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Effect of tillage method and sowing time on phenology, yield and yield components of chickpea (*Cicer arietinum L.*) under semi-arid conditions in Kenya

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ABSTRACT
Objective: To determine the phenology, dry matter yield, grain yield and yield components of chickpea under four tillage methods and three sowing times within a semi-arid area of Kenya.
Methodology and results: Field experiments were carried out at the National Animal Husbandry Research Centre, Naivasha, Kenya, between 2005 and 2007. Four tillage methods (Conventional, Strip, Furrow tillage, and double digging) and three sowing times (at onset, one week, two weeks after onset of rains) were evaluated. The experiment was a Randomized Complete Block Design replicated thrice in a split plot treatment design with tillage methods as main plots and sowing times allocated to the subplots. Days to 50% flowering and physiological maturity was 61 and 120 respectively irrespective of tillage method or sowing time in both seasons. Shoot biomass varied from 3242.1 to 4231.3 kg ha^{-1} in Season 1 and 3035.8 to 4556.1 kg ha^{-1} in Season 2 under tillage treatments, but, no significant differences in season 1 among sowing times. In season 2, the crop sown 2 weeks after onset of rains had significantly lower biomass yield. Plants in strip tilled plots had 36% more pods than other tillage methods in season I but not in 2. Sowing time had no significant effect on number of pods in season 1 but in season 2; the crop sown 2 weeks after the onset of rains had fewer pods. Grain yield was not influenced by tillage method or sowing times in season 1, but in season 2, strip tillage and sowing at the onset of rains yielded significantly higher grain yield than the other respective treatments. Mean grain yield were 1604kg /ha and 1895.95 kg/ha for season 1 and 2 respectively.
Conclusion and application: Tillage methods and sowing times independently influenced growth, biomass development, yield components and grain yield in Kabuli chickpea, Var ICCV 95423 under semi-arid conditions in Kenya. The results were season -dependent. Sowing within two weeks after the onset of rains did not significantly lower biomass and grain yield. Strip tillage was superior to conventional tillage in the parameters measured. The time to 50% flowering and 50% maturity were not affected by tillage methods and sowing times. These results indicate that there is good potential for chickpea production (1.4 to 2.5 tonnes/ha) in this area which could be exploited to diversify grain legume production in Kenya.
Key words: Grain legumes, phenology, flowering, maturity

INTRODUCTION

Semi arid areas are characterized by low rainfall with high evaporative losses, making moisture availability the most limiting factor for crop production (Berliner et al., 2000; Harris et al., 2000). These areas receive between 250-800mm of rainfall annually. Plant biomass and grain yield production is directly influenced by plant water uptake and evapotranspiration (Schultz, 1986; Kibe and Singh, 2002). Inability to properly manage the limited precipitation is as much a problem as is the limited resource (Shedrake and Saxena, 1979).

Kenya's population growth rate at 4.9% implies increasing demand for food requiring an increase in crop production per unit area. However, only 17% of the 58.8 million hectares of Kenyan land is suitable for crop production. Further increase in food production will therefore either come from increase in yield per unit area or expansion of cultivated land in the arid and semiarid regions. There is need for appropriate tillage practices which reduce runoff and increase soil water storage for crop use (Cessman, 2001) as well as, sowing time adjustments and adapted crop cultivars to provide farmers with optimum crop yields.

Chickpea *(Cicer arietinum* L.*)* is a hardy crop grown with residual moisture and on marginal soils that are unsuitable for other crops such as wheat (Saxena, 1984). In the early stages of growth most of the roots are confined to the surface layer of soil from 0-30cm depths. As the surface soil dries out, root growth continues to deeper layers, where more moisture is available (Sheldrake and Saxena, 1979). It is the nineteenth most important crop on the basis of cultivated area globally and is grown in thirty-four countries of the world. India, Pakistan, Bangladesh, and Nepal grow 90% of the world hectare age. It is also an important crop in northern Africa and in parts of North and South America (ICRISAT, 1987).

Tillage is mechanical manipulation of the soil to provide the necessary conditions favourable to the growth of crops (Hedge, 1995). The suitability of a tillage method depends on factors such as soil physical characteristics, rainfall availability and distribution, availability of tillage equipments and cropping history of the land. For hard-setting soils, reduced tillage and stubble retention systems are more beneficial financially (ACA, 2004). Deep tillage or sub-soiling can be used to enhance axial root growth of chickpea by reducing soil strength (Allmaras et al., 1998). The effects of tillage practice may vary, depending on the stage of growth of chickpea (Birch et al., 1996).

Since chickpea depends on stored soil moisture, the crop may face short spells of drought during the growing season, if the moisture at sowing time is inadequate or if short rains fail (Saxena, 1976). Harris et al. (2000) reported that the strongest determinant of seed yield for chickpea and lentil under rain fed conditions is rainfall and its distribution. The productivity of chickpea can be predicted from the stored soil moisture at sowing time plus growing season rains, taking into account temperature and evaporative demand during the growing season (ICRISAT, 1987). A two-year study to examine the effect of sowing time and tillage practices on chickpea grain and dry matter yield showed that sowing time affects these parameters (Birch et al., 1996). This showed that early sowing is more favourable for chickpea. Results for chickpea grown under three levels of limited irrigation showed that the crop experiences terminal drought stress starting between flowering and beginning of seed growth. This terminal drought severely reduced grain yield by 67%, from 2766 kg ha^{-1} under full irrigation conditions to 909 kg ha^{-1} under rain fed conditions (Soltani et al., 2001). Work in Australia by Birch et al. (1996) showed that greater dry matter yield and seed yield of chickpeas (4.18 to 5.95 and 1.63 to 2.25t ha^{-1}) resulted from sowing in autumn or early winter than sowing in late winter (3.39 to 3.86 and 0.97 to 1.22 t ha^{-1}). Dalal et al. (1997) reported that late winter (May-June) sowing time was the best for chickpea yield and nitrogen fixation since it optimised solar energy use and water use and minimized frost damage at Warra, Australia.

Changing the time of sowing has been used to manipulate phenological development (Or and Abbo, 1999) in order to synchronize the period of reproductive growth with available soil moisture. Early sowing allows crops to mature before the complete depletion of conserved soil moisture. Bejiga et al. (1997) obtained seed yield increases in chickpea ranging from 9.5 to 48% and 17.4 to 45% at two sites in response to early sowing. They also found sowing date significantly influenced other phenological parameters such as date of 50% flowering and maturity. Dalal et al. (1998) reported that early to mid sowing of the crop accompanied by zero tillage practice could enhance beneficial effects of chickpea in rotation with cereals. Sowing time had a much large effect on seed yield and nitrogen fixation by chickpeas than tillage practices (conventional and zero tillage) although zero tillage generally increased grain yields (Dalal et al., 1997). They concluded that early sowing time and zero tillage practice, possibly combined with more appropriate cultivars, could enhance chickpea biomass. Birch et al. (1996) observed that significant interaction between sowing time and tillage resulted in greater grain yield obtained from zero tillage than conventional tillage methods.

Transitional rainfall areas in Kenya (Agro ecological zone IV) are characterized by scarce and erratic rainfall (Jaetzold and Schmidt, 1983), resulting in low soil moisture and poor crop growth and yield. Increasing human population pressure on agricultural land in Kenya has forced farmers to move into more marginal production areas. In the process, continual use of cereals and legume species adapted to high rainfall areas has led to frequent crop failures and food insecurity. In Kenya, Chickpea is a relatively new crop with a high grain yield potential (ICPN, 1994; Guto, 1997; Onyari, 2007; Danga, 2008). It matures early compared to the traditional pulses such as pigeon pea and cowpea while the common bean cannot survive in marginal areas. No studies have been conducted on the effect of tillage and sowing time on the growth and yield of chickpea in Kenya. The objective of this research was to study the influence of tillage method, sowing time and their interaction on the phenological development and biomass and grain yield of chickpea in a transitional rainfall area of the Rift Valley province in Kenya.

MATERIALS AND METHODS

The experimental site: Field experiments were carried out at Kenya Agricultural Research Institute, Naivasha (0^0 40’S and 36^0 26’E) in Rift Valley Province, Kenya, over two seasons starting December 29 2004 to May 2005 (Season I) and June to November 2005 (Season II). The area is located at 1900m a.s.l and receives an average of 620mm rainfall, biannually distributed and with 60% reliability. The long rains season starts in March through June while the short rains come in September to November. The rains are generally erratic. The day/ night temperatures range between 16-28^{o}C / 8-18^{o}C, respectively. The soils are clay loam of volcanic origin, alkaline (pH=7.4), sodic and deep (Jaetzold and Schmidt, 1983).

Experimental design and layout: The experiment was laid out as a split-plot in randomised complete block design with three replicates. The main plot treatments consisted of four tillage methods:(i) Conventional tillage (CT) - a single disc ploughing was followed by a single harrowing; (ii) Strip tillage (ST) - a 20 cm strip of land opened manually after a glyphosate herbicide application; (iii) Double digging (DT) - involved a primary and secondary manual hoeing along the rows where sowing was done, and (iv) Furrow tillage (FT) involved making furrows across the treatment plot(s) using hand ridgers after primary and secondary hoeing. The subplot treatments consisted of sowing times (S1, S2, and S3) with the first sowing (S1) beginning at the onset of rains. An interval of seven days separated the sowing dates. The main plot and subplot treatments were randomly allocated to main plots and subplots, respectively. Each sub plot measured 4 x 3 m^2 and sub-plots were separated by a 1m wide path. A 2 m footpath was left between the subplots and 5m spacing between blocks to enable turning of the tractor (head turn). Each subplot had eight rows of kabuli chickpea variety ICCV95423 with fifteen plants each at a spacing of 50 x 20 cm giving a population of 200,000 plants ha^{-1}.

Crop establishment and management: Seedbed preparation was carried out before the onset of the rains for Season I, and immediately after harvesting the first season crop, in readiness for planting season 2 crops. Seed bed preparation was done according to individual treatments. At sowing time a compound fertilizer (17:17:17NPK) was applied at the rate of 150 kg fertilizer ha^{-1}. Two seeds of chickpea were sown per hole at a spacing of 50 cm x 20 cm in the furrow. They were later thinned to one plant per hill a week after emergence. Manual weeding was first done four weeks after emergence in Season I and again before flowering. In the second season the weeding was done only once at 77 DAS. A mixture of 40 cm^3 Dimethoate and 120g of fungicide (Ridomil) were dissolved in 20 litre of water in a knapsack sprayer giving a rate of 2 litres per hectare and sprayed 7d after emergence to control pests and diseases.

Data recording: Data was collected on three randomly selected plants in each plot, tagged and observed throughout the growing period to monitor and/ or measure various parameters. These included plant height, leaf area index, date of 50% flowering, date of 50 % physiological maturity, biomass, no. of pods/plants and grain yield. Parameters were assessed as below:

Plant height: The mean height of the three plants per plot was taken at 35, 63, 91 and 119 DAS. These dates were chosen since they approximated the times of first flower, 50% flowering, maximum LAI and time to physiological maturity.

Leaf Area Index: Leaf area index (LAI) was measured using a leaf area meter (Model LI-3000) by measuring the leaf area of at least three leaves of each of the representative plants at each time of measurement and calculating the mean area. Due to the small size of the chickpea leaves it was found necessary to trace the leaves on paper and calculate the area, then compare with the area recorded by the instrument. A conversion factor was thus more convenient than direct measurement as the crop grew in height and canopy cover (Eq. 1).

Leaf area conversion factor (F_c) = Area of traced leaf/Area of leaf by meter ………… (1)

The numbers of leaves per primary and secondary branch (L_p and L_s) as well as their corresponding number of branches (Bp and Bs) were used to determine the LAI thus:

$LAI = F_c\ A_L\ (B_p.\ L_p + B_s\ L_s)/(0.50 \times 0.20)$. ………………………………………… (2)

Where F_c= area conversion factor; A_L=mean leaf area; B_p and B_s are the mean numbers of primary and secondary branches; L_p and L_s were the mean number of primary and secondary leaves at time of measurement. The 0.50 x 0.20 m^2 defined the area of a representative plant on the ground.

Flowering: Observation for flowering was started at 28 DAS and the number of flowered plants recorded every week thereafter until more than half of the sub-plot plants had flowered. Graphs of percent flowered plants against time (DAS) were plotted to determine time for each sub-plot to attain 50% flowering.

Biomass and grain yield: Data on biomass was taken at 35 DAS, 63 DAS and at harvest. The first two intervals coincided with the approximate time of 50% flowering, respectively. Three plants were randomly selected and uprooted and oven- dried at 60^{0}C to constant dry weight. Dried pods were harvested, threshed and the grain weighed.

Analysis of data: Data collected was subjected to analysis of variance (ANOVA) using PROC GLM of SAS (SAS, 2001). The treatment means were separated using Fisher's protected LSD while the Duncan's multiple range test (DMRT) was used where interactions were observed.

RESULTS

Leaf area index: Irrespective of tillage method, the leaf area index (LAI) of the Kabuli chickpea increased with maturity up to 91 DAS in both seasons after which it declined by 119 DAS. At 91DAS LAI ranged from 2.50-3.31 and 4.2-5.4 in Season I and Season II, respectively. Significantly higher LAI was obtained under ST compared to CT at 91DAS in both season I and II. The strip tillage treatment also maintained significantly higher LAI compared to the other tillage treatments at 119 DAS Table 1). Seasonal comparison showed that under all tillage treatments the LAI was comparatively greater for season II than for the Season I chickpea crop by 91 DAS.

Sowing one week after the onset of rainfall consistently gave lower LAI values compared to sowing at the onset or two weeks after the onset of rains up to 91 DAS during season I. During season I, there were no significant differences (P>0.05) in LAI among sowing times.

Shoot dry matter yield: There was no interaction effect between tillage and sowing time on biomass production throughout the period of chickpea growth in both seasons. The above ground biomass ranged from 3,242.1 - 4,231.3 kg DM/ha at harvest in Season I and 3,035.8 - 4,556.1 kg DM/ha at harvest (133 DAS) in Season II. Chickpea grown under strip tillage (ST) accumulated significantly higher biomass (P<0.05) throughout the growing period compared to conventional tillage, although differences between strip tillage and furrow or double digging were negligible. In Season II, significant differences (P<0.05) in biomass accumulation were obtained only after 77 DAS (pod formation). During the period of reproductive development, chickpeas grown under strip tillage (ST) method resulted in the highest plant biomass production compared to the other tillage methods(Table 1).

Table 1: Effects of tillage method and sowing time on height, Leaf area index and shoot biomass of Chickpea grown at Naivasha, Kenya during two seasons

	Plant height cm (119 DAS)		Leaf area index m^2m^{-2} (119 DAS)		Shoot biomass kg (133 DAS)	
	Season I	**Season II**	**Season I**	**Season II**	**Season I**	**Season II**
Treatment						
Conventional tillage	39.7c	42.8a	1.68b	1.02a	3242.1b	3208.9b
Double digging	43.0b	44.4a	1.97ab	1.04a	3994.9ab	3073.0b
Furrow tillage	43.8b	43.9a	1.90ab	1.03a	4229.0ab	3035.8b
Strip tillage	45.1a	47,7a	2.13a	1.20a	4231.3a	4556.1a
LSD	0.96	6.93	0.325	0.399	715.10	1304.10
Sowing at Onset of rains	42.8b	46.4a	1.90ab	1.34a	3893.0a	4263.2a
Sowing 2 weeks after onset of rains	43.8a	46.1a	2.12a	0.98b	4095.8a	2938.1b
LSD	0.83	6.00	0.281	0.435	619.30	1129.1
CV	0.93	15.51	16.93	37.26	18.23	37.62
Overall mean	42.9	44.7	1.92	1.07	3924.3	3468.4

Means in the same cluster in the same column, either tillage method or sowing date followed by the same letter (s) are not significantly different from each other at 0.05 level of probability; DAS = Days after sowing

Table 2: Effect of tillage method and sowing time of chickpea on numbers of pods per plant, 100-Grain weight and grain yield at Naivasha, Kenya in two seasons.

	No. of pods plant $^{-1}$		100-Grain weight (g)		Grain yield (kg ha $^{-1}$ (133 DAS)		Grain yield (kg ha $^{-1}$ (161 DAS)
	Season I	**Season II**	**Season I**	**Season II**	**Season I**	**Season II**	**Season I**
Treatment							
Conventional tillage	61.2b	131.1a	39.8a	36.7a	1430.6a	1489.0b	1805.4b
Double digging	69.7b	152.9a	39.4a	38.2a	1628.1a	1849.9b	2071.2ab
Furrow tillage	70.4b	150.7a	40.4a	38.6a	1559.6a	1700.0b	2022.2ab
Strip tillage	104.9a	168.3a	37.7b	39.2a	1798.2a	2544.9a	2334.7a
LSD	17.51	40.80	1.32	2.88	364.8	462.9	496.9
Sowing at Onset of rains	72,8a	180.0a	40.2a	37.8a	1607.6a	2235.3a	2033.2a
Sowing 1 Week after onset of rains	77.6a	168.0a	39.0ab	37.5a	1573.8a	1902.9ab	1939.9a
Sowing 2 weeks after onset of rains	79.3a	104.1b	38.7b	39.2a	1631.0a	1549.8b	2202.1a
LSD	35.33	35.33	1.14	1.93	300.4	400.9	421.68
CV	22.89	27.08	3.37	4.94	21.64	24.4	23.67
Overall mean	76.6	150.7	39.1	38.2	1604.1	1896.0	2058.4

Means in the same cluster in the same column, either tillage method or sowing date followed by the same letter (s) are not significantly different from each other at 0.05 level of probability; DAS = Days after sowing

The total aboveground biomass produced as a result of different sowing times of chickpeas ranged from 3,784.3 - 4,095.8 and 2,938.1 - 4,263.2 kg DM/ha at harvest (133 DAS) in Season I and II, respectively. Effects of sowing dates on the plant biomass production were not significant (P<0.05) in Season I, but resulted in significant differences in Season II. In Season II, sowing two weeks after the onset of rains resulted in the lowest dry biomass production throughout the period of growth. Biomass production by chickpea at harvest time showed that late sown chickpea (S2 and S3) produced more aboveground biomass in Season I than in Season II. (Table 1).

Time to 50% flowering: Similarly, tillage method and time of sowing did not significantly change the time required by the chickpea to attain 50% flowering in both seasons. The corresponding overall mean times for Season I and Season II were 61.8 and 61.4 DAS, respectively under different tillage treatments. The mean number of days to 50% flowering in both seasons ranged 57.5-64.8 and 56.9 - 64.8 DAS for sowing treatments in Seasons I and II, respectively.

Physiological maturity: The time to physiological maturity ranged from 119.0 - 122.1 DAS and 119.8 - 121.3 DAS in Season I and Season II, respectively. In Season I, there was an extension of maturity period due to a tendency to indeterminacy in the presence of rainfall. Consequently, physiological maturity for the second growth phase was attained between 146.2 to 147.0 DAS. The growth patterns of the two seasons were different because Season I received rains towards its end (early onset of rains for Season II) that extended the vegetative and reproductive growth of the crop (Fig. 1). Tillage method had no significant effect on the time required for the Kabuli chickpea to reach physiological maturity in both seasons. In season I, the periods ranged from 119.6 - 120.8 and 142.9 – 147.6 DAS for the main crop and the extended crop growth due to late rain- induced indeterminate growth. In Season II, an interaction effect between tillage method and sowing time on physiological maturity was noted and were significantly different for the main crop by 119 DAS. Other than for the interaction effects associated with the CT method, all the other combinations caused an early physiological maturity with late planting of chickpeas in Season II (Table 3). The time ranged from 114.3 (ST x S3) to 126.0 (DT x S1 and FT x S1) DAS, implying that late sown chickpea accelerates it's time to physiological maturity compared to an earlier sown crop. It was observed that FT x S1 and DT x S1 resulted in the longest time (126.0 DAS) for the chickpea to attain physiological maturity (50% dry pods) in Season II compared to FT x S3, ST x S2 and ST x S2.

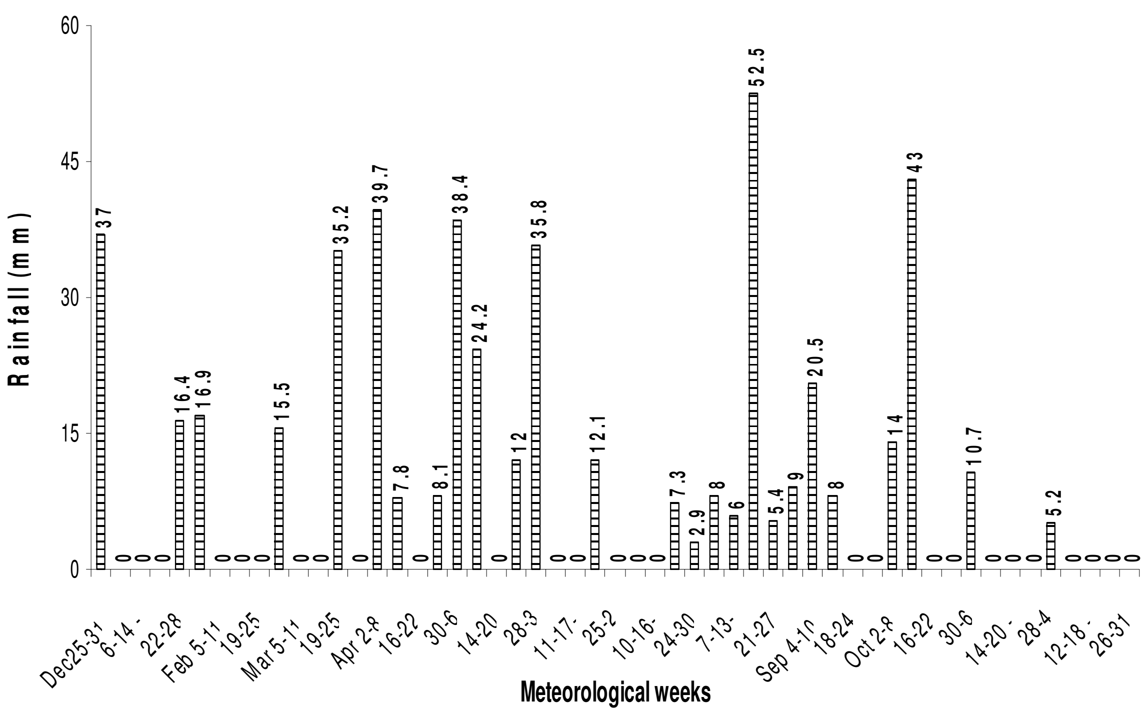

Figure 1: rainfall data over time during the growth of chickpea at Naivasha Kenya (Dec 2005 2004 – Nov 15 2005).

Table 3: Interactive effects of tillage method and sowing time on time to physiological maturity of kabuli chickpea (Season II).

Tillage method	Sowing time		
	Onset of rains	1 week after onset	2 weeks after onset
Conventional tillage	119.0b	121.3ab	121.3ab
Double digging	126.0a	123.7a	123.7a
Furrow tillage	126.0a	119.0ab	116.7bc
Strip tillage	119.0b	116.7b	114.3c
DMRT	5.12	5.12	5.12
Coefficient of variation (CV)	2.16	2.16	2.16
Mean (Overall)	122.9	120.2	119.0

Means within a column followed by the same letter(s) are not significantly different at 0.05 level of probability according to Duncan's Multiple Range Test

DISCUSSION

Strip tillage is a modified form of minimum tillage that helps conserve soil moisture that is then availed for crop consumptive use. Crop roots such as chickpeas absorb this available moisture for growth and development, giving the crop under this treatment better performance in terms of number of pods, biomass and grain yield. The retained soil cover around the stripped section reduces evaporative loss, thereby retaining the soil moisture for longer crop use. Rainfall was less in Season II compared to Season I, resulting in the crop depending mainly on the stored soil moisture. The late sown crop thus had less soil moisture to utilize compared to the early sown one, resulting in significantly low biomass yield for the crop sown two weeks after the onset of rains. The 43 mm rain received in the second half of October (Fig. 1) came rather late as the crop had already matured and hence did not induce the indeterminate growth behavior experienced in Season I. This behavior resulted in extra biomass and grain yield in Season I (26.2 to 29.8% and 26.5 to 35.0% under tillage and sowing treatments respectively). This means that the growth pattern of the chickpea can be manipulated by additional moisture, e.g. through irrigation, to prolong its grain and biomass production if so desired. Similarly, it would be desirable to plant the crop late at this location to reap such benefits without incurring an extra cost.

Dry matter (DM) accumulation of chickpea increased under all tillage treatments to a maximum range of 3,242 to 4,231 kg DM ha^{-1} in Season I and from 3,035 to 4,556 kg DM ha^{-1} in Season II. In India Saxena (1984) reported a DM production range of 2,950 to 6,800 kg DM ha^{-1} while 4300 to 4,800 kg DM ha^{-1} was reported by Kumar et al. (2001). These differences in dry matter production reflect differences in genotypes and diversities in production environments. Dry matter accumulation at all stages of growth, however, revealed no significant differences between the three sowing date treatments in Season I. Leaf area index (LAI) increased to a maximum range of 2.50 to 3.31 in Season I and from 4.22 to 5.44 in Season II by 91 DAS. Beyond 91DAS, LAI declined to between 1.68 to 2.13 in Season I and 1.02 to 1.20 in Season II by 119 DAS in both seasons. This was attributed to leaf fall and concurred with earlier findings of Kumar et al. (2000) who noted that LAI, plant height and functional canopy initially increased with time of growth then decreased due to leaf senescence. Measurement of LAI has been reported to be critical to understanding many aspects of crop growth, development, water use and management (Wilhelm et al., 2000). Kumar et al. (2000) observed that availability of higher amounts of moisture during various stages of crop growth resulted in better crop growth (plant height and LAI), higher amounts of DM production and its translation to branches and thus grain yield. On the other hand Harman et al. (1990) noted that later planting dates result in shorter plants, less yield and late maturity of late formed flowers and pods. In the current study during Season II, The crop sown two weeks after the onset of rains had relatively shorter plants by 63 DAS but was not significantly different from the crops sown at the first and second sowing dates by 91 and 119 DAS. With regard to LAI and DM production, S1 had higher values than S3. This could be explained by the fact that there was more rainfall (58.5 mm) over the initial growing period of Season II (Fig 1). Therefore, the later sown (1 and 2-week late) crop received less amounts of water resulting in lower LAI, DM production and final grain yield.

Chickpea is known to be a cool season crop (Nielson et al., 1999) and therefore, the lower temperatures (max.

21^{0}C and min. 10^0 that prevailed in Season II (June 26 to November 8, 2005) during the branching period of the crop would have contributed to the relatively better grain yield (1.9 – 2.5 ton ha^{-1}) compared to between 1.5 – 1.7 ton ha^{-1} in season 1. This implies that the weather conditions during Season II occurring over the critical chickpea growth stage (branching and 50% flowering – 61 DAS) was more conducive for enhancing yield. Further studies to investigate and quantify rates of yield increments as affected by temperature, water availability and their interactions at various stages of chickpea growth is recommended.

Flowering is a major adaptive trait to survival and cultivation (Marx, 1985). It is estimated that major biotic and abiotic stresses reduce at least 50% realizable potential yield of chickpea in the major production areas of the world (Ryan, 1997). Much of these losses occur at flowering and pod formation time when mean temperatures are high and the days are long but can be avoided if chickpea is harvested early (Kumar et al., 1996). The crop's natural drought resistance makes it eminently suitable for semi-arid environments (Kumar and Abbo, 2001).The mean time to attain 50% flowering in this study was 61 DAS in both seasons irrespective of tillage and sowing treatments. It ranged from 60.1 to 64.1 DAS in Season I and 59.6 to 63.6 DAS in Season II under the various tillage treatments. The mean time to 50% flowering range was from 57.5 to 64.8 DAS in Season I and 56.9 to 64.8 DAS in Season II under varying sowing dates. Work by ICRISAT (1985) on 25 genotypes showed that the time to 50% flowering is influenced by geographical locations. Kumar et al., (1996) concluded that genes controlling flowering time are sensitive to temperature and day length. The number of days taken from sowing to onset of flowering (flowering time) is a major component of crop adaptation, particularly in rain fed environments (Subbarao et al., 1995). The timing of flowering is dependent upon the genotype, the seasonal temperature profile, photoperiod and vernalization responses of the plants: temperatures above 30^{0}C have, however, been reported to inhibit flowering by Kumar and Abbo (2001). The consistency in time to physiological maturity and 50% flowering of the chickpea implied that these traits are genetically controlled and independent of planting time in the tropical semi-arid climate such as of Naivasha, Kenya. The phenology of the crop in terms of the yield parameters was however influenced by the environmental conditions such as soil moisture availability, rainfall amount and distribution.It can be concluded from this study that Kabuli chickpea ICCV95423 is well adapted to Naivasha environment, particularly during June to November and the flowering period and duration is not significantly affected by tillage and sowing dates within a season.

The time to physiological maturity (where over 50% pods were yellow) for Kabuli chickpea in Naivasha was approximately 120 DAS. However, with continued rains in Season I, production of branches, flowers and pods by chickpea continued up to after 145 DAS producing extra grain yields by 23.3 to 35.0% (data not shown) above that produced by 133 DAS. The time to physiological maturity is reported to range from 79 to 155 DAS by Kumar et al. (1996) depending on the location and genotype. The current study on Kabuli chickpea (ICCV 95423) was within this range. On the Indian subcontinent the growing season is limited to a range of 90 to 130 DAS due to higher temperatures and reduced soil moisture (Saxena et al., 1993). Early planting when the soil moisture profile is fully charged is advantageous but prevailing high temperatures in the tropics could adversely affect the final seed yield (Kumar and Abbo, 2001). These researchers recommend early maturity cultivars to help reduce the impact of high temperature and water stress at flowering and podding. Early sowing therefore enables the crop to have more moisture for early growth, produce more biomass and grain yield (Kumar and Abbo, 2001). This was confirmed in the current study where earlier sowing resulted in higher biomass and grain yield, particularly in the June to November 2005 (Season II) sowings. The relatively high temperatures in Season I stressed the crop in early stages of growth.

CONCLUSION

Potential grain yields of 1.4 to 2.5 ton/ha can be obtained from growing Kabuli chickpea ICCV 95243, depending on tillage and sowing time in Naivasha. It is recommended that sowing dates in Season I period be delayed possibly to February/March with onset of rains; while in Season II sowing date should be in late to early June. The February/March sowing time / season is likely to have indeterminate growth when pod filling and flowering coincides with rainfall in the month of May.

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