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GROWTH ANALYSIS OF WHEAT *(TriticumaestivumL.)* AS INFLUENCED BY WATER STRESS AND VARIETY IN SOKOTO, SUDAN SAVANNAH, NIGERIA.

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ABSTRACT

The study was carried out to determine the effect of water stress and variety on growth of wheat (TriticumaestivumL.), during2009/10and 2010/11dry seasons. The treatments consisted of factorial combination of water stress at three critical growth stage which was imposed by withholding water at tillering, flowering, grain filling and control (no control) and two varieties (Star 11 TR 77173/SLM and Kauze/Weaver) laid out in a split plot design with three replications. Water stress was assigned to the main-plot, while variety was assigned to the sub-plots. Result revealed significant (P<0.05) effect of water stress, attilleringreduced plant height, LAI, CGR, and NAR. Variety had significant (P<0.05) effect on plant height, LAI, CGR and NAR. Water stress at tillering was observed to be most critical growth stage in wheat, and water stress at this period should be avoided because it results to decrease in growth components in wheat. Wheat should be sown in November or at least first week of December in this area and other area with similar climatic conditions. Star II TR 77173/ LM is recommended variety for the area.

Key words: Wheat, growth, Water stress, Variety, Sudan savannah

INTRODUCTION

Wheat (*TriticumaestivumL.*) is one of the important cereal staple food crops of the world (Akbar*et al.*, 2001). Wheat ranks first in area and production and contributes more calories and proteins to the world's human diet than any other cereal(Bilgi, 2006).Water constitutes over 90% of plants total mass and has important function inphotosynthesis, transpiration and turgor pressure.Water stress in plants results in reduced growth, vigor, nutrient deficiencies, it also affect health of roots, cooling of canopy and early fall color (Colorado Master Gardener (CMG, 2010).Liheng*et al.*(2009), reported drought can inhibit plant growth and development, Drought stress limits crop production worldwide and causes important agricultural losses particularly in arid and semi-arid areas (Boyer, 1982).Water availability mostly affects growth of leaves and roots, photosynthesis and dry mater accumulation (Blum, 1996). In Sorghum Fagbemi (1996) reported that end of tillering is the most critical stage affected by water stress in Sorghum, the author further observed that changes that occur at different stages of Sorghum determine the quality and quantity of final yield.Siddiqe*et al*. (2000)Reported that developing of drought tolerant varieties is the best option for crop production.

Wheat production has been shown to be limited by a number of factors such as moisture stress (Wajid*,* 2004) and variety (Sellaries, 1975).Muhammad and Eltayeb (1991) observed that higher productivity of wheat in United State was due to favorable environmental conditions which include temperature and moisture. **The objective of the research was to**determine the effect of water stress on growth of twowheat varieties.

MATERIALS AND METHODS

Location

The researchwas conducted during 2009/10 and 2010/11 dry seasons at the *Fadama* Teaching and Research Farm, UsmanuDanfodiyo University, Sokoto, (Latitude 13^0 01'N. longitude 15^0 13E). The farm is located within the Sudan Savanna Zone of Nigeria (Kowal and Knabe, 1972). The relative humidity is between 14-28% and 70-75% during dry and rainy seasons, respectively. The area has a long dry season that is characterized by cool dry air during harmattan from November to February and hot dry air during hot season from March to May. Relative humidity ranges from 26-39 % in the dry season. Maximumtemperature ranges from 30 to 40 ^{0}C and Minimum temperature of 18 to 29 ^{0}C, wind speed ranges between 1.9 to 5M/S [(Sokoto Energy Resource Center) (SERC, 2011).The area was previously used for the cultivation of onions, peppers, tomatoes, corn and sweet potato.

Prior to planting, soil samples werecollectedsoil samples (0 - 15cm) were collected from the site for physic-chemical analysis (Ogunwale*et al.,* 2006). The treatments consisted of factorial combinations of water stress which was imposed by withholding water at (tillering, flowering, grain filling) and control (no control) and two varieties (Star 11 TR 77173/SLM and Kauz/Weaver). The experiment was laid out in a split plot design with three replications. Water stress was allocated the main plot, while variety was assigned to the sub plots.

The land was cleared, ploughed, harrowed, leveled, Gross plot size was 3m x 3m ($9m^2$) while the net plot was ($4.5m^2$). The seeds were sown with Apron star 42 WS (20% w/w thiamethoxam, 20% w/w metalaxyl-M and 2 % w/w difenoconazole) at the rate of 10 g/ 4 kg of seed before sowing.

The seeds were sown **by drilling at 20 cm intra row spacing at 2-3 cm depth and at the rate of 120 kg/ha.**After sowing, the field was irrigated four times for proper establishment of the seedlings. The first was given immediately after sowing, while subsequent irrigation was given at 5 days interval (Lado, 2004). Weeds were controlled by hand weeding at 3 and 6 WAS to ensure weed free plots. Fertilizer was broadcast at the recommended rate of 120, 60 and 60 kg N, P_2O_5 and K_2O per ha^{-1} respectively. Half of nitrogen and full dose of phosphorous and potassium was worked in to the soil during seedbed preparation using NPK 15: 15: 15: while, the second dose of 60 kg N ha^{-1} was applied prior to tillering using Urea (46% N) as source of nitrogen. Birds were controlled by scaring while rodents were controlled by using baits and traps. No Diseases out break was recorded.

Data was collected in respect of plant height, leaf area index (Arunah and Ibrahim 2004), net assimilation rate and crop growth rate.

Plant height

A random sample of 10 plants was and tagged from the 30cm tagged area and average recorded. The length of each of the sampled plant was measured form the ground level to the top of the panicle, using a meter rule.

Leaf area index (LAI)

Leaf area index (LAI) is the ratio of total leaf area to land area. The mean leaf area of ten tagged plants was measured by multiplying the mean leaf size (L*W) by a reduction coefficient of 0.87 for wheat (Owen, 1968 and Ledent, 1976). The LAI was determined by dividing the mean leaf area by land area occupied by the plants. LAI measurement was taken at 3, 6, 9 and 12 WAS.

$$LAI \quad \frac{Leaf \ area}{Land \ area}$$

Crop growth rate (CGR)

This is the measure of the rate of dry matter production per unit time per unit area. Samples were taken in the gross plots to determine the CGR. The sampled plant material was oven- dried at 70°C to a constant weight. CGR was calculated using the following formula as adopted by Watson (1952).

$$\text{CGR} = \frac{W_2 \quad W_1}{SA(T_2 \quad T_1)} \quad \text{g m}^{-2}\ \text{Week}^{-1}$$

W_1= weight at first sampling, W_2= weight at second sampling, $T_{1=}$ time of first sampling in weeks $T_{2=}$ time of second sampling in weeks, SA = soil area occupied by the plants at each sampling

Net assimilation rate (NAR)

Net Assimilation Rate was estimated as reported by Hunt (1978). It measure assimilation efficiency of leaves and calculated using the following formula.

$$\text{NAR} = \frac{1}{A} * \frac{w}{t} \quad \text{g m}^{-2}\ \text{Week}^{-1}$$

A is the leaf area and δw/ δt is the change in plant dry weight per unit time.

The data collected was subjected to analysis of variance (ANOVA)**(Arunah and Ibrahim 2004,** Bibinu*et al*.,2008 and 2009) using SAS (2003). Means were separated using Duncan's Multiple Range Test at 5% level of probability (Imoloame, 2014).

RESULTS AND DISCUSSION

Plant Height

The effects of water stress and variety on plant height at 3, 6, 9 and 12 weeks after sowing (WAS) in 2009/10, 2010/11 dry seasons and the two seasons combined are presented in Figures 1 and 2. The result indicated that the effect of water stress at 3 WAS was not significant ($p<0.05$) in both seasons and combined (Figure 1). Water stress at tillering resulted in shorter plants than water stress at flowering, grain filling or the no stress control at 6, 9 and 12 WAS in 2009/10,. The same trend was obtained in 2010/11 dry season and the two seasons combined. The reduction in plant height could be as a result of water stress imposed at tillering stage. This is because imposing water stress at tillering**resulted in l**ow leaf water potentials and reductions in photosynthesis (Reddi and Reddy, 1995). At the time when water stress was imposed at flowering and grain filling, the jointing stage has taken place and plants have reached their maximum height thus the effect of water stress was ineffective. **The finding is synonymous to that of** Abayomi and Wright (1999) **who reported that** dwarfness in wheat has been identified as a symptom of water stress.

The result on the varietal differences at 3 WAS in 2009/10, 2010/11 dry seasons and the two seasons combined and at 6 WAS in both seasons the two varieties did not differ in height. In the two seasons combined at 6, 9 and 12 WAS, Star II TR 77173/SLM was taller than Kauz/Weaver (Figure 2). The significant differences among genotypes for plant height (Figure2) indicate appreciable amount of variability among the genotypes, this is similar to the finding of Lad *et al.* (2002) who reported significant effect of variety on wheat growth. Bibinu*et al*.(2008 and 2009) reported significant variation among Sorghum genotype.

Leaf Area Index (LAI)

The effects of water stress and variety on LAI at 3, 6, 9 and 12 WAS in 2009/10, 2010/11 dry seasons and two seasons combinedis presented in Figures 3 and 4. The result indicated that the effect of water stress at 3 WAS was not significant in both seasons and combined (Figure 3). At 6 WAS in both seasons and 9 and 12 WAS in 2009/10 dry season, water stress imposed at tillering resulted in lower LAI than water stress imposed at flowering, grain filling or the no stress control which had statistically ($p<0.05$) similar LAI. At 9 and 12 WAS in 2010/11 dry season and the combined water stress had no effect on LAI but control differed significantly ($p<0.05$) with higher CGR. Leaf Area Index increased progressively until 9 WAS and thereafter decreased at 12 WAS in wheat cultivars. Abubakar (1999)had earlier observed similar decrease of LAI among wheat cultivars after anthesisthis is an indication cessation of growth. On varietal differences the result indicated that the two varieties had statistically ($p<0.05$) similar LAI at 3 WAS in 2009/10, 2010/11 dry seasons and the two seasons combined. At 6, 9 and 12 WAS in thetwo dry seasons and the two seasons combined, Star II TR 77173/SLM differed significantly ($p<0.05$)with higher LAI than Kauz/Weaver (Figure 4). The difference in terms of LAI between the two varieties could be as a result genotype.

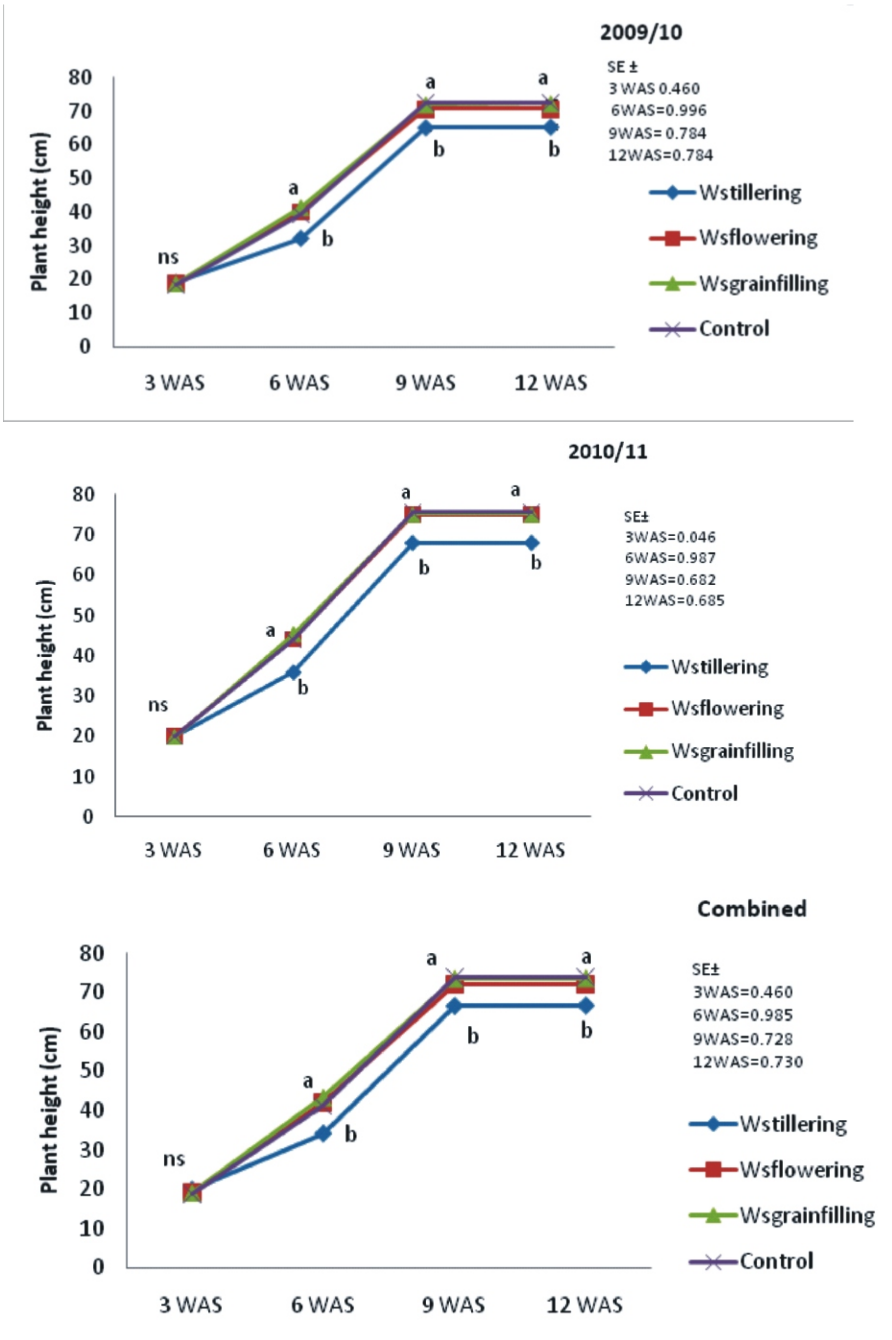


Figure 1: Effect of water stress on plant height at 3, 6, 9, and 12 WAS during the 2009/10, 2010/11 dry seasons and two seasons combined at Sokoto.

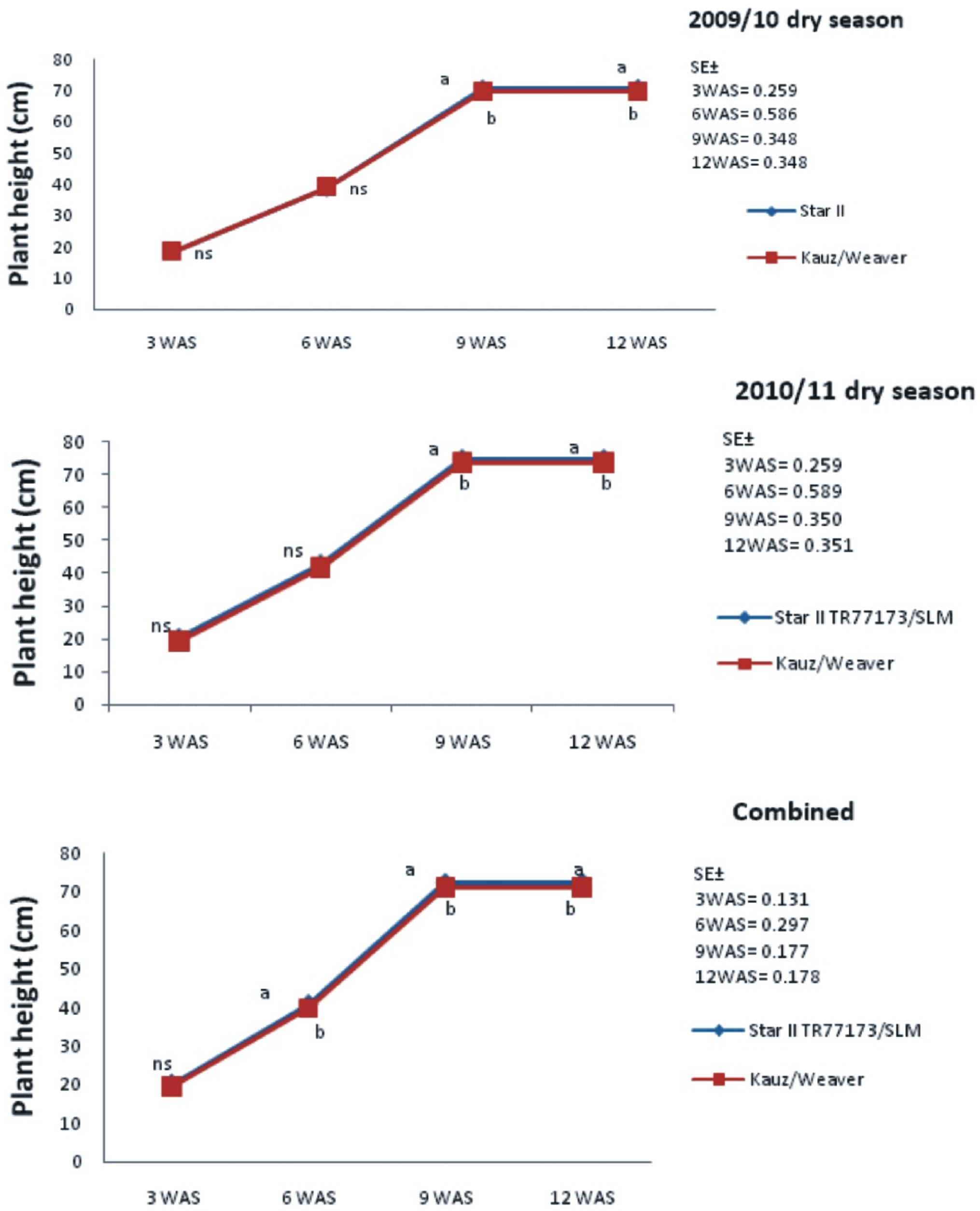


Figure 2: Effect of variety on plant height at 3, 6, 9 and 12 WAS during the 2009/10, 2010/11 dry seasons and two seasons combined at Sokoto

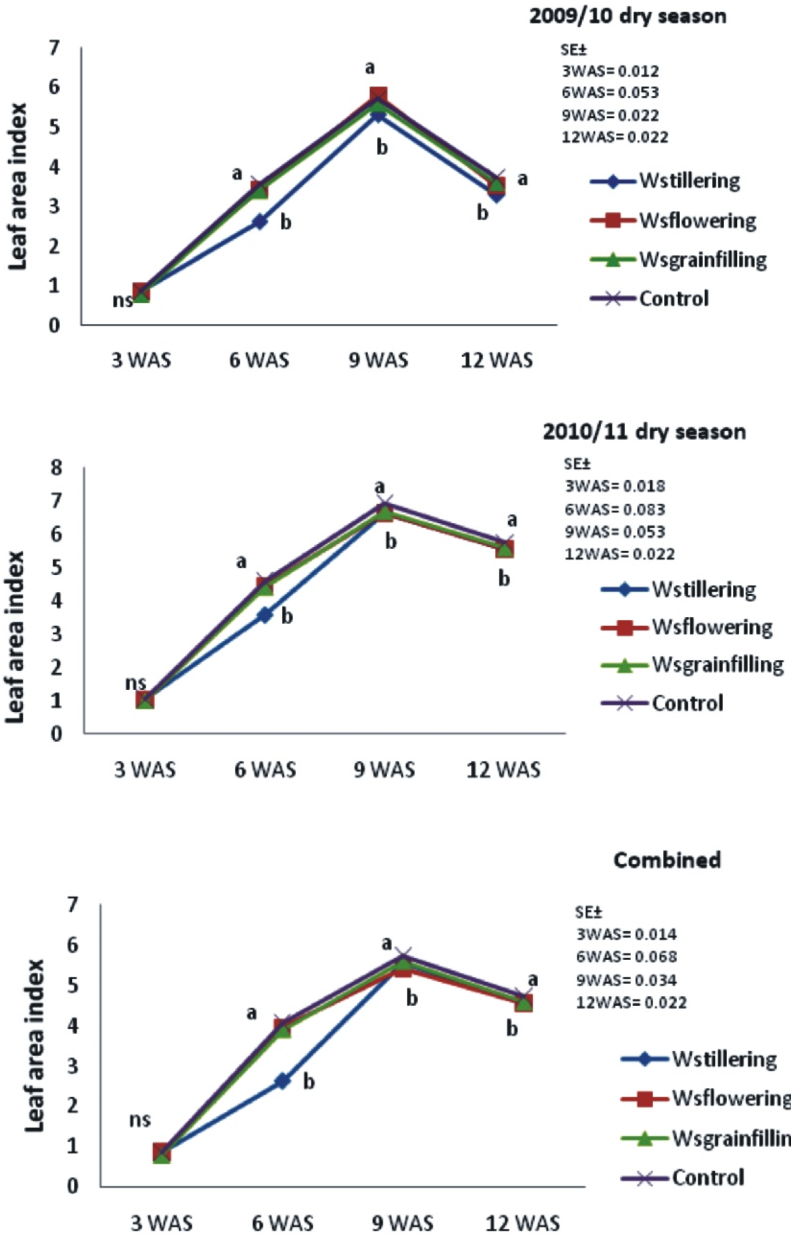


Figure 3: Effect of water stress on LAI at 3, 6, 9 and 12 WAS during the 2009/10, 2010/11 dry seasons and two seasons combined at Sokoto.

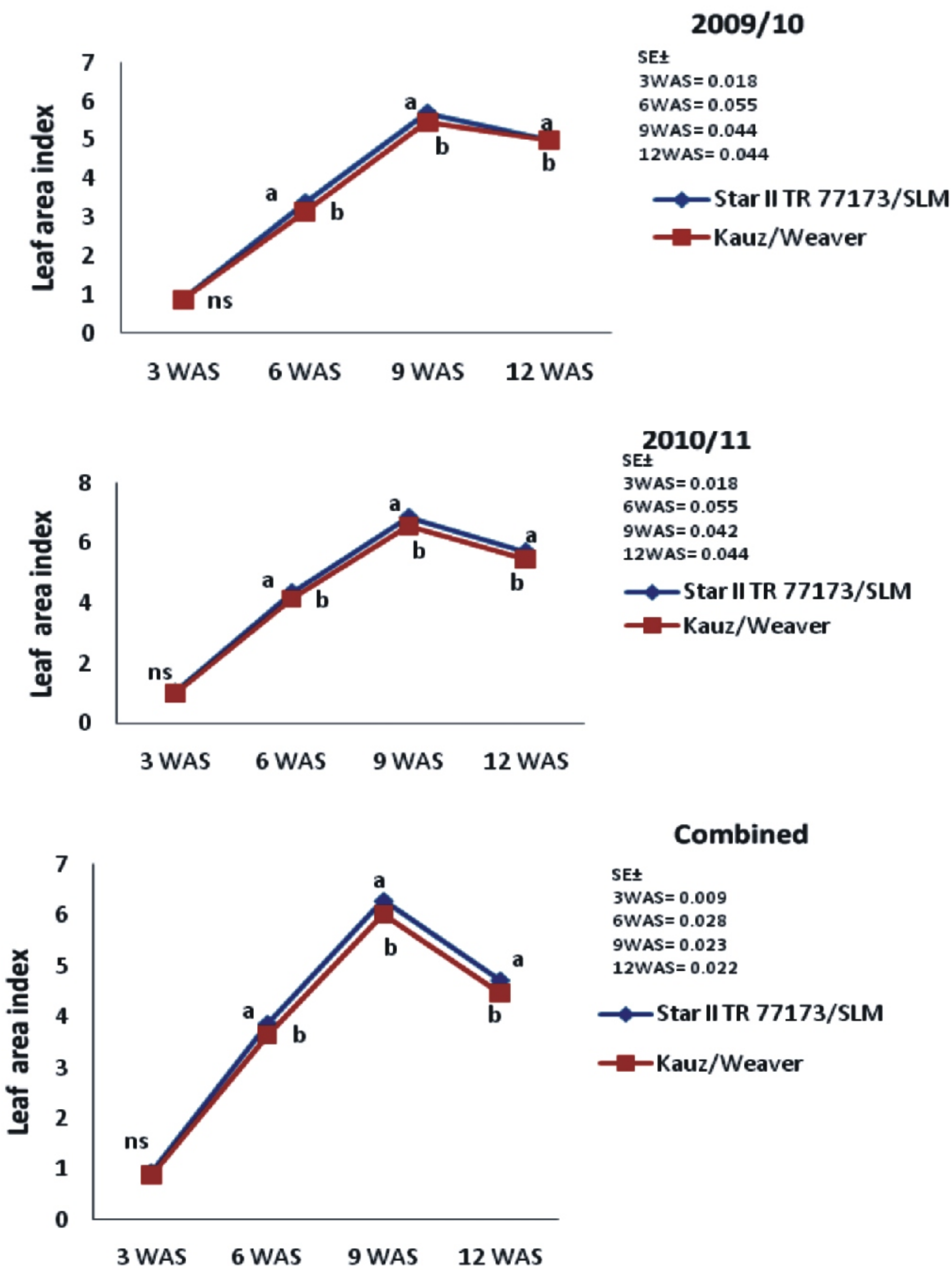


Figure 4: Effect of variety on LAI at 3, 6, 9 and 12 WAS during the 2009/10, 2010/11 dry seasons and two seasons combined at Sokoto.

Net Assimilation Rate (NAR)

The effects of water stress and variety on NAR at 3, 6, 9 and 12 WAS in 2009/10, 2010/11 dry seasons and combined are presented in Figures 5 and 6. The results (Figure 5) indicated that water stress at 3 WAS had no significantly ($p<0.05$) effect in 2009/10, 2010/11 dry seasons and two seasons combined. At 6 WAS in 2009/10 and 2010/11 dry seasons, water stress at tillering resulted in lower NAR, while water stress imposed at flowering, grain filling and the no stress control had statistically higher and similar NAR. This lower NAR at water stress at tillering could be as a result of reduced leaf area and LAI due to water stress imposed at tillering In the combined analysis, the control (no control) differed significantly ($p<0.05$) with higher NAR, followed by **water stress at flowering and grain filling which were statistically similar and the lowest NAR was from water stress at tillering.** At 9 WAS in 2009/10 dry season and two seasons combined, the control differed significantly ($p<0.05$) with higher NAR, while water stress resulted in lower NAR, but in 2010/11 dry season, water stress had no effect on NAR but control differed significantly with higher NAR. At 12 WAS in 2009/10 dry season and the two seasons combined, water stress at tillering resulted in lower NAR and the control differed from the other treatments with a higher NAR. Water stresshad no effect on NAR in 2010/11 dry season at 12 WAS the control differed significantly with higher NAR. As plants grow, there is an increase in the LAI and sometimes there is mutual leaves shading with increase in the age of plants resulting in lower photosynthetic efficiency. The Lower **NAR observed at 6 WAS could be as a result of water stress imposed at tillering,this is similar to the findings of Sharif (1999) who reported significant reduction of NAR due towater stress.** Reddi and Reddy (1995) reported that water stress **resulted in l**ow leaf water potentials and reductions in photosynthesis.

The effect of variety on NAR is presented on Figure 6, the result indicated that there was no significant ($p>0.05$) effect of variety on NAR at 3 WAS in 2009/10 and 2010/11 and combined, but Star II TR 77173/ SLM differ significantly ($p<0.05$) from Kauz/Weaver with highest NAR at 6, 9 and 12 WAS in both seasons and combined and at 12 WAS in 2009/10 dry season, however the two varieties had similar NAR at 12 WAS in 2010/11 dry season (Figure 6). Hussain (2007) also observed that cultivars of wheat exhibited different net assimilation rates.

Crop Growth Rate (CGR)

The effects of water stress and variety on CGR at 3, 6, 9 and 12 WAS in 2009/10, 2010/11 dry seasons and combined are presented in Figures 7 and 8. The result indicated that the effect of water stress on CGR at 3 WAS was not significant in both seasons and the two seasons combined (Figure 8). At 6 WAS in 2009/10, 2010 dry seasons and two seasons combined water stress at tillering resulted in lower CGR than water stress at flowering, grain filling and the control which are statistically similar. At 9 and 12 WAS in both seasons and combined, control differed significantly ($p<0.05$) with higher CGR but water stress had no effect on CGR. The reduction of CGR at tillering may be adduced to water stress imposed at that stage which resulted to fewer tillers, lower LAI, NAR and shorter plants. CGR increased progressively until 9 WAS and thereafter decreased at 12 WAS, maximum CGR was observed at 9 WAS and decreased at 12 WAS due to plant maturity, cessation of vegetative growth, loss of leaves and senescence. **The finding is similar to that of Mirbahar***et al.* (2009) who reported significant effect of water stress on CGR and decline in CGR at 12 WAS. On varietal differences, the result indicated that at 3 WAS in both seasons and the two seasons combined the two varieties did not differ in CGR. At 6, 9 and 12 WAS in both seasons and the two seasons combined Star II TR 77173/SLM has higher CGR than Kauz/Weaver (Figure 8). The difference in terms of CGR between the two varieties could be as a result genotype, which is similar to the finding of Lad *et al*. (2002) and Bilgi (2006) who observed significant effect of variety on CGR.

CONCLUSION

Crops were associated with large values of LAI and CGR under better management of irrigation. Water stress results to reduction in photosynthesis and wheat growth. Water stress at tillering resulted to significant reduction in wheat growth; Star II TR 77173/ LM had better growth than Kauz/Weaver when sown on 21st November and 5th December.

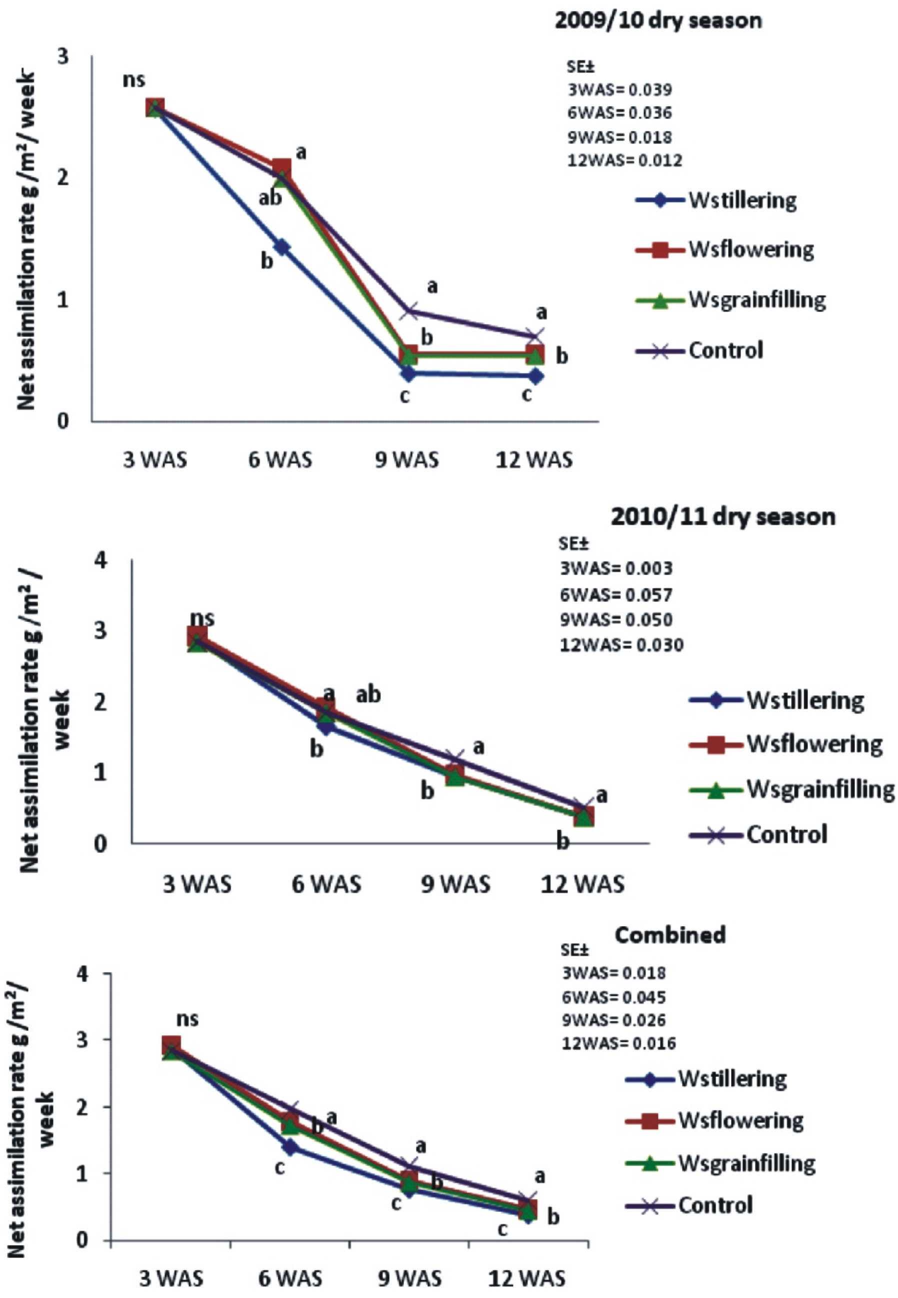


Figure 5: Effect of water stress on NAR (g m^{-2} week^{-1}) at 3, 6, 9 and 12 WAS during the 2009/10, 2010/11 dry seasons and two seasons combined at Sokoto.

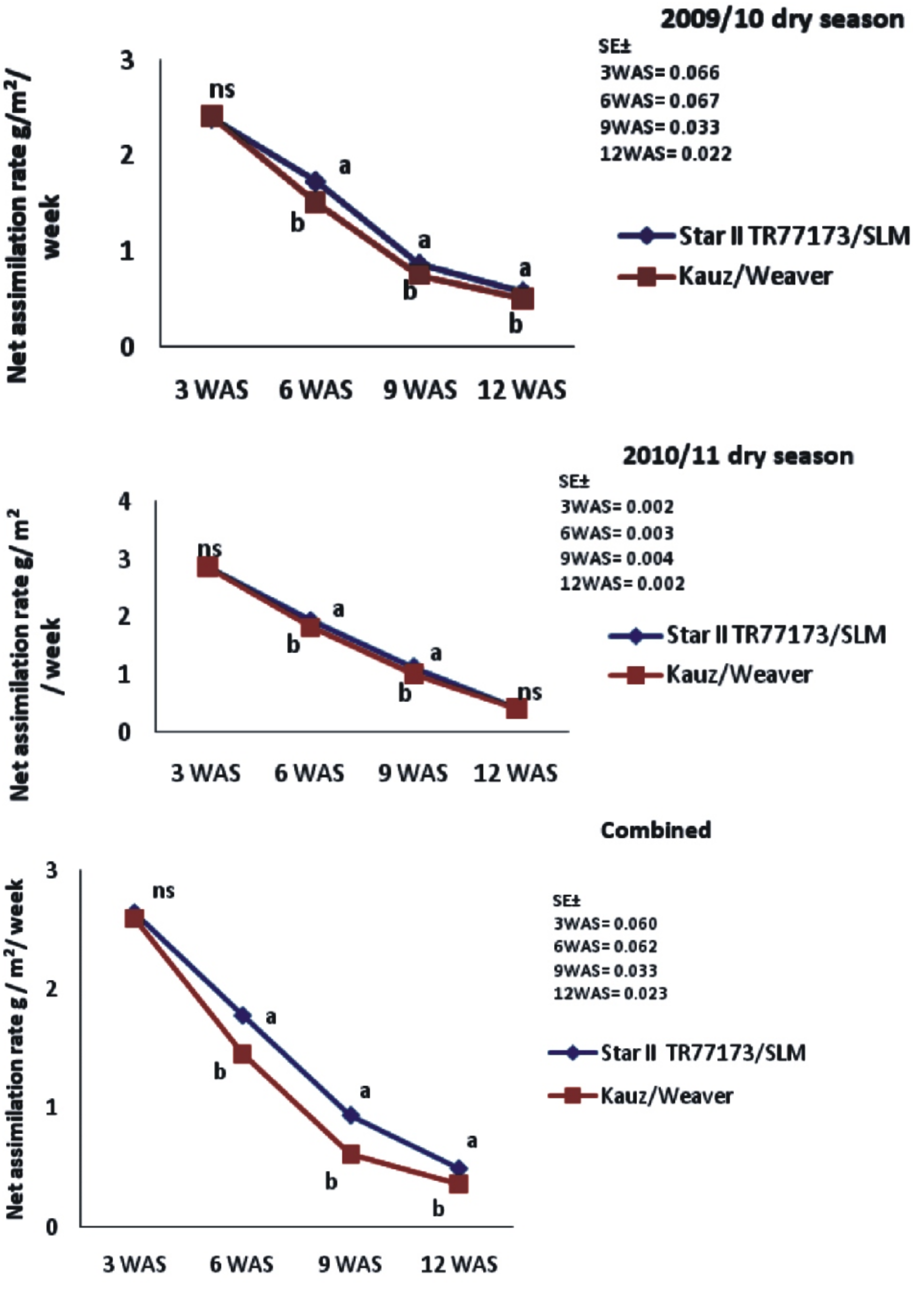
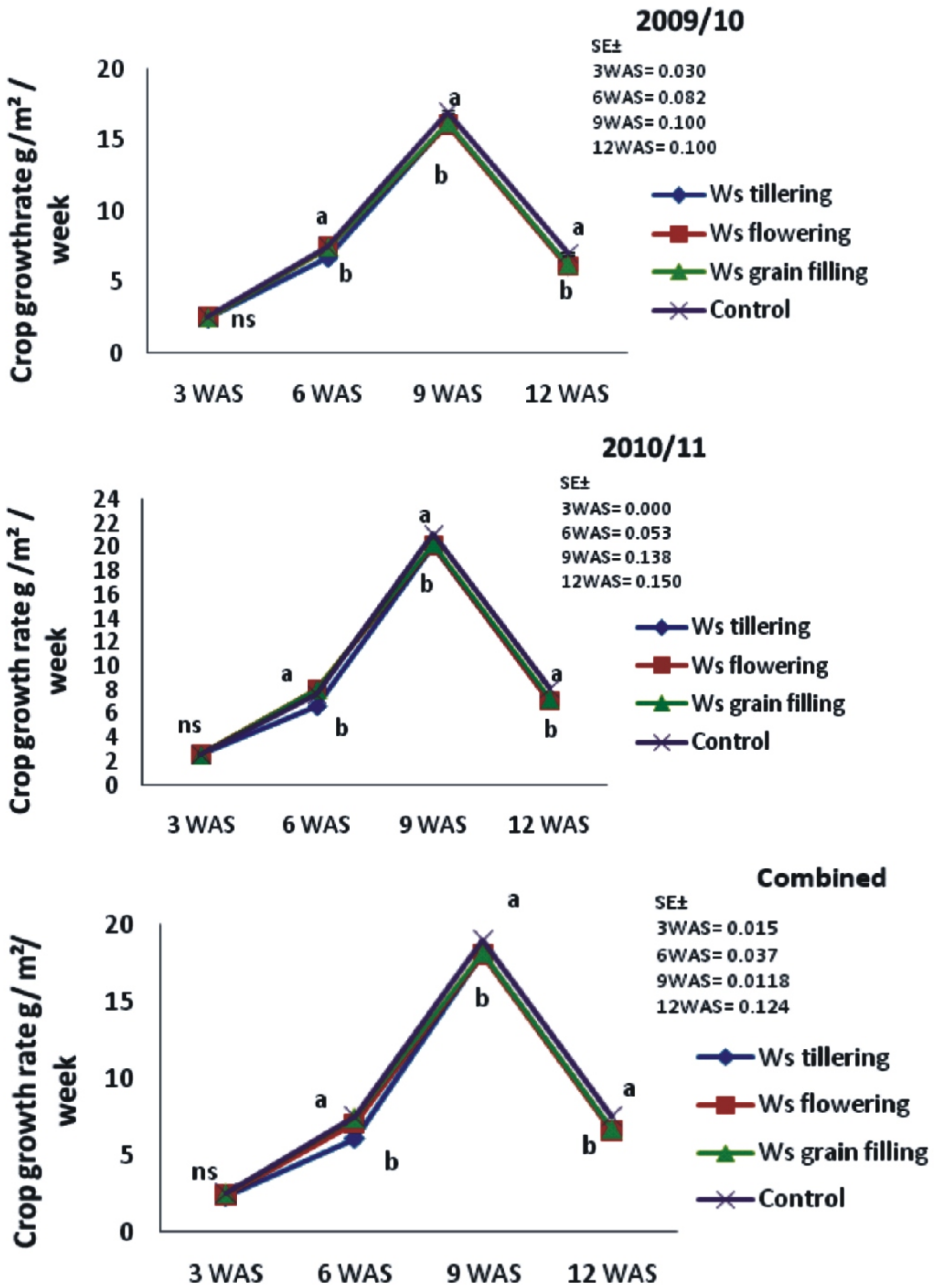


Figure 6: Effect of variety on NAR (g m^{-2} $week^{-1}$) at 3, 6, 9 and 12 WAS during the 2009/10, 2010/11 dry seasons and two seasons combined.



7: Effect of water stress on CGR (g m^{-2} week^{-1}) at 3, 6, 9 and 12 WAS during the 2009/10, 2010/11 dry seasons and two seasons combined at Sokoto.

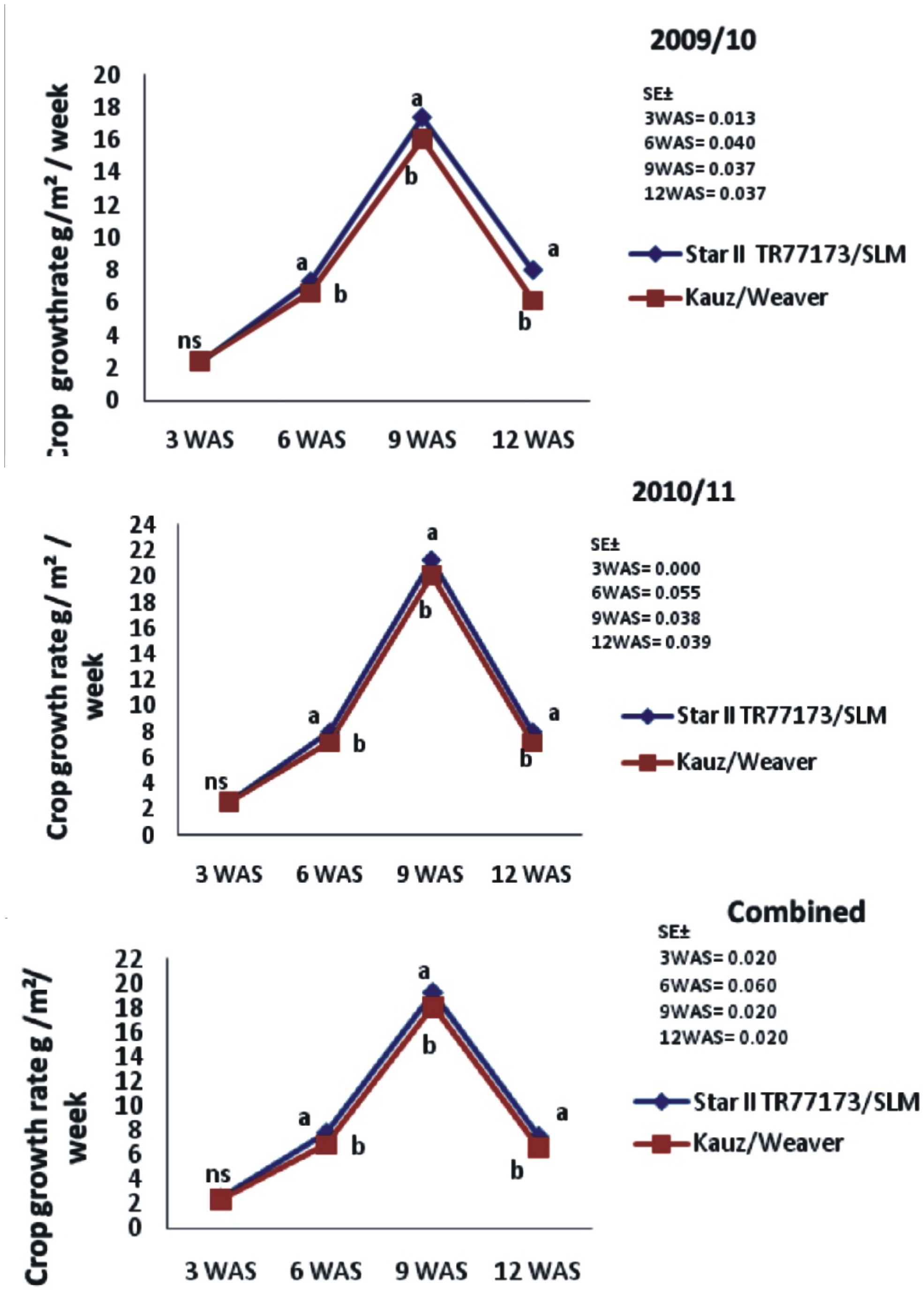


Figure 8: Effect of variety on CGR (g m^{-2} week^{-1}) at 3, 6, 9 and 12 WAS during the 2009/10, 2010/11 dry seasons and combined at Sokoto.

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