degree days with delay in sowing.

Ray *et al.* 2017 reported similar findings states that higher value was recorded at all the stages in early Sown as compared to late sown chickpea. Aziz and Rahman (1996) [3], Shamsi *et al.* (2009) [7], etc. Reported similar types of findings.

Table 4: Mean growing degree days, heliothermal units and Phototherml units affected by different sowing dates and variety

Treatment	GDD (°C days)		HTU (°C days)		PTU (°C days)	
	2020	2021	2020	2021	2020	2021
S1 (38 MW)	1811.40	1751.25	9394.00	9327.50	22738.00	22214.50
S2 (40 MW)	1702.75	1863.45	9068.00	11474.00	21749.50	23254.50
S3 (42 MW)	1529.40	1552.60	8784.00	8857.00	19117.00	19406.00
S4 (44 MW)	1471.85	1444.65	8223.50	8857.00	18396.50	18057.00
V1 (Vijay)	1559.80	1521.18	8827.25	9459.00	19465.50	19810.30
V2 (Digvijay)	1697.90	1784.80	8907.50	9798.75	21535.00	21655.80

Effect of varieties

Among the two cultivars Vijay (V1) and Digvijay (V2), the V2 Digvijay recorded the highest plant height 44.73 cm (2020-21) 47.88 cm (2021-22) 46.32 cm (pooled), highest dry matter 16.67 g (2020-21) 16.97 g (2021-22), 16.82 g (pooled), highest number of pods 33.06 (2020-21), 36.06 (2021-22), 34.44 (pooled), Highest weight of pods 8.68 g (2020-21), 9.5 g (2021-22), 9.31 g (pooled), highest 100 seed weight 21.17 g (2020-21), 22.2 g, (2021-22) 21.88 g (pooled), highest grain yield Grain Yield 836.6 (Kg ha^{-1}) (2020-21), 941.3(Kg ha^{-1}) (2021-22), 888.9(Kg ha^{-1}) (pooled), highest straw yield 1266.6(Kg ha^{-1}) (2020-21) 1399.4 (Kg ha^{-1}) (2021-22) 1333.0(Kg ha^{-1}) (pooled). Highest biological yield 2103.2(Kg ha^{-1}) (2020-21), 2340.7(Kg ha^{-1}) (2021-22), 2222 (Kg ha^{-1}) (pooled), and higher harvest index 39.2(%) (2020- 21), 40 (%), (2021-22) and 39.2 (%) (Pooled). Also higher GDD, PTU Values are recorded by Digvijay (V2) are1697.90 (°C days), (2020-21) and 1784.80 (°C days),), (2021-22) HTU, 8907.50 (°C days) (2020-21), 9798.75(°C days) (2021-22), and PTU 21535.00 (°C days), (2020-21), 21655.80 (°C days) (2021-22), respectively. The results are in line with the findings, Sharma (2002) [8], Shamsi *et al.* (2009) [7]. Kiran and Chimmad (2015) [10].

The interaction between sowing dates and variety shows non-significant interaction for all the parameters.

Conclusion

Among the sowing windows S2 (40 MW) sowing window was found to be the most suitable for growth, yield attributes and yield with S1 (38 MW) sowing window is the second best sowing window which can be used as alternate sowing window The yield of chickpea types decreased with delay in sowing. Among the two varieties, Digvijay was found to be the most promising variety with regard to growth, yield attributes and yield. And in accumulation of different thermal units.

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