Effect of different initial soil moisture on desi chickpea ICCV 95107 (*Cicer arietinum L.*) dry matter production and crop growth rate

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***Abstract*—** *This study aimed to assess some priming methods and durations under ranging field capacities of water in Kirinyaga County in Kenya in 2012/2013 growing seasons. A two season field experiment was conducted at Mwea Irrigation Agricultural Development Centre (MIAD) farm to evaluate chickpea advanced lines of ICCV 97105 for growth and growth rates under no priming, hydro priming and halo prime at three levels of i.e. 0.1, 0.2 and 0.3 % NaCl2 concentration with three priming durations (8, 10 and 12 hours) and varying initial soil moisture levels 100% field capacity (FC), 75 % FC, 50 % FC and 25 % FC). The experiment was laid out in a split plot design with three replications. Pre sowing irrigation, combined priming method and priming duration allocated in the main, and sub-plots, respectively. The control treatment was the pre-sowing irrigation at field capacity (FC). The results revealed the maximum/optimum crop growth rate (CGR) of desi chickpea was achieved with 100% FC during wet season I (October, 2012-January, 2013) which was 181.0kg DM/ha/day, while it was 114 kg DM/ha/day with 90-96% FC during the drier season II (July -Oct 2013). Desi chickpea grows slowly under low seasonal rainfall (311.2 mm) than higher seasonal rainfall (565.1 mm). Therefore, it is necessary to apply higher pre sowing irrigation of up to 100% FC in dry areas. Relating crop growth rate CGR during 75-90 days after sowing (DAS) phase period with DM and CGR to grain yield at harvest 120 DAS revealed that it is possible to predict DM and grain yield with 80.5 and 77.5% confidence by use of linear production functions:*

Key words: Chickpea, Priming, Pre sowing irrigation, growth and growth rate

I. INTRODUCTION

Seed germination is a complex and dynamic stage of plant ontogeny, with a number of interactive metabolic processes undergoing changes from storage to the mobilization phase (Bewley and Black, 1994; Ashraf and Foolad, 2005). The time from sowing to seedling establishment is of considerable importance in crop production as it has major impacts on crop germination, growth, final yield, and post harvest grain quality (Harris *et al.*, 2005).

Seed germination entails three distinct *phases: phase I* is imbibition process, in which water is taken up by the seed but little metabolic activity; *phase II* is a lag phase in which there is little water uptake but considerable metabolic activity; and *phase III* is marked by an increase in water content coinciding with radical growth and emergence (Bradford,1986). The length of *phase III* is important because germination is considered complete when embryo growth is initiated.

During seed germination especially in arid and semi arid lands (ASALs), the soil environment is often not conducive for rapid crop germination and seedling growth. Often, adverse abiotic and biotic constraints, such as low and high temperatures, soil crusting, shortage or excess water, salinity, pathogenic diseases, and insects can reduce the rate or completely inhibit seed germination and seedling emergence (Navkiran *et al.*, 2013).

One of the first physiological disorders taking place during seed germination under dry conditions is a decrease in water uptake by the seed due to low water potential of the germination medium. Rapid seed germination and uniform field emergences are essential for the establishment of successful crops. Slow or sporadic germination and emergence generally result in fewer and small plants, which are more vulnerable to different biotic and abiotic stresses (Harris *et al*., 2005). A prolonged emergence period may also lead to deterioration of the seedbed conditions and increased soil compaction, which result in poor crop establishment. Pre sowing is a common practice used to increase the rate and uniformity of germination and emergence in many important field crops.

Dry lands experience unreliable and erratic rainfall that is always inadequate for crop germination, growth and development to reach maturity. With adequate soil moisture chickpea germination percentages are reported to be high leading to high crop yields. With low soil moisture regimes as it is in ASAL areas, poor crop germination is experienced leading to poor crop stand and hence low crop yields. Primed seed will only germinate if it takes up additional moisture from the soil after sowing. Sowing pre-germinated seed under dry land conditions can result in total failure to emerge (Ashraf *et al*., 2003). There is therefore need to explore various technologies that can ensure early and uniform crop germination that will enhance optimum crop stand and establishment that will lead in to optimal crop yields in the ASAL environments. This study aimed to asses to evaluate the performance of chickpea under varying initial soil moisture levels on chickpea dry matter yield (DM) and crop growth rate (CGR).

II. MATERIALS AND METHOD

Two season's field experiments were conducted at Mwea Irrigation Agricultural Development Centre (MIAD) Kirinyaga County, Kenya farm during the 2012/2013 seasons. The centre is located on grid $0^0 39^1$S and $37^0 17^1$E, at an altitude of 1195m above sea level (m asl) .The experimental site lies in transition between middle highlands 5 (UM_5) and lower highlands (LH_4) agro ecological zone and as such, it has a hot and dry climate most of the year. The area receives a bimodal rainfall with an annual mean below 700mm, with a wide variation between the years. Although mean temperature is about 18^0C, daily values range from 7^0C at late night during the wet chilly season (July to August) to about 32^0C during the dry months. The relative humidity varies between 70-85%. The soils are slightly acidic (pH 5.5-6.5). Soil analysis that was done in MIAD centre showed that, the soils are insufficient in nitrogen (N; 0.053-0.144%) and phosphorus (P; 6-12ppm).

The experiment was laid out in a split plot design and desi chickpea ICCV 97105 was planted. The pre-sowing irrigation on soils was at four levels of field capacity (100% FC), 75 % FC, 50 % FC and 25 % FC were employed as main plots. The treatments comprised of three different priming methods (no priming , hydro priming & halo prime at three levels of i.e. 0.1, 0.2 and 0.3 % $NaCl_2$ concentration) , and three priming durations (8, 10 and 12 hours) were sub plots. Hence there were 13 treatment combinations totally replicated three times**.** Data was collected on dry matter (kg/ha) and rate of dry matter (kg/ha) accumulation and analysis of variance (ANOVA) of data collected was evaluated using GEN STAT Program package version No. 8 June 2008. Means were separated by the Turkey's least significant difference (LSD) at $P \leq 0.05$.

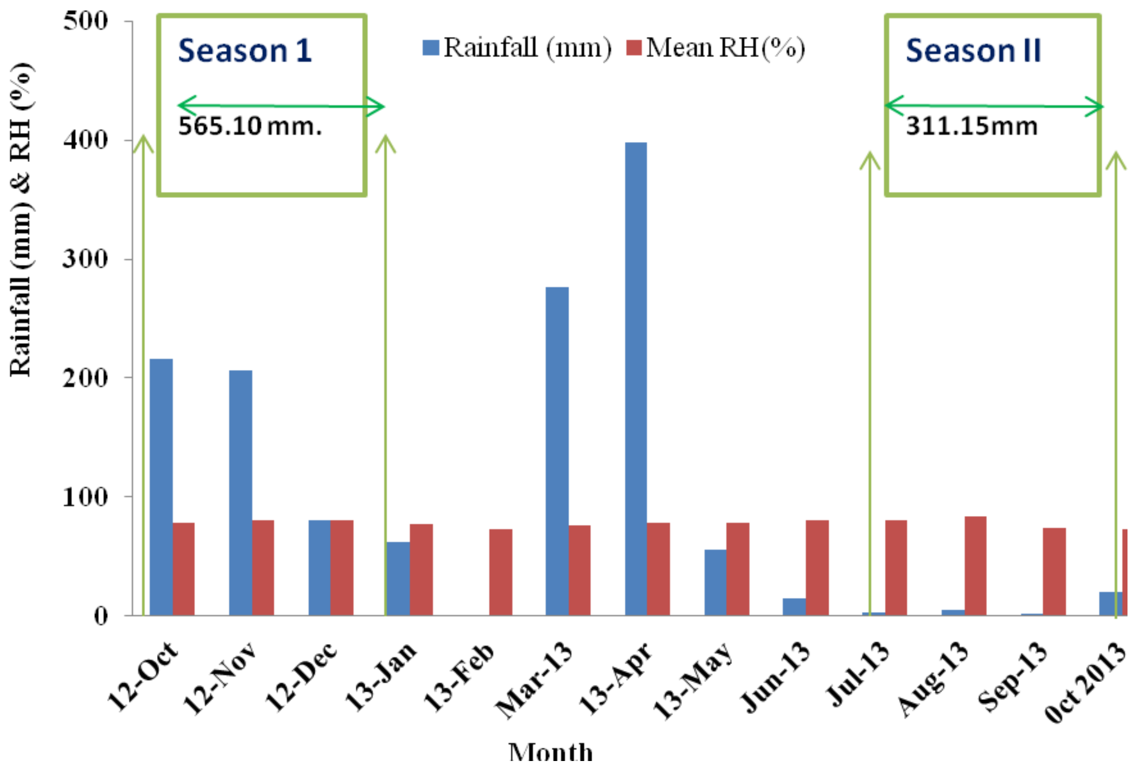

FIG 1: RAINFALL (MM) AND RELATIVE HUMIDITY (%) DURING SEASON I AND II

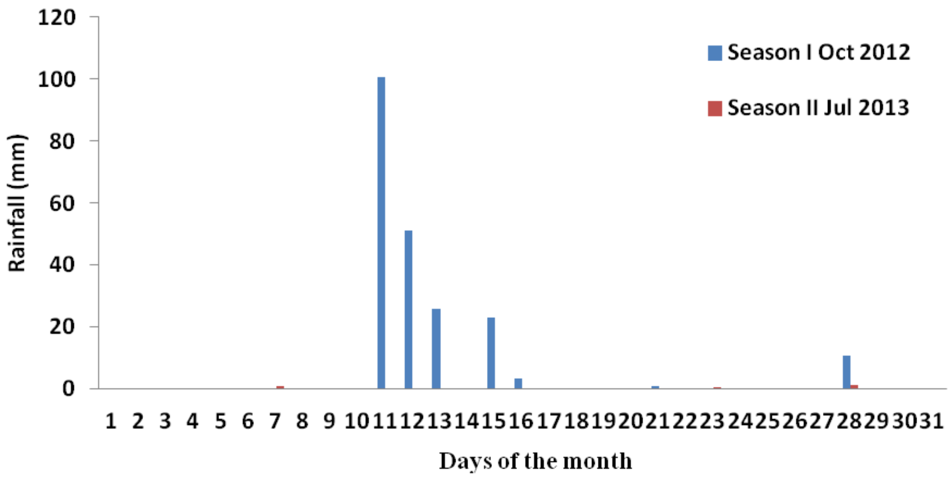

FIG 2: RAINFALL RECEIVED AT SOWING OF CHICKPEA IN MWEA FOR SI (OCT 2012) AND SII (JUL 2013)

III. RESULTS

TABLE 1
EFFECT OF PRE SOWING IRRIGATION ON CHICKPEA DM AT 25, 50, 75, 90 AND 105 DAS

	Plants/m^2		Dry matter (kg/ha)									
	7 DAS		25 DAS		50 DAS		75 DAS		90 DAS		105 DAS	
Irrigation	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II
25%FC	11	5	75.2	36.6	197.1b	85.5	511.0c	329	3000.0c	1709	3375.6	2652
50%FC	11	5	75.8	37.5	230.4a	128	512.0c	336	3377.0 bc	1738	3835.2	2755
75%FC	14	6	83.3	47.5	234.1a	119.2	707.0b	385	4097.0a	2480	4610.1	3657
100%FC	15	6	91.6	52.2	224.7ab	137.9	982.0a	447	4524.0a	2851	5001.1	3973
LSD (P<0.05)	10	4	13.33	37.46	30.99*	98.33	172.9*	209.1	718.4*	1976.3	3533.11	2949.6

TABLE 2
EFFECT OF PRE-SOWING IRRIGATION AT 25%, 50%, 75% AND 100% FIELD CAPACITY ON CHICKPEA CROP GROWTH RATE (KG/HA/DAY)

Pre sowing irrigation	25%FC		50%FC		75%FC		100%FC	
Growth phase	CGR SI	CGR SII	CGR SI	CGR SII	CGR SI	CGR SII	CGR SI	CGR SII
0-25 - Emergence & establishment	3.3	1.5	3.0	1.5	3.3	1.9	3.7	2.1
25-50 -Vegetative Lag	7.9	3.4	9.2	5.1	7.4	4.8	9.0	5.5
50-75 - Early branching & flowering	39.3	17.9	28.3	15.4	20.5	13.4	20.4	13.2
75-90 - Branching & podding	120.0	68.4	135.1	69.5	163.9	99.2	181.0	114.0
90-105 - Maturity	135.0	106.1	153.4	110.2	184.4	146.3	200.0	158.9
DM (kg/ha)	3000.0	1709.0	3377.0	1738.0	4097.0	2480.0	4524.0	2851.0
Grain yields (kg/ha)	943.0	375.6	1017	458.2	1177.0	513.1	1122.0	477.1

IV. DISCUSSIONS

The highest dry matter yield (DM) was realized under 100 % FC at 105 DAS (5001.1 and 3973.0 kg/ha) in season I and II, respectively (Table 1). Dry matter accumulation (kg/ha) increased with plant growth, i.e., from 25 DAS to 105 DAS in both season under all pre sowing irrigation conditions. Dry matter also increased with increased pre sowing irrigation from 25 % to 100% FC, and at every stage of growth i.e., 25,50,75,90 and 105 DAS (Table 1). Similar findings have been reported by Muhammad *et al*., (2010); Parvender, (2006) and Anwar *et al*. (2003) who demonstrated that water deficit decreased dry matter accumulation (biological yield) and grain yield per unit area and the fully irrigated crop had taller plants, maximum dry matter accumulation and higher grain yield than plants that were irrigated once. Anwar *et al.* (2003) also showed that irrigation increased grain yields by 74-124% and these trends were similar for dry matter (DM) yields. Similarly, Malhotra *et al.* (1997) observed increased total dry biomass (49%) and plant height (26%) with increased irrigation. Water stress is known to decrease dry matter accumulation (DMA) and grain yields per unit area (Ghassemi – Golezani *et al.*, 1998, Singh *et al*., 2006).

There was a positive linear regression coefficients R^2= 0.708-0.985 when pre sowing water content (through irrigation) was regressed with dry matter (Figs. 3-7), indicating high reliability ($P \leq 0.05$) of the functions to predict the responses of chickpea dry matter to pre sowing (initial) soil water content. This response curves explained dry matter production (Figs.13, 15, 17 and 19) and crop growth rates (Figs 14, 16, 18 and 20) at various growth phases of chickpea. The crop growth rate (CGR) increased gradually as the plant grew from 0– 25 DAS to 90-105 phasic periods irrespective of pre sowing irrigation treatments (Table 2). A maximum crop growth rate (CGR) of 158.9 kg DM/ha/day (Table 2 & Fig 15) with 100% FC (was obtained during the drier season II (Oct 2012-Jan 2013). It was higher at 200 kg DM/ha/day during July-October, 2013 (wet season I); with 100% FC initial soil water content. This is the period from branching, indeterminate flowering and podding (B-IFl-P). This was in agreement with previous studies done by Fazlulf, *et al*. (2009) and Kamithi, *et al*. (2008). Therefore, Desi chickpea grew slowly under a lower seasonal (SII) rainfall of 311.2 mm than the higher seasonal (SI) rainfall of 565.1 mm. This suggests that it is beneficial to apply higher pre sowing irrigation of up to 100% FC across seasons, with respect to subsequent growth of chickpea.

Relating CGR during 75-90 days after sowing (DAS) phase period with DM and CGR to grain yield (Fig. 16) at harvest 120 DAS revealed that it is possible to predict DM and grain yield with 80.5 and 77.5% confidence by use of linear production functions:

$$\text{DM (at harvest)} = 2480 + 9.777x \quad \text{(i)}$$

$$\text{Grain yield} = 875.2 + 1.46x \quad \text{(ii)}$$

In season II, it was possible to predict DM and grain yield (Fig.17) by use of linear production functions:

$$\text{DM (at harvest)} = 1320 + 11.62x \ (R^2 = 0.762) \quad \text{(iii)}$$

$$\text{Grain yield} = 361.5 + 1.256x \ (R^2 = 0.837) \quad \text{(iv)}$$

This has great implications as it enables planning for harvest, storage and marketing 30 days prior to final harvesting

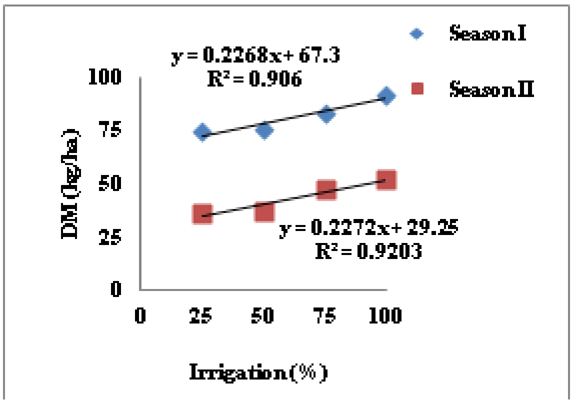

FIG 3: RELATIONSHIP OF PRE SOWING IRRIGATION (%FC) TO DRY MATTER 25 DAS

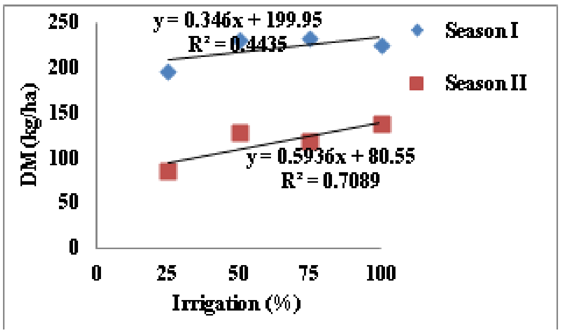

FIG 4: RELATIONSHIP OF PRE SOWING IRRIGATION (% FC) TO DRY MATTER 50 DAS

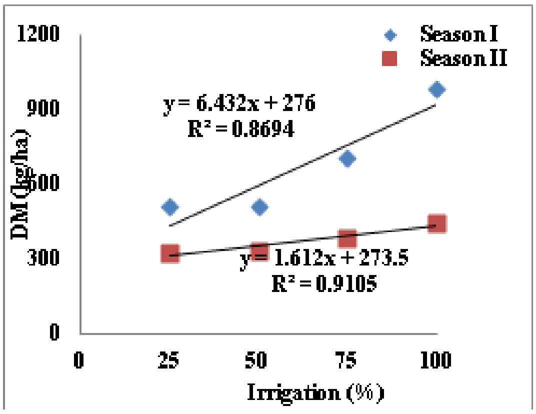

FIG 5: RELATIONSHIP OF PRE SOWING IRRIGATION (%FC) TO DRY MATTER 75 DAS

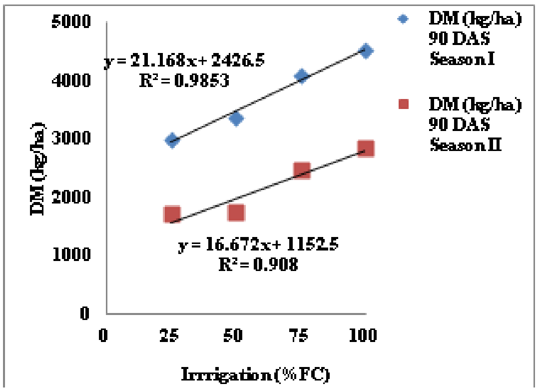

FIG 6: RELATIONSHIP OF PRE SOWING IRRIGATION TO DRY MATTER 90 DAS

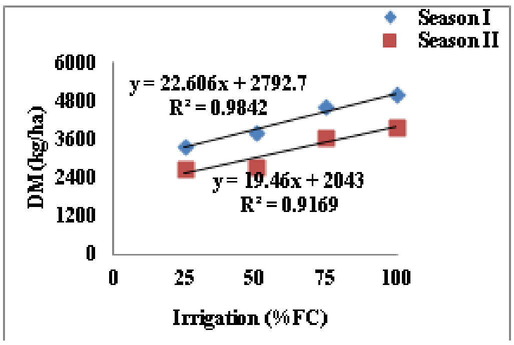

FIG 7: RELATIONSHIP OF PRE SOWING IRRIGATION (% FC) TO DRY MATTER AT 105 DAS

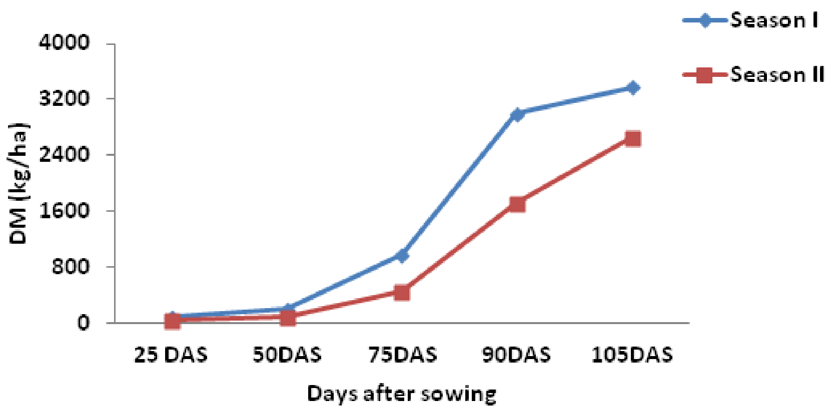

FIG 8: RELATIONSHIP OF 25% FC-PRE SOWING IRRIGATION ON GROWTH OF CHICKPEA IN SEMI ARID OF MWEA

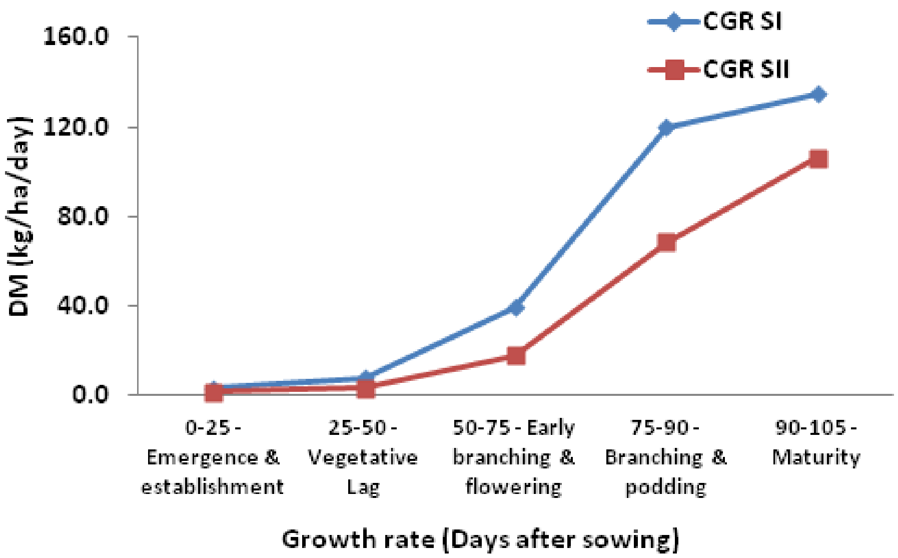

FIG 9: RELATIONSHIP OF CHICKPEA GROWTH RATE UNDER 25%FC PRE SOWING IRRIGATION IN SEASON I & II

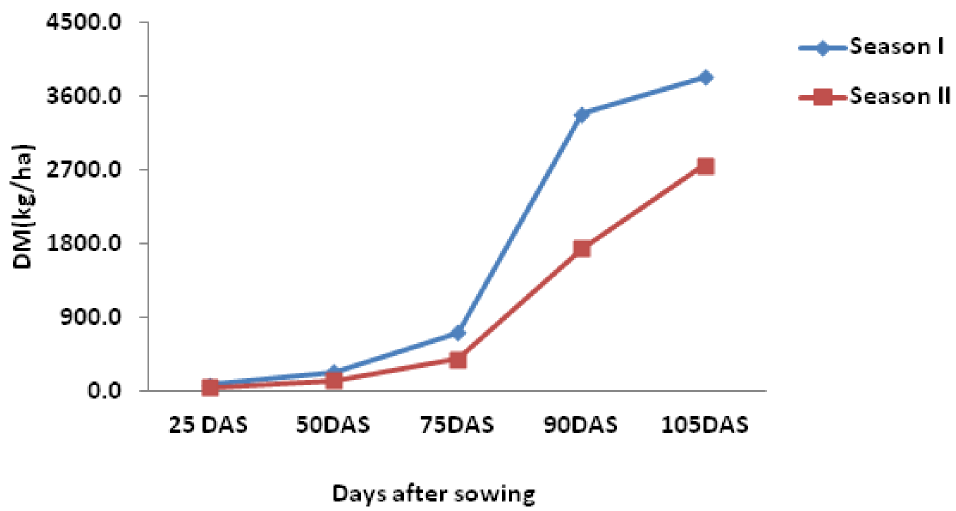

FIG 10: RELATIONSHIP OF 50% FC-PRE SOWING IRRIGATION ON GROWTH OF CHICKPEA IN SEMI ARID OF MWEA

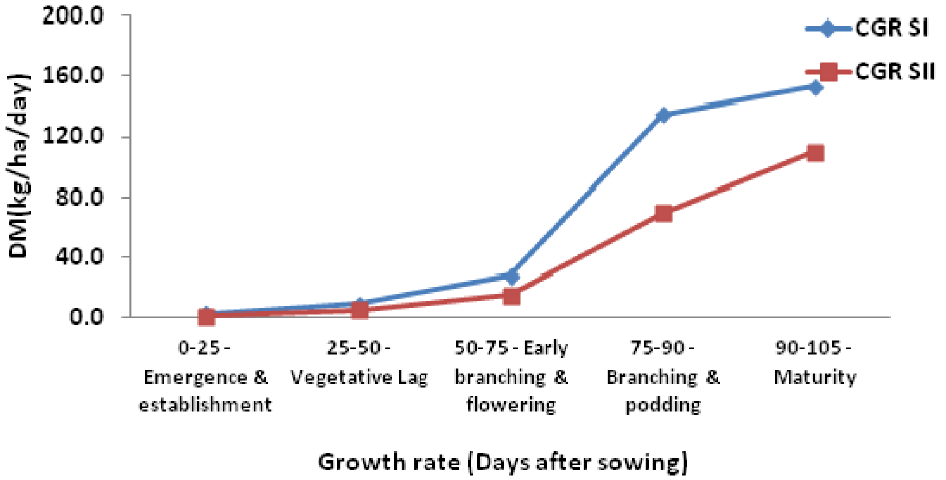

FIG 11: RELATIONSHIP OF CHICKPEA GROWTH RATE UNDER 50% FC PRE SOWING IRRIGATION IN SEASON I & II

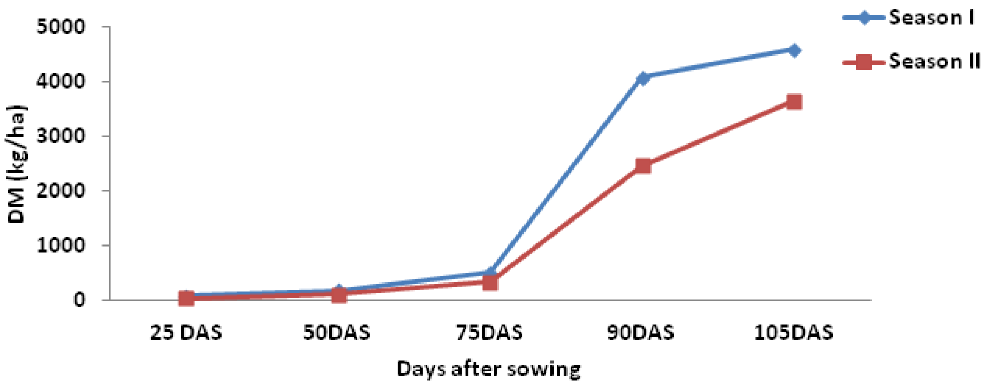

FIG 12: RELATIONSHIP OF 75%FC-PRE SOWING IRRIGATION ON GROWTH OF CHICKPEA IN SEMI ARID OF MWEA

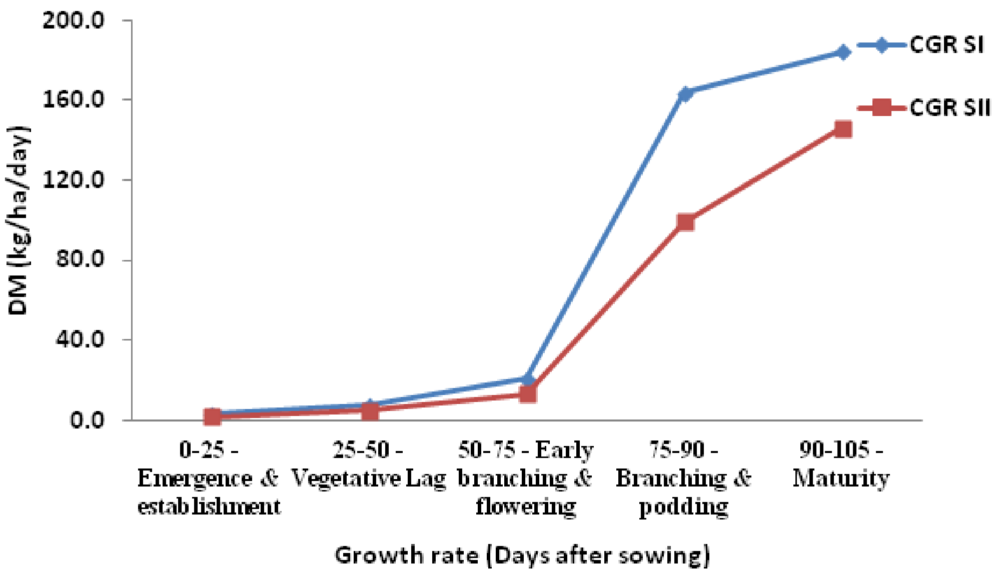

FIG 13: RELATIONSHIP OF CHICKPEA GROWTH RATE UNDER 75%FC-PRE SOWING IRRIGATION IN SEASON I & II

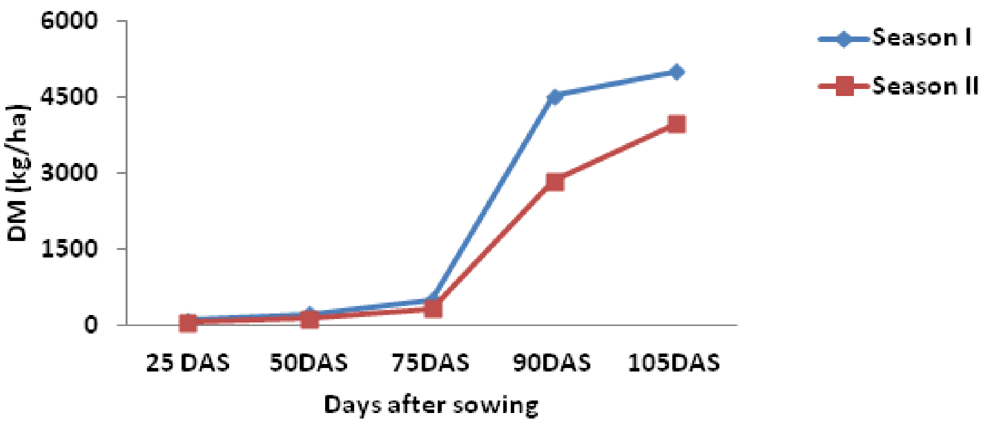

FIG 14: RELATIONSHIP OF FC-PRE SOWING IRRIGATION ON GROWTH OF CHICKPEA IN SEMI ARID MWEA

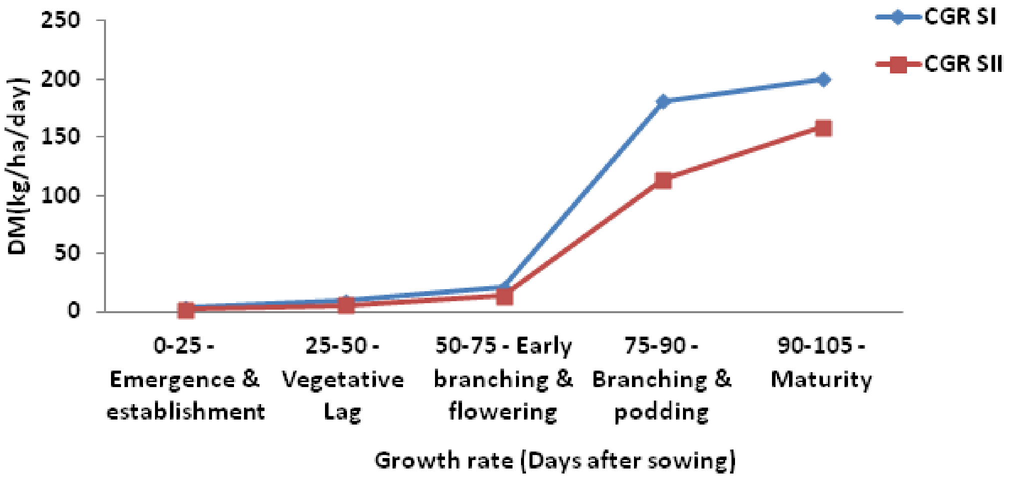

FIG 15: RELATIONSHIP OF CHICKPEA GROWTH RATE UNDER 100% FC-PRE SOWING IRRIGATION IN SEASON I &II

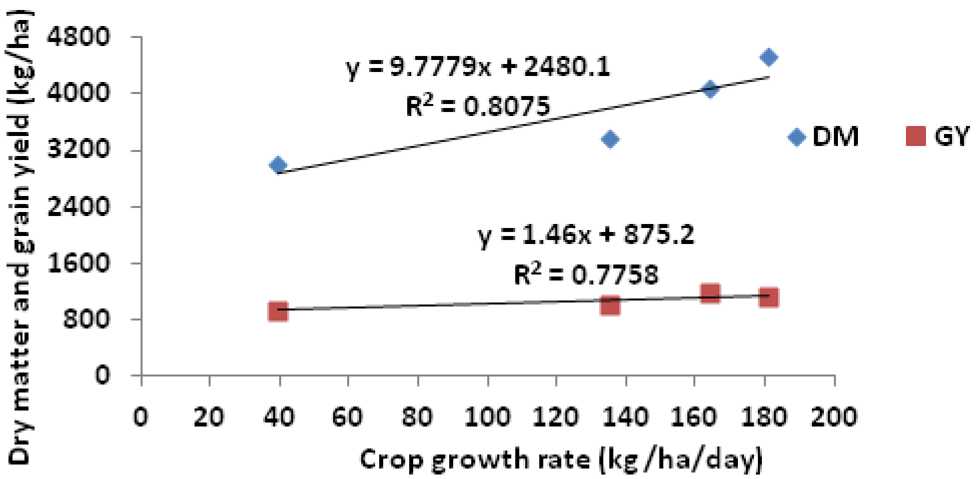

FIG 16: RELATIONSHIP OF CGR AT 75-90 DAS -DM AND GRAIN YIELD AT HARVEST (120 DAS) OF DESI CHICKPEA GROWN UNDER VARYING PRE SOWING IRRIGATION AND PRIMING IN SI

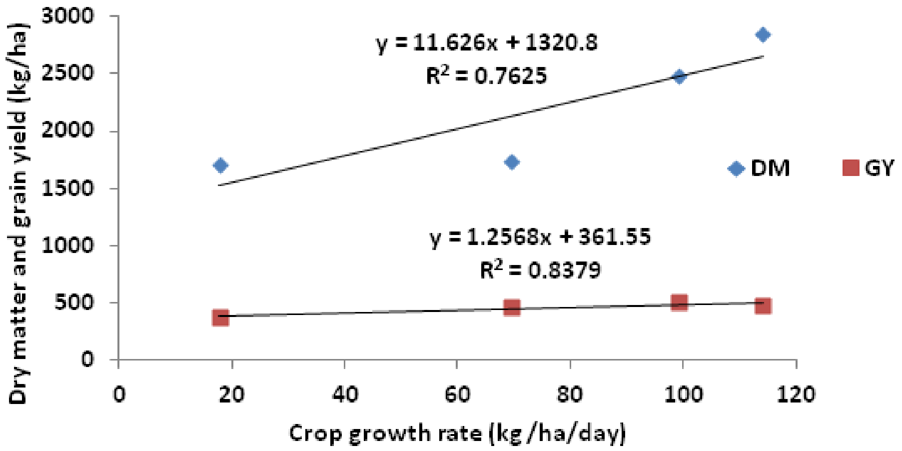

FIG 17: RELATIONSHIP OF CGR AT 75-90 DAS -DM AND GRAIN YIELD AT HARVEST (120 DAS) OF DESI CHICKPEA GROWN UNDER VARYING PRE SOWING IRRIGATION AND PRIMING IN SII

V. CONCLUSION

The maximum/optimum crop growth rate (CGR) of desi chickpea was achieved with 100% FC during wet season I (October, 2012-January, 2013) which was 181.0kg DM/ha/day, while it was 114 kg DM/ha/day with 90-96% FC during the drier season II (July -Oct 2013). Desi chickpea grows slowly under low seasonal rainfall higher seasonal rainfall. The Crop growth rate (CGR) at 25 % FC was highest (39.3 kg/ha/day in season I & 17.9 kg/ha/day for SII) between 50-75 DAS, period of early branching and flowering (EBF), followed by (120 kg/ha/day in season I & 68.4 kg/ha/day for SII) between 75 – 90 DAS ,the period from branching and podding (B-Fl-P). The chickpea crop growth rate (CGR) at 50 % FC was highest (135.1 kg/ha/day for SI & 69.5 kg/ha/day for SII) between 75 to 90 DAS, the period from branching and podding (B-Fl-P). The Crop growth rate (CGR) at 75 % FC was highest (163.9 kg/ha/day for SI & 99.2 kg/ha/day for SII) between 75 to 90 DAS, the period from branching and podding (B-Fl-P). The desi chickpea crop growth rate (CGR) at 100 % FC was highest (181.0 kg/ha/day for SI & 114.0 kg/ha/day for SII) between 75 to 90 DAS, the period from branching and podding (B-Fl-P).

RECOMMENDATIONS

In order to get higher dry matter (kg/ha) and therefore higher crop growth rate (CGR),application of pre sowing soil moisture of 75% FC and above is necessary under black cotton clay soils of Mwea, Kirinyaga,Kenya.

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