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Studies on shifting of sowing window for sustainable production of rabi chickpea (*Cicer arietinum* L.) under changing rainfall situation in medium deep soil of scarcity zone of Maharashtra

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Abstract
The present investigation entitled "Studies on shifting of sowing window for sustainable production of *rabi* chickpea (*Cicer arietinum* L.) under changing rainfall situation in medium deep soil of scarcity zone of Maharashtra" was carried under rainfed condition during *rabi* season of 2011- 2015 at research farm of Zonal Agricultural Research Station, Solapur, Maharashtra State (India). The experimental was laid out in split plot design with four replications. The treatments comprised of four sowing time *viz*., S_1 = MW 38 (Sept 17-23), Uttara nakshtra, S_2 = MW 40 (Oct. 01-07), Hasta nakshtra, S_3 = MW 42 (Oct. 15-21), Chitra nakshtra and S_4 = MW 44 (Oct. 29- Nov.04), Swati nakshtra in main plot and two varieties V_1 = Vijay V_2 = Dig vijay in sub plot. The results of the experiment indicated that the growth and yield parameter *viz*., grain yield (1439.8 kg ha^{-1}) and total monetary returns (Rs. 45286 ha^{-1}), average CUM (255 mm), MUE (6.6 kg ha^{-1} mm) were maximum when chickpea sown at MW 38 (S_1) (Uttara Nakshtra). Among the genotypes Digvijay produced more grain yield (1327.2 kg ha^{-1}), and total monetary returns (Rs. 41707 ha^{-1}). The graphs under correlation studies showed polynomial relationship in case of consumptive use of moisture, Tmax and Tmin However, linear relationship showed under Moisture use efficiency with grain yield.

Keywords: *Rabi* chick pea, sowing windows, yield attributes, cultivar

Introduction
Chickpea (*Cicer arietinum* L.) is an important food legume crop. It is cultivated for food and fodder on a large scale in arid and semiarid regions. It is the second-most important pulse crop after pigeon pea in the World for human diet and other use. Pulses, once referred to as the poor man's meat are becoming increasingly important in crop production systems. Poor agronomic practice such as seed rate, date of sowing, selection of suitable genotypes, fertilizer management, *etc.* are responsible for low productivity of chickpea in India. In northern part of India, chickpea is normally sown during second fortnight of October. Within the genetic limits, time of sowing is an important agronomic factor affecting the productivity of most of the arable crops, owing to changes in environmental conditions to which phenological stages of crops are exposed. A good genotype under modified environment of different dates of sowing and maintenance of optimum plant population may help in realizing optimum yield level. Amongst the agronomic practices, sowing methods and proper seed rate are of great importance (Reddy *et al*., 2003) [7]. Generally, chickpea adapts to high temperatures, however, heat stress during reproductive phase can cause significant yield loss. The current chickpea-growing area is under threat from increasing temperature and so, production may extend to cooler regions.

Material and Methods
The study was conducted at research farm of Zonal Agricultural Research Station, Solapur, Maharashtra State (India) during in year 2011-2015 in the *rabi* season. The area is positioned at 75º 65' N latitude 75º 90'E longitude and at the altitude of 483.6 meters above the sea level. The experiment was conducted in split plot design with four replications. Treatment combinations were formed considering different cultivars *viz*., S_1 = MW 38 (Sept 17-23), Uttara nakshtra, S_2 = MW 40 (Oct. 01-07), Hasta nakshtra, S_3 = MW 42 (Oct. 15-21), Chitra

nakshtra and S_4 = MW 44 (Oct. 29- Nov.04), Swati nakshtra. It is valued for its nutritive seeds with an inexpensive and high quality source of protein (18-22%), carbohydrate (52-70%), fat (4-10%), crude fibers (1.37%), lysine (195-205 mg-1), carotene (89-94 mg-1), fiber (3%), minerals (calcium, magnesium, phosphorus, iron, zinc) and vitamins (Yadav *et al*., 2007) [8].

There are two kinds of chickpea Desi and Kabuli. Kabuli type is grown in temperate regions while the desi type chickpea is grown in the semi-arid tropics (Malhotra *et al*., 2007) [3]. Some time, its sowing is delayed depending upon the withdrawal of monsoon and late harvest of preceding *kharif* crop like rice, cotton etc., which ultimately results in poor seed yield. (Jettner *et al.*,1999) [2]. Late sowing, after November 18 reduced yield by 28% for every 10 day interval delay (Paikaray and Misra, 1992) [5]. Late sowing, after November 18 reduced yield by 28% for every 10 day interval delay (Paikaray and Misra, 1992) [5]. Late sowing, after November 18 reduced yield by 28% for every 10 day interval delay (Paikaray and Misra, 1992) [5]. Late sowing, after November 18 reduced yield by 28% for every 10 day interval delay (Paikaray and Misra, 1992) [5].

The soil comes under the vertisol (medium black) clayey loam in texture and slightly alkaline (pH-7.4) in nature and having the depth up to 90 cm. The monsoon lasts from June to the end of September, with moderate rainfall. It has an average rainfall of about of 545 mm per year. The annual maximum and minimum temperature ranged between 25.0 to 43.2^{0}C and 7.3 to 27.1 ^{0}C, respectively. All the cultivars are were dibbled as per different sowing windows at a spacing of 45 cm x 20cm. Amongst the agronomic practices, sowing methods and proper seed rate are of great importance (Reddy *et al*., 2003) [7].

Results and Discussion

A. Agronomical studies

Chickpea sown at MW 38 (S_1) (Uttara Nakshtra) produced significantly maximum grain yield (1439.8 kg ha^{-1}) and total monetary returns (Rs. 45286 ha^{-1}) over S_3 and S_4 sown crop i.e. MW 42 and 44 (Chitra and Swati Nakshtra). Results are in close agreement with finding of Indu Bala Sethi *et al*, (2016) [1] and Prasad *et al*. (2012). Variety Digvijay produced more grain yield (1327.2 kg ha^{-1}), and total monetary returns (Rs. 41707 ha^{-1}) over variety Vijay. This might be due to efficient utilization of available soil moisture and radiation use efficiency at proper time (Table 1 and 2). Parmar *et al*. (2015) [4] revealed that maximum grain yield was recorded from early sown whereas minimum yield was obtained from late sown crop of chickpea.

B. Meteorological studies

The average CUM (255 mm) was recorded higher by the S_1 sown crop (MW 38 (Sept. 17-23), *Uttara nakshtra*) and MUE (6.6 kg ha^{-1} mm) was recorded higher by the S_1 sown crop (MW 38 i.e. *Uttara* sown crop). Among the varieties Digvijay recorded highest average value of CUM and MUE (Table 3). This might be due to more days required for Digvijay variety for growth and development. The GDD required to maturity by chick pea crop was 1027 to 1442 (Table 4).

RUE of different treatments are presented in Table 5 Initially the RUE values were low it increases up to 70 DAS *i.e.* up to 50 per cent flowering stage further it was decreases in all most all the sowing dates and treatments.

C. Correlations studies

The consumptive use of moisture (CUM) during total growth period of chick pea (Fig.1) showed a polynomial relationship with grain yield. The CUM of 245 mm was found to be optimum for getting higher grain yield and thereafter there was decrease in chickpea yield. The MUE was correlated with the grain yield of chick pea and depicted in Fig. 2. It showed a linear relationship with grain yield. The Tmax during total growth period of chick pea (Fig.3) showed a polynomial relationship with grain yield. The yield was decrease if Tmax increases above 32.2 ^{0}C. The Tmin during total growth period of chick pea (Fig. 4) showed a polynomial relationship with grain yield. The Tmin of 18.2 ^{0}C was found to be optimum for getting higher grain yield and thereafter there was decrease in chickpea yield.

Table 1: Pooled grain yield (kg ha^{-1}) of *rabi* chickpea as influenced by various sowing dates and varieties. (2011-12 to 2015-16).

Treatment	2011-12	2012-13	2013-14	2014-15	2015-16	Pooled	SYI
Main=Sowing dates							
S_1 = MW 38 (Sept 01-07) *Uttara nakshtra*	1788.3	1496.7	1604.1	1611.9	697.7	1439.8	0.57
S_2 = MW 40 (Oct. 01-07) *Hasta nakshtra*	1529.2	1245.8	1387.9	1497.9	644.6	1261.1	0.73
S_3 = MW 42 (Oct. 15-21) *Chitra nakshtra*	1414.6	1106.2	1294.1	1372.5	519.2	1141.3	0.70
S_4= MW 44 (Oct. 29- Nov.04) *Swati nakshtra*	1181.2	889.6	1000.7	1273.2	419.9	952.9	0.68
Mean	1478.3	1184.6	1321.7	1438.9	570.4	1198.8	
Sub=Two varieties							
V_1 = Vijay	1296.0	983.5	1198.1	1363.7	510.4	1070.4	0.70
V_2 = Digvijay	1660.6	1385.6	1445.3	1514.1	630.3	1327.2	0.71
Mean	1478.3	1184.6	1321.7	1438.9	570.4	1198.8	
S.E.+ (Sowing dates)	52.2	51.0	65.5	25.7	25.2	30.8	
C.D. at 5%	167.3	163.3	209.5	82.2	80.6	95.0	
S.E.+ (Varieties)	24.8	23.4	69.9	24.7	20.1	25.9	
C.D. at 5%	76.5	72.2	215.4	76.0	62.0	77.7	
S.E.+ (SD X V)	49.6	46.9	139.8	49.3	40.2	51.9	
C.D. at 5%	NS	NS	NS	NS	NS	NS	

Table 2: Pooled total monetary returns (Rs. ha^{-1}) of *rabi* chickpea as influenced by various sowing dates and varieties. (2011-12 to 2015-16).

Treatment	2011-12	2012-13	2013-14	2014-15	2015-16	Pooled	SYI
Main=Sowing dates							
S_1 = MW 38 (Sept 01-07) *Uttara nakshtra*	53650	44900	48122	48357	31399	45286	0.69
S_2 = MW 40 (Oct. 01-07 *Hasta nakshtra*	45875	37375	41637	44937	29006	39766	0.77
S_3 = MW 42 (Oct. 15-21) *Chitra nakshtra*	42437	33187	38822	41175	23362	35797	0.73
S_4= MW 44 (Oct. 29- Nov.04) *Swati nakshtra*	35437	26687	30022	38197	18896	29848	0.72
Mean	44350	35537	39651	43167	25666	37674	
Sub=Two varities							
V_1 = Vijay	38881	29506	35943	40911	22967	33642	0.64
V_2 = Digvijay	49819	41569	43358	45422	28365	41707	0.75
Mean	44350	35537	39651	43167	25666	37674	
S.E.+ (Sowing dates)	1569.0	1530.9	1964.8	770.5	1133.7	757.0	
C.D. at 5%	5019.5	4897.6	6285.6	2464.9	3626.9	2332.4	
S.E.+ (Varieties)	744.8	703.1	2096.7	739.6	904.9	685.4	
C.D. at 5%	2295.0	2166.4	6460.5	2279.0	2788.2	2054.9	
S.E.+ (SD X V)	1489.6	1406.2	4193.3	1479.2	1809.8	1370.8	
C.D. at 5%	NS	NS	NS	NS	NS	NS	

Table 3: CUM and MUE as influenced in chickpea (2011-12 to 2015-16)

Treatment	CUM (mm)	MUE (kg ha^{-1} mm)	Treatment	CUM (mm)	MUE (kg ha^{-1} mm)
S_1V_1	255.0	5.0	S_3V_1	255.0	3.8
S_1V_2	245.0	6.6	S_3V_2	243.9	5.4
S_2V_1	246.7	4.7	S_4V_1	223.6	3.9
S_2V_2	249.5	5.5	S_4V_2	231.7	4.5
Mean	249.1	5.5	Mean	238.6	4.4

Table 4: Growing degree days by sowing dates in chickpea (2011-12 to 2015-16)

Sowing time	Phenological stage				
	Emer.	Branching	50%Flow	Pod Form	Pod mat.
S_1V_1	142	434	306	161	271
Cumulative	142	576	882	1043	1314
S_1V_2	163	474	330	169	306
Cumulative	163	637	967	1136	1442
S_2V_1	136	419	269	144	259
Cumulative	136	555	824	968	1227
S_2V_2	157	452	296	162	279
Cumulative	157	609	905	1067	1346
S_3V_1	122	364	253	130	252
Cumulative	122	486	739	869	1121
S_3V_2	142	384	272	149	268
Cumulative	142	526	798	947	1215
S_4V_1	112	336	225	118	236
Cumulative	112	448	673	791	1027
S_4V_2	132	363	252	138	255
Cumulative	132	495	747	885	1140

Table 5: Periodical radiation use efficiency (RUE g mj^{-1}) in chickpea (2011-12 to 2015-16)

		S_1		S_2		S_3		S_4	
MW	DAS	**Vijay**	**Digvijay**	**Vijay**	**Digvijay**	**Vijay**	**Digvijay**	**Vijay**	**Digvijay**
38	SO	SOW	SOW	-	-	-	-	-	-
40	14	0.42	0.56	SOW	SOW	-	-	-	-
42	28	1.53	1.67	0.32	0.41	SOW	SOW	SOW	SOW
44	42	2.67	2.90	1.38	1.45	0.36	0.39	0.24	0.28
46	56	2.57	2.71	2.34	2.41	1.40	1.45	1.28	1.30
48	70	2.33	2.45	2.28	2.35	2.51	2.56	2.39	2.43
50	84	2.01	2.11	1.96	2.03	2.35	2.40	2.21	2.23
52	98	-	2.08	1.74	1.81	2.05	2.09	1.97	1.98
2	112	-	-	1.67	1.74	1.85	1.89	1.66	1.68
3	119	-	-	-	-	-	1.80	-	1.63

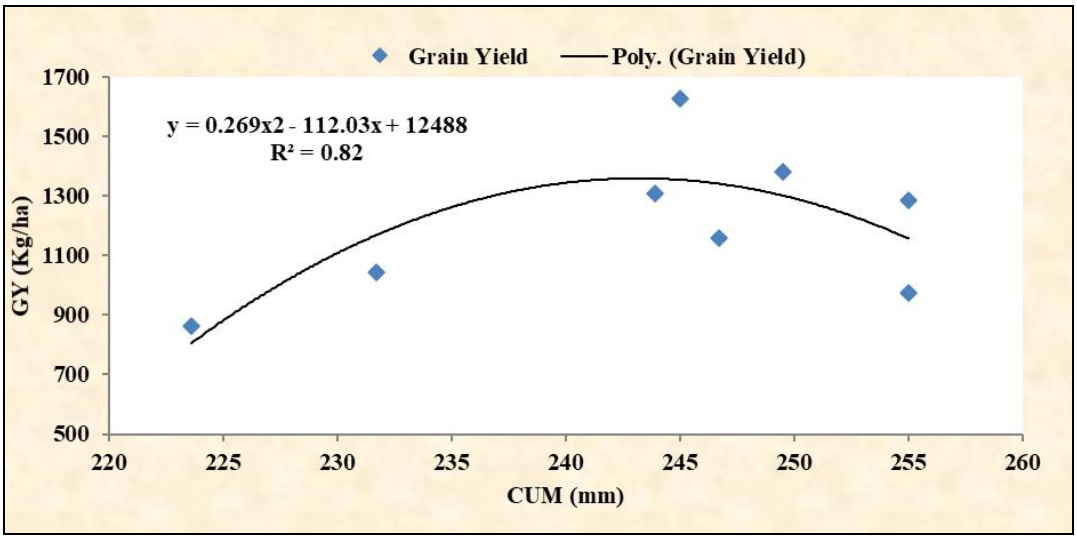

Fig 1: Grain yield with CUM in Chickpea (2015-16)

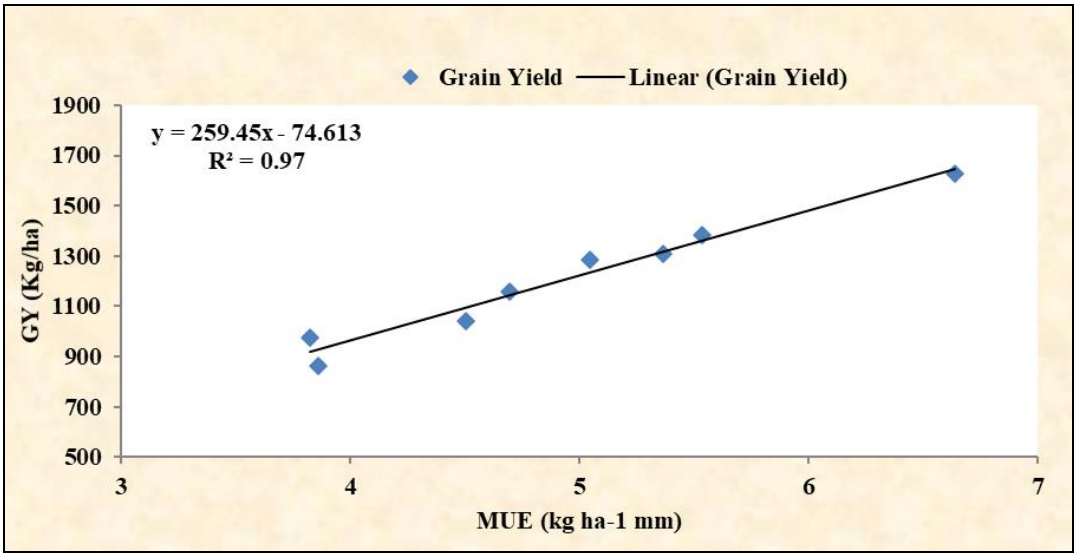

Fig 2: Grain yield with MUE in Chickpea (2015-16)

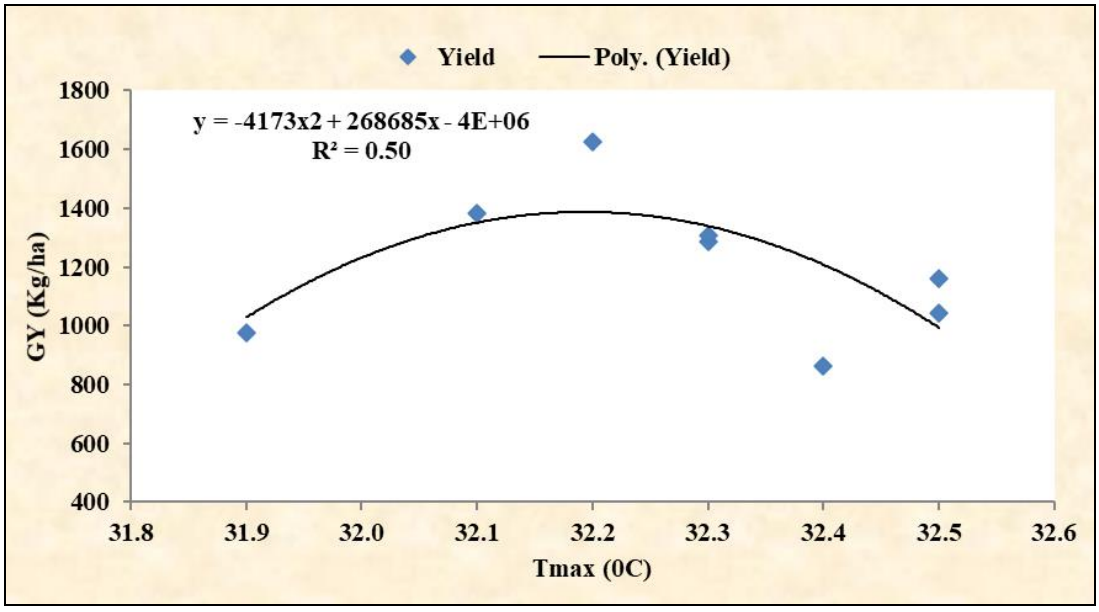

Fig 3: Grain yield with Tmax in Chick pea (2015-16)

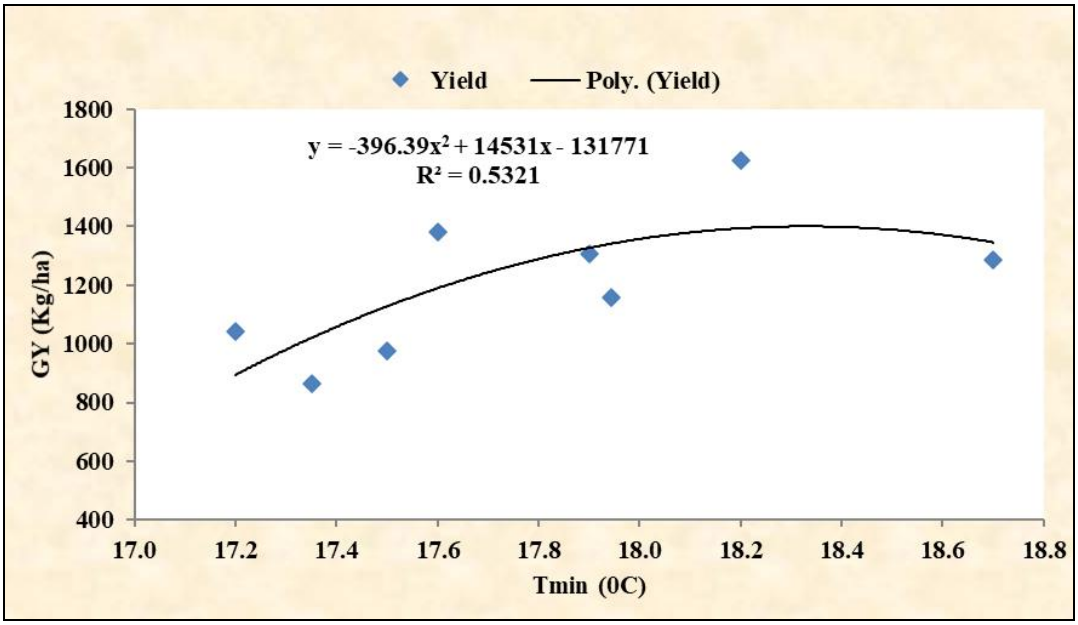

Fig 4: Grain yield with Tmin in Chick pea (2015-16)

Conclusion

From the above study it is concluded that the sowing of chickpea in MW 38 i.e. during 17-23 of September has recorded highest grain yield (1439.8 kg ha^{-1}) and genotype Digvijay has given maximum grain yield i.e. 1327.2 kg ha^{-1}.

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