Effect of priming and different initial soil moisture on desi chickpea ICCV 95107 *(Cicer arietinum* L.) dry matter production (kg/ha)

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Abstract

Technologies such as seed priming have been reported to result in early and uniform crop germination, enhancing optimum crop stand and establishment, eventually leading to optimal crop yields in the Arid and Semi-Arid Lands (ASALs). This study, therefore, was initiated to evaluate the dry matter production of chickpea under different priming methods, varying priming durations and different initial soil moisture levels. Field experiments were carried out at Mwea Irrigation Agricultural Development Centre (MIAD) farm Kirinyaga County, Kenya during 2012/2013 seasons. A split plot experimental design was used to test effects of no priming, hydro priming and halo priming at 0.1, 0.2 and 0.3 % $NaCl_2$ concentration) and at 8, 10 and 12 hours priming duration on germination and growth of desi chickpea ICCV 95107. Altogether, the trial comprised 13 treatment combinations replicated three times with pre-sowing irrigation to soils at field capacity (FC) (100%), 75 %, 50 % and 25 %. Data was collected at growth stages of 25,50,75,90 and 105 days after sowing (DAS). The highest dry matter (DM) yields of 5001.1 and 3973.0 kg/ha was realized under 100 % FC at 105 DAS in season I and II, respectively. Dry matter accumulation (kg/ha) increased from 25 DAS to 105 DAS in both season under all pre sowing irrigation conditions, which correlates to growth stages. Dry matter also increased with increased pre sowing irrigation from 25% FC to 100% FC, and at every stage of growth. Halo priming for 8 hours with 0.2% $NaCl_2$ distilled water solution gave the highest DM at all stages of growth ($P \leq 0.05$). Significantly higher DM yields ($P \leq 0.05$) were produced at 25% FC pre sowing irrigation with no priming (6500.0 kg/ha) and 0.2% $NaCl_2$ for 12 hours (5900.0 kg/ha) by 90 DAS D during the wet season (SI). Dry matter ranged from 6440.0kg/ha at 50% FC- 0.2% $NaCl_2$ for 8 hours to 6713.0kg/ha at 75% FC- 0.1% $NaCl_2$ for 10 hours 6970.0 kg/ha at 0.2% $NaCl_2$ for 8 hours. During the drier season (SII), the highest DM yields of 5017.0 and 4285.0 kg/ha were realized from 100% FC pre-sowing irrigation and priming of 0.2% $NaCl_2$ for 12 hours and 0.2% $NaCl_2$ for 10 hours, respectively. Therefore, adequate soil moisture of over 75% FC is necessary if effectiveness of priming 0.1 to 0.2% $NaCl_2$ for 8 to 12 hours is to be realized under clay ASALs sandy loam soils of Mwea where droughts lead to prolonged seed emergence period, leading to deterioration of the seedbed and increased soil compaction, that eventually result in poor crop emergence, establishment and poor crop yields.

Introduction

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

Seed germination entails three distinct *phases: phase I* is imbibitions process, in which water is absorbed by the seed with limited 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, the soil environment in ASALs is often not conducive to rapid germination and seedling growth due to low or no soil moisture levels. Often, adverse abiotic and biotic stresses, such as low and high temperatures; soil crusting, shortage or excess of water, salinity, pathogenic diseases, and insects can reduce the rate or completely inhibit seed germination and seedling emergence.

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. Controlled imbibitions of seed followed by dehydration, also referred as "seed priming", have been shown to improve germination and early seedling growth under salt stress compared to plants grown from untreated seed (Bradford, 1986). During priming, the seed is generally exposed to an external water potential that is low enough to prevent germination but allows some pre-germinative physiological and biochemical processes to take place (Bradford, 1986).

Primed seed germinate more rapidly than unprimed seed when placed in an appropriate germination environment (Ashraf and Foolad, 2005). A rapid seed germination and uniform field emergence is essential to the establishment of successful crops. Slow or sporadic germination and emergence generally results in fewer and smaller 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 and increased soil compaction, which result in poor crop establishment. Seed priming is a common practice to increase the rate and uniformity of field crop germination and emergence in many important crop plants (Ashraf and Foolad, 2005).

Dry lands experience unreliable erratic rainfall that's never adequate for crop development to reach maturity. With adequate soil moisture, chickpea (*Cicer arietinum L.*) germination percentages are reported to be high leading to high crop yields (Kamithi *et al,* 2008). With low soil moisture regimes characteristic of arid and semi arid lands (ASALs), 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. There is need to explore various technologies that can ensure early and uniform crop germination to enhance optimum crop stand and establishment leading to optimal crop yields in the ASALs where prolonged emergence period may also lead to deterioration of the seedbed and increased soil compaction, which in turn result in poor crop emergence and establishment leading to poor crop yields.
The objective of this study was therefore to evaluate the performance of chickpea under different priming methods, varying priming durations and different initial soil moisture levels within the dry lands of Kenya.

Materials and Method

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

Experimental design

The study comprised three different primes (no priming, hydro priming & halo prime at 0.1, 0.2 and 0.3 % $NaCl_2$ concentration), at three priming durations (8, 10 and 12 hours**)**. There were 13 treatment combinations thrice**.** The pre-sowing irrigation on soils was at field capacity (FC) (100%), 75 %, 50 % and 25 %. The experimental design was a split plot design. Analysis of variance of data collected was done using GEN STAT Program package and means separated using the Turkey least significant difference (LSD) at $P \leq 0.05$.

Results And Discussion

Effect of pre-sowing irrigation at 25%, 50%, 75% and 100% field capacity on dry matter in both seasons

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); Anwar *et al*. (2003), and Parvender, (2006) 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. 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.

4.11.5 Effects of priming on dry matter at 25, 50, 75 and 90 DAS

Halo priming for 8 hours with 0.2% $NaCl_2$ distilled water solution gave the highest DM ($P \leq 0.05$) at all stages of growth (Table 1). This treatment also produced the highest dry matter of 5092.0 and 3074.0 kg/ha in seasons I and II, respectively at 90 days after sowing (DAS). These was found to be statistically similar with HCL2T12 (0.2 % $NaCl_2$ for 12 hours) which produced 4647.0 and 2880.0 kg/ha in season I and II, respectively. Harris *et al.*, (2001); Scotte *et al.*, (1973) and Henckel, (1964) showed that primed crops grew more vigorously, flowered earlier, had an increased leaf area index, accumulated more dry matter and ultimately gave higher grain yields. On-farm seed priming with water (hydro priming) in maize, rice and chickpea has been shown to result in faster emergence of seeds, improved establishment, crops grew more vigorously, flowered earlier and yielded higher (Harris *et al*., 1999).

There were significant ($P \leq 0.05$) interactions between FC and priming at all treatments. DM yields obtained at 90 DAS for the wet season I (SI) from 25% FC pre sowing irrigation with no priming of seed (6500.0 kg/ha) and 0.2% $NaCl_2$ for 12 hours (5900.0 kg/ha). Equal dry matter was obtained from 50% FC- 0.2% $NaCl_2$ for 8 hours -6440 kg/ha; 75% FC- 0.1% $NaCl_2$ for 10 hours- 6713.0 kg/ha and 0.2% $NaCl_2$ for 8 hours-6970 kg/ha (Table 2). During the dry season (SII), highest DM/ha of 5017.0 and 4285.0 kg/ha was realized from 100% FC pre-sowing irrigation combined with priming of -HCL2T12 0.2% $NaCl_2$ for 12 hours and 0.2% $NaCl_2$ for 10, respectively, (Table 3). The season II dry matter yield was lower probably due to lower and poorly distributed rainfall of 311.2 mm compared to the season I rainfall of 565.10 mm that was well distributed. Navkiran *et al.* (2013) noted that restricted soil moisture decreases dry matter (biomass) yields. Furthermore, Murungu *et al.* *(*2004) reported that in semi-arid lands, seed priming had little effect on growth, time to flowering and maturity or yield of the plants during the crop growth and development. It can be concluded that seed priming had less effect on growth parameters. Therefore, adequate soil moisture of over 75% FC is necessary if effectiveness of priming 0.1 to 0.2% $NaCl_2$ for 8 to 12 hours is to be realized under black cotton clay soils (Fig.3-7).

Table 1. Effect of Irrigation and Priming 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	
	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II
Main Plot: Irrigation												
$I_{25\%FC}$	11	5	75.2	36.6	197.1 b	85.5	511.0 c	329	3000.0 c	1709	3375.6	2652
$I_{50\%FC}$	11	5	75.8	37.5	230.4 a	128	512.0 c	336	3377.0 bc	1738	3835.2	2755
$I_{75\%FC}$	14	6	83.3	47.5	234.1 a	119.2	707.0 b	385	4097.0 a	2480	4610.1	3657
$I_{100\%FC}$	15	6	91.6	52.2	224.7 ab	137.9	982.0 a	447	4524.0 a	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
Sub-plot: Priming												
HyT_0	14a	6bc	99.6 bc	56.0a	228.3 ab	119.2 a	671.0 c	448.0 b	4153.0 b	2408.0 ab	4593.8 a	3323 a
HyT_8	14a	7ab	79.7 d	49.6a b	216.2 b	132.5 a	646.0 c	396.0 b	4035.0 bc	2621.0 a	4502.9 a	3807 a
HyT_{10}	14a	4de	56.7e	26.4c	192.5 bc	67.1b	655.0 c	218.0 d	3840.0 c	1675.0 c	4318.3 a	2708 b
HyT_{12}	13a	7ab	79.2 d	56.1a	202.5 b	144.6 a	565.0 d	381.0 bc	3920.0 c	2795.0 a	4337.7 a	3763 a
HCL_1T_8	14a	8a	63.4e	36.6 bc	143.8 d	108.3 b	526.0 d	329.0 c	3678.0 cd	2009.0 b	4241.8 a	3374 a
HCL_1T_{10}	13a	7ab	65.8 de	37.7 b	200.2 b	130.3 a	618.0 c	389.0 b	4122.0 b	2187.0 b	4563.7 a	3261 ab
HCL_1T_{12}	14a	7ab	104.8b	53.6a	208.3 b	109.6 ab	803.0 b	398.0 b	3695.0 c	1813.0 bc	4101.3 ab	2862 b

HCL_2T_8	14a	7ab	126.8a	60.2a	229.2a	141.7a	1073.0a	688.0a	5092.0a	3074.0a	5559.7a	4048a
HCL_2T_{10}	13a	5cd	71.3d	41.2b	233.3a	152.7a	815.0b	462.0b	3095.0d	1958.0b	3580.2b	2832b
HCL_2T_{12}	14a	6bc	100.2b	51.6a	164.2cd	116.2a	735.0bc	449.0b	4647.0ab	2880.0a	5186.4a	4131a
HCL_3T_8	14a	4de	80.7d	36.8b	273.3a	156.2a	542.0d	299.0cd	4378.0b	2348.0b	4833a	3406a
HCL_3T_{10}	13a	3e	73.3d	30.3c	205.4b	87.1b	548.0d	229.0d	3270.0d	1304.0c	3667.3b	2436b
HCL_3T_{12}	12b	3e	82.0cd	29.0c	219.6b	64.2b	617.0cd	179.0d	4195	1459.0c	4562.3a	2425b
LSD $P\leq0.05$	1.6	1.3	17.21*	18.61*	46.85*	46.82*	126.6*	119.2*	643.8*	703.6*	1867.6	1252.2
CV%	36.9	7	8	43.1	7.4	41.8	12.8	28	**9**	45.1	11.1	26.2

Table 2: Interaction effects of Irrigation and Priming on dry matter (DM) 90 Days after sowing (DAS) during season I

Irrigation	Priming												
	HyT_0	HyT_8	HyT_{10}	HyT_{12}	HCL_1T_8	HCL_1T_{10}	HCL_1T_{12}	HCL_2T_8	HCL_2T_{10}	HCL_2T_{12}	HCL_3T_8	HCL_3T_{10}	HCL_3T_{12}
$I_{25\%FC}$	6500a	3680c	5212b	3055c	3610c	2453d	5520b	4813b	3097d	5900a	1927d	1800df	4940b
$I_{50\%FC}$	2513d	2925d	1680f	3850c	2860d	3453c	3570c	6440a	2687d	2118d	5200b	3750c	2860d
$I_{75\%FC}$	3167cd	4500bc	2947d	5400b	3312c	6713a	1280f	6970a	1410f	4700b	5330b	3212c	4320c
$I_{100\%FC}$	4433c	5035b	5520b	3373c	4930b	3870c	4410c	2147d	5185b	5870ab	5053b	4320c	4660b
LSD	1370.9*		CV%	19.8									

Table3: Interaction effects of Irrigation and Priming on dry matter (DM) 90 Days after sowing (DAS) during season II

Irrigation	Priming												
	HyT_0	HyT_8	HyT_{10}	HyT_{12}	HCL_1T_8	HCL_1T_{10}	HCL_1T_{12}	HCL_2T_8	HCL_2T_{10}	HCL_2T_{12}	HCL_3T_8	HCL_3T_{10}	HCL_3T_{12}
$I_{25\%FC}$	3417a	2027a	1413a	2015a	1900a	1188b	2240a	1393a	1943a	2700a	595b	720b	665b
$I_{50\%FC}$	1213b	1950a	805b	3190a	1000b	2282a	1540a	3650a	883b	535b	2410a	1692a	1450a
$I_{75\%FC}$	1963a	3300a	1757a	3750a	2188a	1910a	862b	5872a	720b	3267a	3485a	1410a	1760a

$I_{100\%FC}$	3040a	3207a	2723a	2227a	2950a	3368a	2610a	1380ab	4285a	5017a	2900a	1393a	1960a
LSD	2228.8		CV%	39.6									

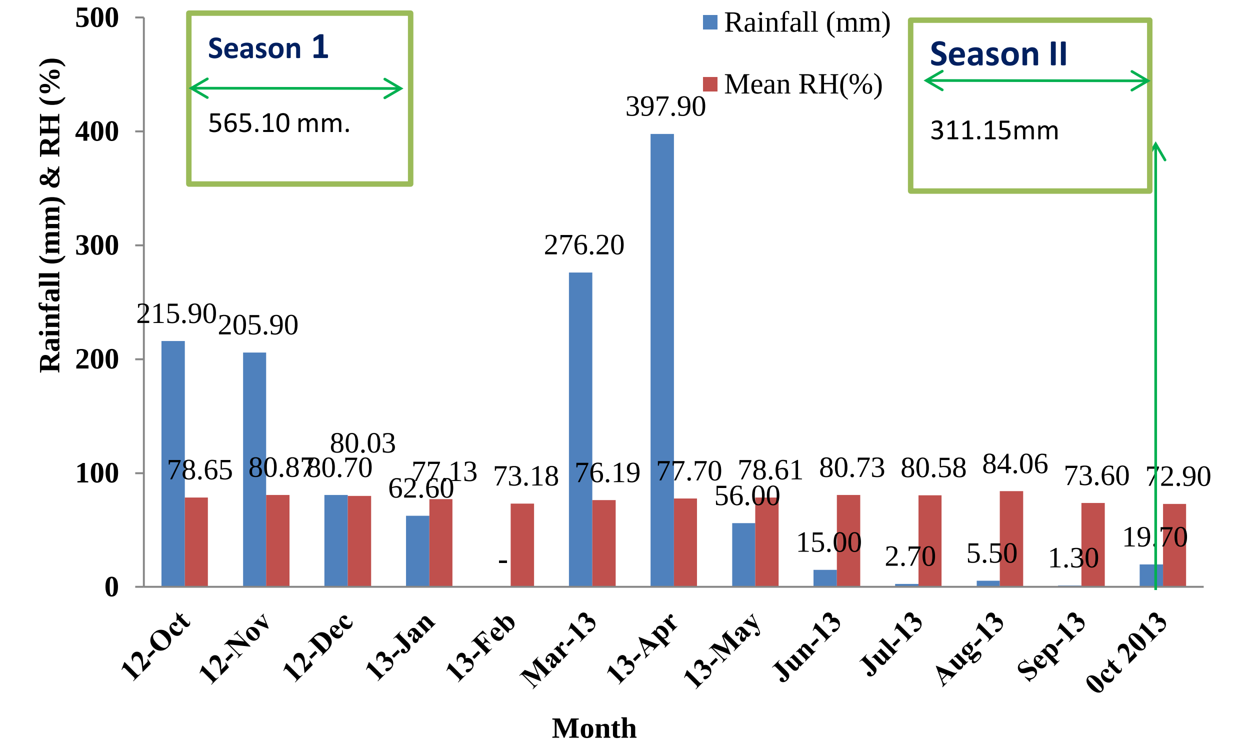

Fig. 1: Rainfall (mm) and Relative Humidity (%) during Season I and II

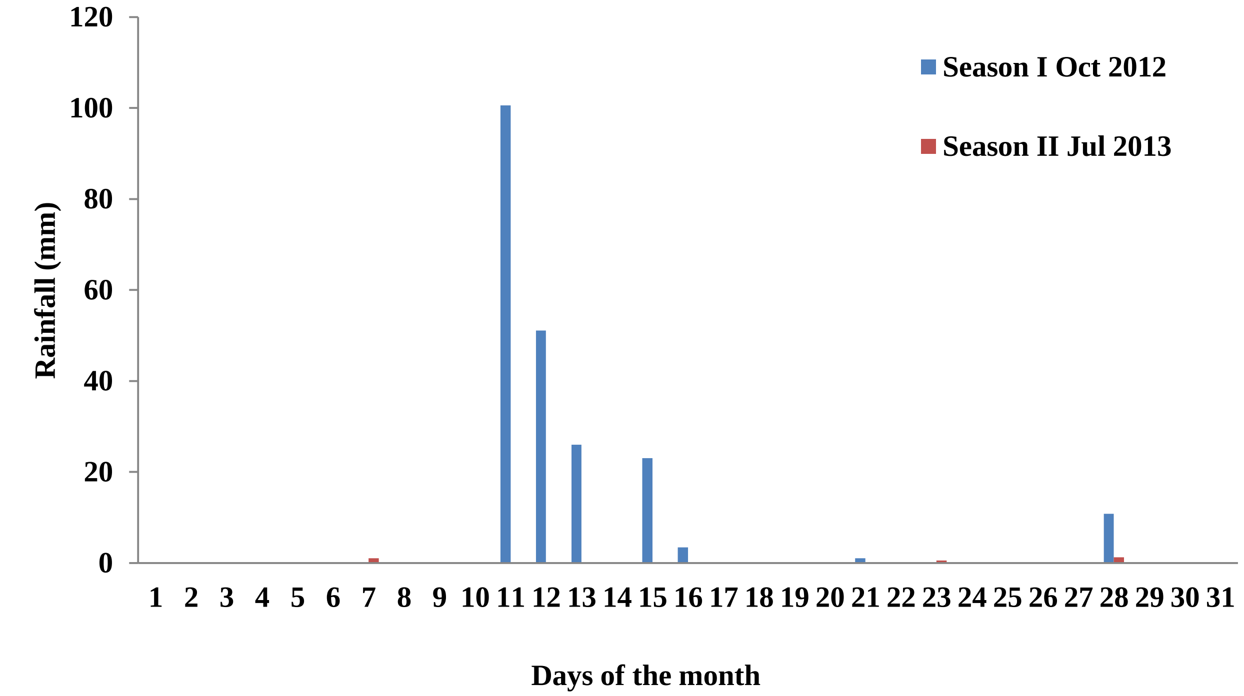

Fig. 2: Rainfall received at sowing of chickpea in Mwea for SI (Oct 2012) and SII (Jul 2013)

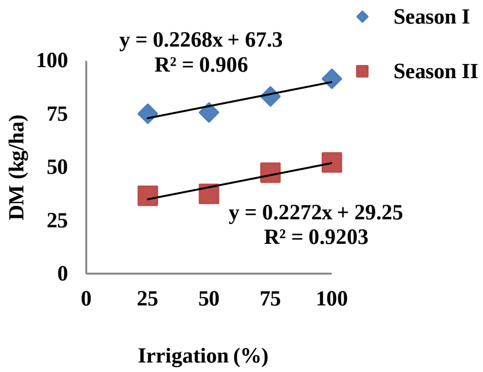

Fig 3: Relationship of pre sowing irrigation (%FC) to dry matter 25 DAS

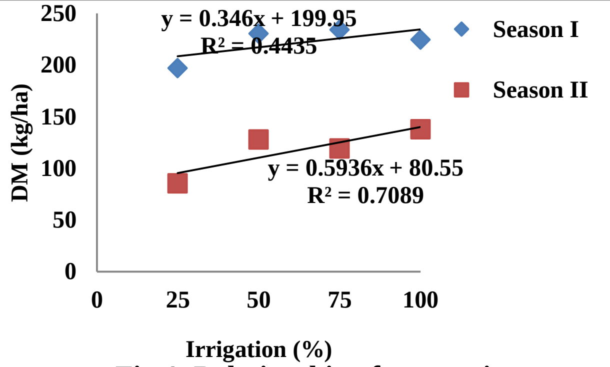

Fig 4: Relationship of pre sowing irrigation (% FC) to dry matter 50 DAS

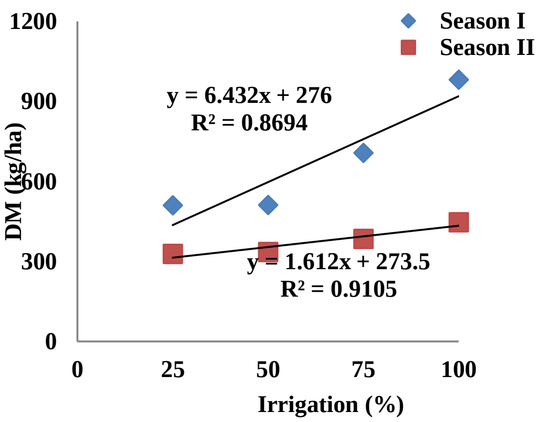

Fig 5: Relationship of pre sowing irrigation (%FC) to dry matter 75 DAS

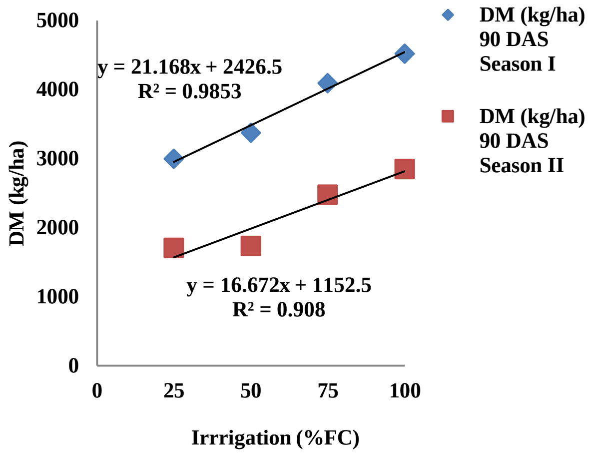

Fig 6: Relationship of pre sowing irrigation to dry matter 90 DAS

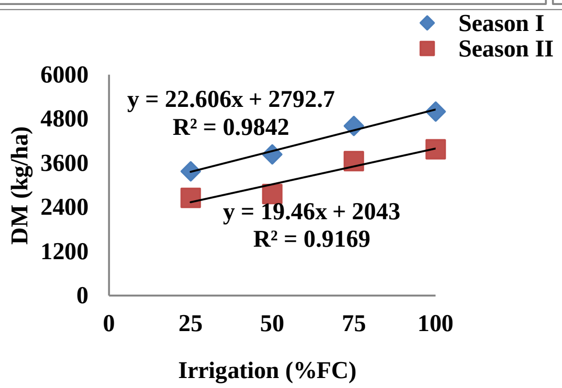

Fig 7: Relationship of pre sowing irrigation (% FC) to dry matter at 105 DAS

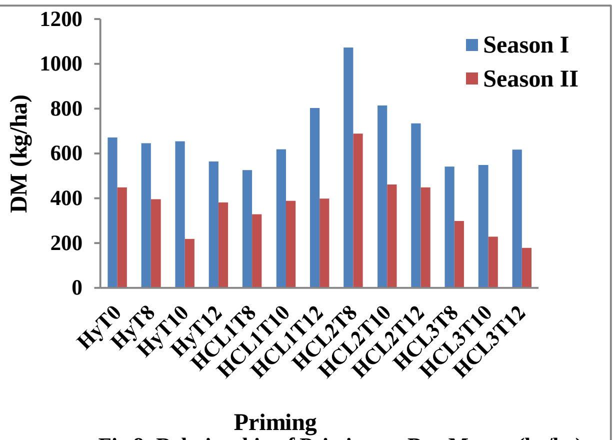

Fig 8: Relationship of Priming on Dry Matter (kg/ha) 75 DAS

Conclusion

It can be concluded that seed priming had less effect on growth parameters and yields in season II because of the low soil moisture occasioned by lower rainfall. Therefore, adequate soil moisture of over 75% FC is necessary if effectiveness of priming 0.1 to 0.2% $NaCl_2$ for 8 to 12 hours is to be realized under black cotton clay soils.

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