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Physiological Growth Indices and Yield Attributes of Groundnut (*Arachis Hypogaea* L.) Varieties as Affected by Weed Control Methods and Season in Northern Guinea Savanna Ecology, Nigeria

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Abstract: *Three years (2018-2020) field trials were conducted to evaluate the influence of ten weed control methods on the growth and yield of three groundnut varieties (SAMNUT 23, SAMNUT 22 and SAMNUT 14). The experimental treatments were replicated three times in a split plot design arrangement. Findings from the trials indicated that weed parameters such as weed dry biomass, weed control efficiency and weed index were significantly lower under the application of pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS and hoe weeding at 3 and 6 WAS compared to weedy check that resulted in higher value. Weed control efficiency on the other hand was significantly higher in all herbicidal treatments that received supplementary hoe weeding at 6 WAS than those that received only pre-emergence herbicide alone. Similarly, the physiological growth attributes such as leaf area index (LAI), dry matter production, relative growth rate (RGR), net assimilation rate (NAR) and crop growth rate (CGR) were significantly higher under the application of hoe weeding at 3 and 6 WAS, pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS while yield attributes such as number of pods, pod weight, 100 seed weight, seed yield and harvest index were significantly higher under herbicidal treated plots that are supplemented with hoe weeding at 6 WAS. The two groundnut varieties (SAMNUT 22 and SAMNUT 23) exhibited similar pattern of results with respect to LAI, dry matter accumulation, RGR, NAR and CGR as well as yield attributes. Growing groundnut in the 2019 and 2020 seasons produced significantly higher yield related attributes as well as on weed control efficiency of groundnut than in 2018. Findings from the trials revealed that cultivation of SAMNUT 22 or SAMNUT 23 varieties using pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS and butachlor at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS for controlling weeds in place of the conventional 2-3 manual hoe weeding's which is associated with drudgery, can be adopted by farmers in the study area towards increasing groundnut yield.*

Keywords: *Leaf area index, Net assimilation rate, Relative growth rate, Crop growth rate, Yield attributes, Groundnut, weed control*

INTRODUCTION

Arachis hypogaea L., a common groundnut, is self-pollinated, allotetraploid (2n = 4x = 40), and has a genomic size of 2891 Mbp. It is ranked fifth among all oilseed crops in the world, behind oil palm, soybean, rapeseed, and sunflower (FAO, 2013). Depending on its usage, groundnut yield can be divided into pod, kernel, oil, and haulm yields. The most crucial factor is pod yield, which depends on crop growth rate, length of reproductive growth, and the percentage of crop growth rate partitioned to pod production (Janila *et al*., 2013; 2016). These attributes, however, were disrupted by several biotic factors, of which weed infestation stood out as the greatest. According to Etejere *et al*. (2013), uncontrolled weeds reduced potential groundnut production by 51%. Weed and crop competition is a natural phenomenon in agro-ecosystems; weeds compete with crops for nutrients, moisture, light, and space. This competition results in yield and quality loss, which causes enormous economic losses amounting to billions of dollars annually (Siddhu *et al.,* 2018). Other detrimental impacts of weeds include delaying or hindering harvesting processes, tainting animal feed, which affects the health of the animals, obstructing water flow in irrigation canals and other waterways, parasites on plants, etc (Kraehmer & Baur, 2013; Singh, 2016). In both crop and non-crop species, rapid establishment and growth rates have been recognized as essential competitive qualities (Cosser *et al*., 1997; de Vida *et al*., 2006; Didon & Hansson, 2002). However, the leaf area index (LAI) controls these traits. The extent of yield loss owing to weed interference may be regulated by the crop's LAI occupied, which aids in weed suppression. Compared to early and late season LAI, a mid-season increase in LAI is more important for controlling weeds, according to Fradgley *et al*. (2017). This is because there is less competition for production and partitioning of assimilates in the former. Amaregouda *et al*. (2013) and Shittu *et al*. (2021) discovered that soybeans and maize grown in weed-treated plots had higher levels of the crucial physiological traits RGR, CGR, and NAR than those grown in untreated (weedy check) plots, which resulted in a decrease in all the metrics The need for a strategy to boost competitive ability without limiting yield potential in the absence of weeds was emphasized by de Vida *et al*. (2006) and Dingkuhn *et al*. (1999). This strategy aimed to boost competitive traits like LAI and vegetative growth early in the season, while limiting competitive traits later in the season, when dry matter partitioning to grain filling becomes necessary. In order to identify the best variety with weed-competing potential, the physiological growth parameters of three groundnut varieties as influenced by weed management methods and season were evaluated.

MATERIALS AND METHODS

The field experiment reported was conducted during the 2018, 2019 and 2020 cropping seasons at the Abubakar Tafawa Balewa University Research and Teaching Farm, Gubi (Lat. 10^{o} 45 N and Long. 9^{o}.82' E, 616m *asl),* situated in the Northern Guinea savanna ecological zone of Nigeria. The experimental area receives a total of 1667.9, 2113.5, and 1749.3mm of rainfall in the three seasons, respectively, which is characterized by a uni-modal rainfall pattern which peaks in the month of August. The soil of the experimental site is sandy loam with moderate water holding capacity and a slightly acidic pH (5.95), low organic carbon (2.23), and moderately high nitrogen (0.97g kg^{-1}). The average temperature and relative humidity were 34.54^{o} C and 45.08% for 2018, 29.99^{o} C and 49.42% for 2019, and 33.28^{o}C and 46.75% for the 2020 season, respectively.

Varietal description

Three improved varieties of groundnut were used for the study, which are: SAMNUT 14 (Ex-Dakar), an early maturing (85-90 days), resistant to rosette, drought tolerant, high yielding with small sized seeds; SAMNUT 22 (M 572.80I), a medium-late maturing (115-120 days), dual purpose (kernel and haulm), high haulm yield (4-5 t ha^{-1}), high pod yield (2-2.5 t ha^{-1}) and good oil content (45%); and SAMNUT 23 (ICGV-IS 96894): medium maturing (90-100 days), 2 t ha^{-1}, good pod yield (2-2.5 t ha^{-1}) and high oil content (53%) and quality. The seeds were obtained from the Bauchi State Agricultural Development Programme (BSADP) seed office. The seed varieties were separately dressed with Apron plus (Thiametoxam + Metalaxyl-N and Difenoconazole) at the rate of 10g a.i./3kg seeds prior to sowing to control soil-borne pests, and later planted manually at the rate of 2 seeds per hole at a spacing of 0.75m x 0.20m.

Treatments and Experimental design

The treatments were laid out in a split plot design and replicated three (3) times, with varieties assigned to the main plots while weed control treatments were assigned to the sub-plots. The treatments consisted of ten (10) weed control treatments which comprised Butachlor at 2.5 kg a.i.ha^{-1}, Pendimethalin at 2.5 kg a.i.ha^{-1}, Pendimethalin at 2.0 + Butachlor 1.0 kg a.i.ha^{-1}, Butachlor at 2.0 + Pendimethalin 1.0 kg a.i.ha^{-1}, Butachlor at 1.5 kg a.i.ha^{-1} *fb* SHW (Supplementary hoe weeding) at 6 WAS (Weeks after sowing), Butachlor at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS, Pendimethalin at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS, Pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS, two hoe weeding at 3 and 6 WAS and weedy check (control) and three varieties of groundnut (SAMNUT 14, SAMNUT 22 & SAMNUT 23). The field was harrowed twice to fine tilth and ridged into 0.75 m apart using ox-drown ridge each year of the trial. It was then marked into the required number of plots each of gross area of 3 m x 4 m (12 m^2) and a net plot size of 1.5 m x 3 m (4.5 m^2). The ally between main plots, sub-plots and replicates were 1.0 m, 0.5 m and 1.5 m respectively. The pre-emergence herbicides were applied as per treatment basis a day after sowing using a Cp3 knapsack sprayer set at a pressure of 2.1 kg/m^2. Hoe weeding was carried out at 3 and 6 WAS for the hoe weeded plots while weedy check was left unweeded throughout the experimental period.

Data collection

Weed samples collected at harvest by placing a $1m^2$ quadrant three times within the net plot area (4.5 m^2) were cleaned of sands and other debris, oven dried to a constant weight at 80°C, and determined as weed dry weight. The weed control efficiency and weed index were calculated by adopting the formulas suggested by Mani *et al.* (1976) and Rana and Kumar (2014), respectively. Plant samples were harvested at an interval of 3 weeks within the treatment plots. Three plants from each treatment were carefully harvested from the discard rows meant for destructive sampling at times 1 and 2 above the soil surface, which were washed with tap water and segmented into leaves and stems. Plant samples were thereafter oven dried at 80° C to a constant weight and measured using a digital weighing balance (Metlar MT-2000) with a precision of 1 mg. LAI was determined as (LAI = leaf area/ground area occupied by the sampled plants). Physiological growth parameters such as relative growth rate (RGR), net assimilation rate (NAR) and crop growth rate (CGR) were estimated according to Gardner *et al*. (1985). Data on seed yield was collected on 5 randomly selected plants harvested and dried to 12% moisture content in each experimental net plot area (4.5 m^2). The harvest index and other yield-related attributes such as dry matter, number of pods per $plant^{-1}$ and 100-seed weight were also determined.

Data Analysis

All data collected were subjected to analysis of variance using Genstat (17th Edition) and treatment means were separated using Duncan's multiple range test (DMRT) (Duncan, 1955).

RESULTS AND DISCUSSION

Weed studies

Table 1 presents the mean of combined analysis on the effect of weed control, variety and season on weed dry weight weed control efficiency and weed index of groundnuts. Result reveal that significantly ($P \leq 0.01$) higher value of weed dry biomass and weed index were obtained in weedy check compared hoe weeding's at 3 and 6 WAS and pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS that resulted in lower values. This is however, unconnected to uncontrolled weeds resulting in stiff competition for growth resources in the former compared to the later which might be attributed to effective weed suppression arising from the treatments received. This finding corroborates the work of Kashid (2019) who reported significant reduction in weed biomass and weed index due to herbicide application compared to the control plots. Weed dry biomass and weed index did not revealed any significant (($P > 0.05$) effect due to variety. Cultivating groundnut during 2018 season significantly produced higher weed dry biomass than other seasons which could be ascribed to variation in environmental condition particularly intermittent drought which reduces the efficacy of the pre-emergence herbicide days after application, which gave the weeds an advantage to prosper more than the crops due to their vigorous competitive mechanisms, which in turn increases weed density and weed biomass. Interaction between weed control and season was significant and as shown in Table 2, where weedy check in 2018 season significantly produced higher weed biomass than the rest of the interaction effects.

Weed control efficiency (WCE) on the other hand was significantly influenced by weed control, variety, season and interaction where hoe weeding twice at 3 and 6 WAS significantly ($P \leq 0.05$) gave higher WCE though at par with pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS and butachlor at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS compared with butachlor at 2.5 kg a.i.ha^{-1} that resulted in lower WCE. Greater WCE achieved with the treatments might be attributed to low weed biomass values as a result of effective weed management. This discovery backs up the findings of Lal *et al*. (2017) and Omisore *et al*. (2016) who found that two hoe weeding's and pre-emergence herbicide + SHW resulted in significantly higher weed control efficacy due to reduced weed dry weight brought about by low weed density. This was facilitated by higher LAI and canopy cover registered with the variety which smoother the growth of weeds.

Although, WCE was greater in the 2019 and 2020 seasons due to suitable environmental conditions that enhanced nutrient uptake for the development of more leaf area index plant^{-1} and canopy expansion, which in turn suppressed weed growth as depicted in higher weed control efficiency. The significant interaction discovered between weed control and variety on WCE (Table 3) showed that significantly ($P \leq 0.01$) higher values were obtained under the following treatments: hoe weeding at 3 and 6 WAS, pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, butachlor at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, and butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS in SAMNUT 23, SAMNUT 22 and SAMNUT 14, respectively. This was aided by season long weed control which reduces crop-weed rivalry for limited growth resources which simultaneously increased the ability of the varieties ability to establish additional branches and canopy capable of inhibiting weed growth. Our findings corroborate those of Meena *et al*. (2011), Yadav *et al*. (2011), Tripathy *et al*. (2013) and Rathod *et al*. (2014) who discovered higher WCE and WCI pigeon pea, cluster bean, onions respectively due to maximum weed management resulting in yield gain. Table 4 shows the significant interaction effect between weed control and variety on weed index revealed that SAMNUT 14, SAMNUT 22 and SAMNUT 23 in weedy check significantly ($P \leq 0.01$) resulted in producing the highest weed index, which was aided by uninterrupted crop-weed competition for limited growth resources which decreased the ability of the varieties to develop more branches plant^{-1}, LAI and canopy spread capable of suppressing weed growth. Our findings corroborate those of Prashanth *et al*. (2016) and Chandu *et al*. (2018) who discovered higher weed index in rice due to uncontrol weeds resulting in yield penalty.

Leaf area index (LAI)

The mean of combined analysis on the effect of weed control treatment, variety and season on leaf area index, dry matter production, and relative growth rate is presented in Table 5. Results indicate that LAI was significantly influenced by weed control, variety and interaction. Significantly ($P \leq 0.01$) larger leaves were obtained under hoe weeded twice at 3 and 6 WAS and pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS than weedy check that consistently resulted in producing smaller LAI at 6, 9 and 12 WAS respectively. This can be attributed to efficient and sustainable season-long weed control achieved during the initial stages of the crop growth and the later growth of weeds was checked by hoeing at 6 WAS, resulting in less weed competition. This finding is in agreement with those of Priya *et al*. (2013) and Jat *et al*. (2011) who reported the efficiency of pendimethalin in smothering the growth of weeds at an initial growth stage and later checked by supplementary hoe weeding similar to weed-free treatments depicted in higher WCE. SAMNUT 22 variety significantly ($P \leq 0.01$) produced larger LAI compared to the other varieties throughout the sampling periods. The advantage of SAMNUT 22 in producing higher LAI throughout the sampling period than other varieties could be related to its genetic make-up to produce broader leaves. The significant interaction obtained between weed control and variety on LAI at 6 and 9 WAS is shown in Table 6 were hoe weeded twice at 3 and 6 WAS and pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS though at par in SAMNUT 22 significantly ($P \leq 0.01$) had larger LAI compared with the rest of the interaction effects. Similar pattern of result was equally obtained on LAI of groundnut at 9 WAS. The attainment of larger leaves could be attributed to improved weed management during the early stages of crop growth, and later weed growth was checked by hoeing at 6 WAS, which extends the range of the herbicide combined with the genetic composition of the variety. This backed up Trezzi *et al*. (2013) and Ferdous *et al*. (2017) findings that less weed density and biomass resulted in gains in peanut variety development characteristics.

Dry matter production

Dry matter production was significantly influenced by weed control and variety (Table 5) where the application of hoe weeding twice at 3 and 6 WAS significantly ($P \leq 0.01$) resulted in higher dry matter production though at par with pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS and pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS compared with the weedy check that resulted in lower dry matter accumulation. The increase in the dry matter could be attributed to weed competition for available environmental resources being reduced as a result of the treatments' effective weed control. This finding is consistent with that of Patel *et al*. (2016) who reported that dry matter production is largely a function of the photosynthetic surface, which has influenced more in weed management treatments, resulting in higher dry matter accumulation in weed-free treatments due to less competition for growth resources which aided larger LA and LAI, resulting in higher dry matter production. Conversely, the weedy check significantly accumulates lower dry matter due to unabated weed control. SAMNUT 22 variety significantly ($P \leq 0.05$) produced higher dry matter than other varieties under investigation. The superiority of SAMNUT 22 in accumulating higher dry matter could be attributed to their genetic make-up and environmental interaction, which aided the variety to produce more nodules, LAI and canopy spread which in turn leads to higher dry matter production. Growing groundnut in the 2019 and 2020 seasons, significantly ($P \leq 0.05$) resulted in higher dry matter accumulation and production compared with those grown in the 2018 season which could also be attributed to a sufficient distribution of environmental growth resources combined with effective weed control, resulting in mutual symbiosis activity between the soil flora and fauna. This current finding is in agreement with those of Sangeetha *et al*. (2012) and Smita *et al*. (2014) who reported that dry matter production is largely a function of the photosynthetic surface, which is influenced by weed control treatments, resulting in higher dry matter accumulation in weed-free treatments due to less competition for growth resources. Furthermore, the efficacy of herbicide is also known to be influenced by environmental factors across seasons or locations.

Relative growth rate (RGR)

Results shows that the application of hoe weeding at 3 and 6 WAS significantly ($P \leq 0.01$) resulted in higher RGR at 6 WAS compared to other weed control treatments (Table 5). The application of weeding twice at 3 and 6 WAS, pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS and pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS significantly had higher RGR at 9 and 12 WAS respectively. However, weedy check significantly ($P \leq 0.01$) produced lower RGR across the sampling periods. The lethal impact of hoe weeding could explain the optimum RGR reported at 6 WAS in hoe weeding at 3 and 6 WAS. Similarly, weeding at 3 and 6 WAS, pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, and pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS all resulted in higher RGR as the season progressed, which could be attributed to season-long weed control that reduces crop-weed competition for growth resources, favoring the production larger leaves and wider canopy which leads to higher dry matter production. SAMNUT 23 variety significantly ($P \leq 0.01$) produced higher RGR at 6 WAS than other varieties while SAMNUT 22 and SAMNUT 23 varieties resulted significantly in higher RGR than SAMNUT 14 that resulted in lower RGR at 9 and 12 WAS, respectively which could be attributed to their genetic composition, which produces taller plants with a wider canopy, smothering weed growth while utilizing available growth resources for crop growth. The significant interaction obtained between weed control and variety on RGR at 9 and 12 WAS shows that weeding twice at 3 and 6 WAS in SAMNUT 22 and SAMNUT 23 significantly ($P \leq 0.01$) had higher RGR though at par with other interaction effects compared to weedy check in the three varieties that resulted in lower RGR (Table 7). The significant interaction between weed control and variety on RGR at 12 WAS (Table 7) also shows that application of two hoe weeding's at 3 and 6 WAS in SAMNUT 22 significantly ($P \leq 0.05$) resulted in higher RGR though at par with other weed control treatments that received SHW at 6 WAS compared with the rest of the interaction effects that resulted in lower RGR which could be attributed to the superiority of the treatments in suppressing weed growth. Nonetheless, CGR, RGR, and NAR initially showed an increasing tendency that peaked at the active vegetative stage before gradually decreasing up until the harvesting stage. It could be owing to an increase in CGR and dry matter buildup from the early to reproductive stages, which will be greater than in later stages. When the crop enters the reproductive stage, it begins to translocate and remobilize photosynthetic material from source to sink.

Net assimilation rate (NAR)

The mean of combined analysis on the effect of weed control treatment, variety and season on net assimilation rate and crop growth rate is presented in Table 8. Results shows that NAR was significantly influenced by weed control, variety and interaction between weed control and variety at 9 WAS. Weedy check significantly ($P \leq 0.01$) resulted in lower NAR compared with other weed control treatments that had higher NAR at 6 WAS. However, as the season progresses, the application of two hoe weeding's at 3 and 6 WAS and pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS resulted significantly ($P \leq 0.01$) in higher NAR compared to weedy check that had lower NAR at 9 and 12 WAS respectively but decline later in the season. Findings from NAR correspond to those of RGR and CGR results. As a result, they support Rezvani *et al*. (2012) and Soliman *et al*. (2015). Similarly, Olayinka and Etejere (2015) found that groundnut RGR was higher in largely weed-free circumstances and plots raised under rice straw mulch + one-hand weeding at 6 WAS compared to the weedy check produced lower NAR value. The SAMNUT 23 variety significantly produced higher NAR than the rest of the varieties at 9 WAS. This could be attributed to its genetic propensity for providing superior physiological growth metrics at 9 WAS. This discovery is similar with the findings of Zerner *et al*. (2016), who discovered that certain genotypes outperform others in terms of growing taller and providing greater physiological growth features. The significant interaction between weed control and variety on NAR at 9 WAS (Table 9) indicates the application of weeding twice at 3 and 6 WAS in SAMNUT 23 produced significantly ($P \leq 0.05$) higher NAR though at par with weeding twice at 3 and 6 WAS in SAMNUT 22, pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS in SAMNUT 22 and SAMNUT 23, hoe weeded twice and pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS in SAMNUT 14 compared with the remaining interaction effects that resulted in lower NAR. This could also be favored by season long weed control achieved which in turn facilitates the utilization of the growth resources in production of assimilates. This supports earlier findings by Mitra *et al*. (2019) and Shittu & Abdullahi (2022a & 2022b), who found that maize and sorghum performed better in a weed-free environment than in a weed-infested one.

Crop growth rate (CGR)

The same pattern of result obtained in NAR above was also depicted in CGR throughout the growth stages (Table 8). This could be ascribed to the increased spectrum activity of the pre-emergence herbicide by supplementary hoe weeding, which promoted crop growth by reducing weed competition for growth resources such as water, light, nutrients, and space. Greater LAI and NAR could also explain the higher CGR observed in such treatments. Our findings are consistent with those of Olorunmaiye and Olorunmaiye (2009), who found that pre-emergence herbicide applications without supplementary hoe-weeding were unable to offer season-long weed control due to their short persistence. Weedy check, on the other hand, resulted in lower CGR due to significant weed-crop rivalry for growth resources, as reported by Ferdous *et al*. (2017), and Shittu et al. (2021) who observed a decline in soybean and maize growth performance in terms of plant height, LAI, and CGR due to weed competition with soybean and maize, respectively.

Yield components and yield

The mean of combined analysis on the effect of weed control treatment, variety and season on number of pods plnat^{-1}, mean pod weight, 100 seed weight, seed yield and harvest index are presented in Table 11. Results shows that application of two hoe weeding's at 3 and 6 WAS and pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS produced significantly ($P \leq 0.01$) higher number of pods plant^{-1} compared with weedy check that produced lower pods plant^{-1}. Pod weight was significantly higher under application of two hoe weeding's at 3 and 6 WAS though at par with pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS and pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS compared weedy check that produced lower pod weight. On the other hand, 100 seed weight and harvest index were significantly produced with application of hoe weeding at 3 and 6 WAS, pendimethalin at 2.0 and 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, butachlor at 2.0 and 1.5 kg a.i.ha^{-1} + SHW at 6 WAS while application of two hoe weeding at 3 and 6 WAS and pendimethalin at 2.0 and 1.0 kg a.i.ha^{-1} + SHW at 6 WAS significantly produced higher seed yield compared to weedy check that had lower yield. It is clear that employing pre-emergence herbicides + SHW at 6 WAS to control weeds eliminates weed interference and increases podding, mean pod weight and seed yield due to optimal nutrient uptake. Adhikary *et al*. (2016) and Danful *et al.* (2019) discovered that a larger number of pods plant^{-1} and mean pod weight collected were associated with improved nutrient accretion, which translates to increased dry matter and CGR from agricultural plants. Similarly, Sinha *et al*. (2018) reported same on 100 seed weight due to effective weed management. Weedy check, on the other hand, resulted in fewer pods per plant^{-1}, which could be due to competition between groundnut and weeds for water, light, space, and nutrients, as well as allelopathic impacts of weed biotypes in weedy check, which resulted in poor crop growth and yield quality. SAMNUT 22 and SAMNUT 23 varieties significantly ($P \leq 0.01$) produced higher number of pods plant^{-1}, mean pod weight and harvest index compared to SAMNUT 14 that had lower number of pods while SAMNUT 22 significantly produced heavier 100 seed weight and seed yield. Growing groundnut in 2019 and 2020 seasons significantly ($P \leq 0.05$) produced higher number of pods plant^{-1}, mean pod weight, 100 seed weight, seed yield and harvest index than 2018 season. The capacity of the SAMNUT 22 and SAMNUT 23 varieties to express their genetic composition in a more weed-free environment could explain their superiority in generating a significantly ($P \leq 0.05$) higher number of pods per plant. Similarly, the larger number of pods plant^{-1} and pod weight in the 2019 and 2020 seasons can be linked to favorable environmental conditions and nutrient uptake, which allowed for a higher number of pods plant^{-1}, pod weight, seed yield production than the previous season. Our findings support those of Agasimani *et al*. (2010), who found that crops perform better when weeds are appropriately managed. Pereira *et al*. (2015) and Melaku (2008) both indicated that the number of pods plant^{-1} and mean pod weight produced at harvest depends on a number of environmental and management practices employed. Similarly, Omisore *et al*. (2016) & Kashid (2019) asserted that the number of pods generated plant^{-1} favors mean pod weight and pod yield production at harvest, both of which are controlled by a variety of environmental and management parameters.

The significant interaction obtained between weed control and variety on number of pods plant^{-1} (Table 12) shows that weeding at 3 and 6 WAS in SAMNUT 23 significantly ($P \leq 0.05$) produced higher number of pods plant^{-1} which is comparable with weeding twice at 3 and 6 WAS in SAMNUT 22 and pendimethalin at 3.0 kg a.i.ha^{-1} + SHW at 6 WAS in SAMNUT 22 and SAMNUT 23 compared with the rest of the interaction effects. Interaction between weed control and season on number of pods plant^{-1} (Table 13) indicates that hoe weeded twice at 3 and 6 WAS and pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS in 2019 and 2020 seasons resulted significantly ($P \leq 0.05$) higher pods number plant^{-1}, mean pod weight compared with the remaining interaction effects. On the other hand, interaction between variety and season on number of pods plant^{-1}, mean pod weight (Table 14) reveals that SAMNUT 22 and SAMNUT 23 in 2019 and 2020 seasons produced significantly ($P \leq 0.05$) higher number of pods plant^{-1} and heavier pods than the rest of the interactions. This could be owing to the changing seasons' climatic conditions (reduced crop-weed competition for water, light, space, and nutrients), which allow cultivars to better understand their genetic make-up and produce more pods plant^{-1} with a greater mean pod weight. This finding complements the findings of Danful *et al.* (2019), who found that growth under less environmental stress resulted in an increase in the number of pods plant^{-1} and pod weight. The significant interaction obtained between weed control and variety on seed yield and harvest index (Table 15) which enabled hoe weeding at 3 and 6 WAS and Pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS in SAMNUT 22, produced significantly ($P \leq 0.01$) higher values, though at par with Pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, butachlor at 2.0 and 1.5 kg a.i.ha^{-1} + SHW at 6 WAS in SAMNUT 22 and SAMNUT 23, respectively. This could be attributed to the relatively long-term weed control obtained, which improves the variety's ability to use available growth resources for the production of dry matter, which is then translated into the variety's ability to produce higher yield components. This corresponds with Shalu *et al*. (2020) who reported higher yield attributes of groundnut as a result of effective weed control. The significant interaction between weed control and season on the seed yield and harvest index (Table 16) enabled hoe weeding at 3 and 6 WAS in SAMNUT 23 to produce a significantly ($P \leq 0.05$) higher seed yield and harvest index, though on par with Pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, Pendimethalin at 1.0 kg a.i.ha^{-1} + SHW at 6 WAS, butachlor at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS in SAMNUT 23 and SAMNUT 22. This could be attributed to the relatively long-term weed control obtained coupled with prevailing environmental conditions as provided by 2019 and 2020 seasons which improves the variety's ability to use available growth resources for the production of dry matter, which is further translated into the variety's ability to produce higher yield components. Reid *et al*. (2014) discovered that a crop's superiority in producing higher yield components was due to the prevailing environmental conditions which increased the occurrence of groundnut plant flowering, pegging and hence dry matter production and partitioning to various sinks. Mekonnen *et al*. (2015) and Shalu *et al*. (2020) earlier reported similar findings on increased yield attributes of groundnut owing to effective weed control.

CONCLUSION AND RECOMMENDATION

Findings from the trials indicated that weed parameters such as weed dry biomass and weed control efficiency and weed index were significantly lower under the application of pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS and hoe weeding at 3 and 6 WAS compared to weedy check that resulted in higher value. Weed control efficiency on the other hand was significantly higher in all herbicidal treatments that received supplementary hoe weeding at 6 WAS than those that received only pre-emergence herbicide alone. Similarly, the physiological growth attributes such as LAI, dry matter production, RGR, NAR and CGR were significantly higher under the application of hoe weeding at 3 and 6 WAS, pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, pendimethalin at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS while yield attributes such as number of pods, pod weight, 100 seed weight, seed yield and harvest index were significantly higher under herbicidal treated plots that are supplemented with hoe weeding at 6 WAS. SAMNUT 22 variety produced higher LAI and dry matter while SAMNUT 23 variety produced higher NAR, 100 seed weight and seed yield, respectively. However, RGR, CGR, number of pods plant^{-1} and harvest index were significantly higher in both SAMNUT 22 and SAMNUT 23 varieties. Growing groundnut in the 2019 and 2020 seasons produced significantly higher yield related attributes as well as on weed control efficiency of groundnut than in 2018. Findings from the trials revealed that cultivation of SAMNUT 22 or SAMNUT 23 varieties using pendimethalin at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS, pendimethalin at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS and butachlor at 2.0 kg a.i.ha^{-1} + SHW at 6 WAS for controlling weeds in place of the conventional 2-3 manual hoe weeding's which is associated with drudgery, can be adopted by farmers in the study area towards increasing groundnut yield.

Table 1: Mean of combined analysis across seasons on effect of weed control and variety on weed dry weight, weed control efficiency and weed index of groundnut during 2018, 2019 and 2020 cropping seasons

Treatment	Rate (Kg a.i.ha^{-1})	Weed dry weight (kg ha^{-1})	Weed control efficiency (%)	Weed index (%)
Weed control (W)				
BUTA	2.5	2120^{b}	46.30^{f}	53.28^{b}
PENDA	2.5	1868^{c}	49.44^{e}	46.38^{c}
BUTA + PENDA	2.0 + 1.0	1711^{d}	49.77^{e}	38.70^{d}
PENDA + BUTA	2.0 + 1.0	1458^{e}	51.30^{e}	31.77^{e}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	613^{f}	78.59^{d}	12.34^{f}
BUTA fb SHW at 6 WAS	2.0	564^{g}	86.96^{c}	8.38^{g}
PENDA fb SHW at 6 WAS	1.5	522^{h}	87.61^{bc}	4.99^{h}
PENDA fb SHW at 6 WAS	2.0	497^{i}	90.29^{ab}	3.06^{i}
Weeding at 3 and 6 WAS	-	496^{i}	91.03^{a}	2.99^{i}
Weedy check	-	4558^{a}	-	91.90^{a}
Level of significance		**	**	**
SE (±)		8.00	1.059	0.66
Variety (V)				
SAMNUT 22		1438	72.03^{a}	28.67
SAMNUT 23		1436	69.33^{b}	28.98
SAMNUT 14		1448	68.12^{c}	29.73
Level of significance		NS	**	NS
SE (±)		5.83	0.460	0.45
Season (Y)				
2018		1631^{a}	67.64^{b}	28.34
2019		1340^{b}	71.40^{a}	30.70
2020		1345^{b}	71.34^{a}	29.15
Level of significance		*	*	NS
SE (±)		5.46	0.940	0.90
Interaction				
W x V		NS	**	**
W x Y		**	NS	NS
V x Y		NS	NS	NS
W x V x Y		NS	NS	NS

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability using Duncan Multiple Range Test. BUTA =Butachlor; PENDA = Pendimethalin; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% ($P \leq 0.01$); * = significant at 5% ($P \leq 0.05$); NS = Not significant.

Table 2: Interaction between weed control and season on weed dry weight of groundnut in 2018, 2019 and 2020 seasons

Weed control	Rate (Kg a.i.ha^{-1})	Season		
		2018	2019	2020
BUTA	2.5	2129^{c}	2102^{cd}	2115^{cd}
PENDA	2.5	2088^{d}	1750^{g}	1758^{g}
BUTA + PENDA	2.0 + 1.0	1982^{e}	1571^{h}	1575^{h}
PENDA + BUTA	2.0 + 1.0	1831^{f}	1265^{i}	1271^{i}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	706^{j}	561^{m}	567^{m}
BUTA fb SHW at 6 WAS	2.0	665^{k}	508no	513^{n}
PENDA fb SHW at 6 WAS	1.5	619^{l}	470^{np}	474^{op}
PENDA fb SHW at 6 WAS	2.0	565^{m}	461^{p}	467^{p}
Weeding at 3 and 6 WAS	-	556^{m}	460^{p}	463^{p}
Weedy check	-	5172^{a}	4243^{b}	4251^{b}
Level of significance			**	
SE (±)			14.24	

Table 3: Interaction between weed control and variety on weed control efficiency of groundnut in 2018, 2019 and 2020 seasons

Weed control	Rate (Kg a.i.ha^{-1})	Variety		
		SAMNUT 22	SAMNUT 23	SAMNUT 14
BUTA	2.5	43.69^{i}	43.00^{i}	42.90^{i}
PENDA	2.5	46.77^{ghi}	46.70^{ghi}	45.44^{hi}
BUTA + PENDA	2.0 + 1.0	50.18^{fgh}	49.90^{fgh}	49.49^{fgh}
PENDA + BUTA	2.0 + 1.0	52.56^{f}	51.16^{fg}	50.18^{fgh}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	82.73^{bc}	81.81^{c}	71.22^{d}
BUTA fb SHW at 6 WAS	2.0	87.21^{ab}	87.12^{ab}	86.62^{abc}
PENDA fb SHW at 6 WAS	1.5	89.56^{a}	88.49^{a}	86.68^{abc}
PENDA fb SHW at 6 WAS	2.0	90.72^{a}	90.69^{a}	87.58^{ab}
Weeding at 3 and 6 WAS	-	91.47^{a}	90.93^{a}	90.59^{a}
Weedy check	-	-	-	-
Level of significance			**	
SE (±)			1.790	

Table 4: Interaction between weed control and variety on weed index of groundnut in 2018, 2019 and 2020 seasons

Weed control	Rate (Kg a.i.ha^{-1})	Variety		
		SAMNUT 22	SAMNUT 23	SAMNUT 14
BUTA	2.5	39.84^{f}	48.61^{d}	57.04^{b}
PEND	2.5	39.84^{f}	48.61^{d}	52.62^{c}
BUTA + PENDA	2.0 + 1.0	38.01^{f}	48.61^{d}	52.62^{c}
PENDA + BUTA	2.0 + 1.0	32.28^{g}	31.98^{g}	31.07^{g}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	12.03^{h}	12.18^{h}	12.81^{h}
BUTA fb SHW at 6 WAS	2.0	7.60^{ij}	7.61^{ij}	9.93^{hi}
PENDA fb SHW at 6 WAS	1.5	4.13^{k}	4.88^{jk}	5.96^{jk}
PENDA fb SHW at 6 WAS	2.0	2.92^{kl}	3.07^{kl}	3.19^{kl}
Weeding at 3 and 6 WAS	-	2.21^{l}	2.46^{l}	2.82^{l}
Weedy check	-	91.23^{a}	92.37^{a}	92.37^{a}
Level of significance			**	
SE (±)			1.17	

Table 5: Mean of combined analysis across seasons on effect of weed control and variety on leaf area index, dry matter production and relative growth rate of Groundnut during 2018, 2019 and 2020 cropping seasons.

Treatment	Rate (Kg a.i.ha^{-1})	Leaf area index			Dry matter production	Relative growth rate (g g^{-1} day^{-1})		
		Weeks after sowing (WAS)						
		6	9	12	12	3-6	6-9	9-12
Weed control (W)								
BUTA	2.5	0.38^{f}	0.44^{g}	0.43^{g}	311.0^{g}	0.43^{g}	0.52^{g}	0.33^{f}
PENDA	2.5	0.38^{f}	0.44^{g}	0.44^{g}	326.1^{f}	0.43^{g}	0.53^{f}	0.35^{e}
BUTA + PENDA	2.0 + 1.0	0.39^{e}	0.54^{f}	0.54^{f}	330.8^{f}	0.48^{f}	0.57^{e}	0.35^{de}
PENDA + BUTA	2.0 + 1.0	0.40^{d}	0.57^{e}	0.58^{e}	353.1^{e}	0.48^{e}	0.64^{d}	0.36^{d}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	0.40^{d}	0.59^{d}	0.59^{d}	392.2^{d}	0.57^{d}	0.78^{c}	0.43^{c}
BUTA fb SHW at 6 WAS	2.0	0.40^{c}	0.61^{c}	0.61^{c}	428.7^{c}	0.57^{d}	0.80^{b}	0.45^{b}
PENDA fb SHW at 6 WAS	1.5	0.42^{b}	0.62^{b}	0.62^{b}	434.5^{b}	0.60^{c}	0.86^{a}	0.46^{a}
PENDA fb SHW at 6 WAS	2.0	0.43^{a}	0.63^{a}	0.63^{a}	442.9^{ab}	0.61^{b}	0.87^{a}	0.47^{a}
Weeding at 3 and 6 WAS	-	0.43^{a}	0.63^{a}	0.63^{a}	447.9^{a}	0.64^{a}	0.88^{a}	0.47^{a}
Weedy check	-	0.31^{g}	0.38^{h}	0.38^{h}	203.7^{h}	0.30^{h}	0.39^{h}	0.28^{g}
Level of significance		**	**	**	**	**	**	**
SE (±)		0.001	0.002	0.002	3.72	0.002	0.009	0.005
Variety (V)								
SAMNUT 22		0.44^{a}	0.58^{a}	0.58^{a}	404.9^{a}	0.52^{b}	0.67^{a}	0.40^{a}
SAMNUT 23		0.38^{b}	0.52^{b}	0.52^{b}	390.6^{b}	0.53^{a}	0.68^{a}	0.41^{a}
SAMNUT 14		0.37^{c}	0.49^{c}	0.49^{c}	315.1^{c}	0.48^{c}	0.64^{b}	0.38^{b}
Level of significance		**	**	**	**	**	**	**
SE (±)		0.001	0.001	0.001	2.33	0.001	0.005	0.002
Season (Y)								
2018		0.39	0.51	0.51	349.3^{b}	0.50	0.64	0.40
2019		0.41	0.53	0.53	380.6^{a}	0.51	0.66	0.41
2020		0.40	0.52	0.52	379.3^{a}	0.51	0.65	0.41
Level of significance		NS	NS	NS	**	NS	NS	NS
SE (±)		0.001	0.002	0.002	3.28	0.004	0.006	0.004
Interaction								
W x V		**	**	NS	NS	NS	**	**
W x Y		NS	NS	NS	NS	NS	NS	NS
V x Y		NS	NS	NS	NS	NS	NS	NS
W x V x Y		NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability using Duncan Multiple Range Test. BUTA =Butachlor; PENDA = Pendimethalin; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% ($P \leq 0.01$); NS = Not significant.

Table 6: Interaction between weed control and variety on leaf area index of groundnut at 6 & 9 WAS during 2018, 2019 and 2020 (combined seasons)

Weed control	Rate (Kg a.i.ha^{-1})	Variety					
		SAMNUT 22	SAMNUT 23	SAMNUT 14	SAMNUT 22	SAMNUT 23	SAMNUT 14
		6 WAS			9 WAS		
BUTA	2.5	0.43^{e}	0.37^{kl}	0.35^{m}	0.48^{n}	0.42^{qr}	0.39^{t}
PENDA	2.5	0.45^{d}	0.37^{jkl}	0.37^{kl}	0.48^{mn}	0.42^{q}	0.41^{s}
BUTA + PENDA	2.0 + 1.0	0.45^{cd}	0.36^{l}	0.35^{m}	0.49^{m}	0.45^{p}	0.41^{rs}
PENDA + BUTA	2.0 + 1.0	0.47^{b}	0.38^{hi}	0.37^{jk}	0.52^{l}	0.49^{m}	0.47^{o}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	0.44^{e}	0.37^{jk}	0.37^{jkl}	0.65^{d}	0.54^{j}	0.53^{k}
BUTA fb SHW at 6 WAS	2.0	0.45^{cd}	0.38^{hi}	0.38^{ij}	0.66^{c}	0.56^{i}	0.55^{j}
PENDA fb SHW at 6 WAS	1.5	0.46^{c}	0.40^{g}	0.39^{h}	0.68^{b}	0.58^{g}	0.57^{h}
PENDA fb SHW at 6 WAS	2.0	0.48^{ab}	0.40^{g}	0.40^{g}	0.70^{a}	0.61^{e}	0.58^{g}
Weeding at 3 and 6 WAS	-	0.48^{a}	0.42^{f}	0.40^{g}	0.71^{a}	0.59^{f}	0.57^{gh}
Weedy check	-	0.33^{n}	0.31^{o}	0.30^{p}	0.42^{qr}	0.41^{s}	0.38^{u}
Level of significance			**			**	
SE (±)			0.003			0.003	

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability using Duncan Multiple Range Test. BUTA =Butachlor; PENDA = Pendimethalin; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% ($P \leq 0.01$).

Table 7: Interaction between weed control and variety on relative growth rate of groundnut at 9 & 12 WAS during 2018, 2019 and 2020 (combined seasons)

Weed control	Rate (Kg a.i.ha^{-1})	Variety					
		SAMNUT 22	SAMNUT 23	SAMNUT 14	SAMNUT 22	SAMNUT 23	SAMNUT 14
		9 WAS			12 WAS		
BUTA	2.5	0.50^{lm}	0.51^{lm}	0.49^{m}	0.33^{lm}	0.34^{kl}	0.31^{no}
PENDA	2.5	0.52^{lm}	0.51^{lm}	0.49^{m}	0.33^{lm}	0.37^{hij}	0.32^{mn}
BUTA + PENDA	2.0 + 1.0	0.58^{k}	0.60^{k}	0.53^{l}	0.36^{ijk}	0.38^{hi}	0.34^{klm}
PENDA + BUTA	2.0 + 1.0	0.65^{j}	0.66^{j}	0.60^{k}	0.37^{hij}	0.38^{h}	0.35^{jkl}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	0.73^{ghi}	0.74^{fgh}	0.69^{ij}	0.43^{f}	0.43^{f}	0.41^{g}
BUTA fb SHW at 6 WAS	2.0	0.77^{efg}	0.78^{def}	0.70^{hi}	0.44^{ef}	0.46^{cde}	0.43^{f}
PENDA fb SHW at 6 WAS	1.5	0.84^{bc}	0.84^{bc}	0.80^{cde}	0.48^{abc}	0.47^{bcd}	0.45^{def}
PENDA fb SHW at 6 WAS	2.0	0.86^{ab}	0.87^{ab}	0.82^{cd}	0.48^{ab}	0.47^{bcd}	0.46^{cde}
Weeding at 3 and 6 WAS	-	0.89^{a}	0.90^{a}	0.82^{c}	0.50^{a}	0.49^{ab}	0.46^{cde}
Weedy check	-	0.40^{n}	0.41^{n}	0.37^{n}	0.28^{p}	0.29^{op}	0.26^{q}
Level of significance			**			**	
SE (±)			0.015			0.011	

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability using Duncan Multiple Range Test. BUTA =Butachlor; PENDA = Pendimethalin; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% ($P \leq 0.01$).

Table 8: Mean of combined analysis across seasons on effect of weed control and variety on Net assimilation rate and Crop growth rate of groundnut at different growth stages during 2018, 2019 and 2020 cropping seasons

Treatment	Rate (Kg a.i.ha^{-1})	Net assimilation rate (g cm^{-2} wk^{-1})			Crop growth rate (g m^{-2} day^{-1})		
		Weeks after sowing (WAS)					
		3-6	6-9	9-12	3-6	6-9	9-12
Weed control (W)							
BUTA	2.5	0.024^{a}	0.030^{e}	0.031^{h}	1.84^{h}	1.88^{h}	1.10^{f}
PENDA	2.5	0.024^{a}	0.035^{g}	0.037^{efg}	1.90^{g}	1.93^{g}	1.16^{e}
BUTA + PENDA	2.0 + 1.0	0.026^{a}	0.037^{f}	0.039^{ef}	1.93^{f}	1.95^{f}	1.19^{e}
PENDA + BUTA	2.0 + 1.0	0.026^{a}	0.040^{e}	0.040^{e}	1.99^{e}	2.05^{e}	1.52^{d}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	0.026^{a}	0.049^{d}	0.044^{bcd}	2.02^{d}	2.24^{d}	2.37^{c}
BUTA fb SHW at 6 WAS	2.0	0.028^{a}	0.051^{c}	0.046^{bc}	2.04^{c}	2.26^{c}	2.41^{c}
PENDA fb SHW at 6 WAS	1.5	0.028^{a}	0.056^{b}	0.047^{b}	2.08^{b}	2.31^{b}	2.56^{b}
PENDA fb SHW at 6 WAS	2.0	0.029^{a}	0.060^{a}	0.057^{a}	2.11^{a}	2.36^{a}	2.64^{a}
Weeding at 3 and 6 WAS	-	0.029^{a}	0.061^{a}	0.057^{a}	2.12^{a}	2.37^{a}	2.65^{a}
Weedy check	-	0.015^{b}	0.019^{g}	0.013^{i}	1.35^{i}	1.68^{i}	1.01^{g}
Level of significance		*	**	**	**	**	**
SE (±)		0.0028	0.0004	0.0026	0.004	0.004	0.020
Variety (V)							
SAMNUT 22		0.025	0.041^{b}	0.024	2.01^{a}	2.36^{a}	1.94^{a}
SAMNUT 23		0.025	0.043^{a}	0.026	2.02^{a}	2.38^{a}	1.96^{a}
SAMNUT 14		0.027	0.038^{c}	0.025	1.93^{b}	1.98^{b}	1.71^{b}
Level of significance		NS	**	NS	**	**	**
SE (±)		0.0007	0.0003	0.0015	0.002	0.004	0.011
Season (Y)							
2018		0.025	0.042	0.025	1.67^{b}	1.96^{b}	1.86^{b}
2019		0.027	0.044	0.026	1.99^{a}	2.05^{a}	1.98^{a}
2020		0.026	0.043	0.026	1.98^{a}	2.03^{a}	1.96^{a}
Level of significance		NS	NS	NS	**	**	**
SE (±)		0.0029	0.0002	0.0011	0.005	0.022	0.013
Interaction							
W x V		NS	**	NS	**	**	**
W x Y		NS	NS	NS	NS	NS	NS
V x Y		NS	NS	NS	NS	NS	NS
W x V x Y		NS	NS	NS	NS	NS	NS

Table 9: Interaction between weed control and variety on Net assimilation rate and Crop growth rate of groundnut at during 2018, 2019 and 2020 (combined seasons)

Weed control	Rate (Kg a.i.ha^{-1})	Variety: Net assimilation rate at 9 WAS			Crop growth rate at 6 WAS		
		SAMNUT 22	SAMNUT 23	SAMNUT 14	SAMNUT 22	SAMNUT 23	SAMNUT 14
BUTA	2.5	0.021^{no}	0.023n	0.019^{op}	1.85^{mn}	1.85^{no}	1.84^{o}
PENDA	2.5	0.035^{l}	0.037^{kl}	0.030^{m}	1.93^{l}	1.94^{kl}	1.84^{no}
BUTA + PENDA	2.0 + 1.0	0.039^{jk}	0.039^{ij}	0.032^{m}	1.95^{jk}	1.96^{j}	1.84^{no}
PENDA + BUTA	2.0 + 1.0	0.041^{hi}	0.041^{hi}	0.039^{jk}	2.05^{g}	2.06^{fg}	1.87^{m}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	0.043^{fg}	0.045^{f}	0.040^{hij}	2.07^{ef}	2.07^{ef}	1.97^{j}
BUTA fb SHW at 6 WAS	2.0	0.048^{e}	0.048^{e}	0.047^{e}	2.08^{def}	2.08^{de}	1.99^{i}
PENDA fb SHW at 6 WAS	1.5	0.050^{e}	0.056^{d}	0.048^{e}	2.11^{bc}	2.12^{ab}	2.01^{h}
PENDA fb SHW at 6 WAS	2.0	0.060^{bc}	0.061^{ab}	0.058^{cd}	2.12^{ab}	2.12^{ab}	2.09^{cd}
Weeding at 3 and 6 WAS	-	0.061^{ab}	0.062^{a}	0.059^{c}	2.12^{ab}	2.13^{a}	2.11^{ab}
Weedy check	-	0.018^{p}	0.019^{op}	0.016^{q}	1.80^{p}	1.80^{p}	1.79^{p}
Level of significance			**			**	
SE (±)			0.0007			0.006	

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability using Duncan Multiple Range Test. BUTA =Butachlor; PENDA = Pendimethalin; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% ($P \leq 0.01$).

Table 10: Interaction between weed control and variety on crop growth rate of groundnut at 9 & 12 WAS in 2018, 2019 and 2020 (combined seasons)

Weed control	Rate (Kg a.i.ha^{-1})	Variety: 9 WAS			12 WAS		
		SAMNUT 22	SAMNUT 23	SAMNUT 14	SAMNUT 22	SAMNUT 23	SAMNUT 14
BUTA	2.5	1.88^{lm}	1.87^{mn}	1.85^{o}	1.12^{ijk}	1.13^{ij}	1.07^{jkl}
PENDA	2.5	1.96^{jk}	1.97^{ij}	1.86^{no}	1.17^{i}	1.19^{h}i	1.12^{ijk}
BUTA + PENDA	2.0 + 1.0	1.98^{ij}	1.99^{i}	1.86^{mno}	1.20^{hi}	1.21^{hi}	1.15^{ij}
PENDA + BUTA	2.0 + 1.0	2.16^{g}	2.17^{fg}	1.93^{l}	1.45^{g}	1.81^{f}	1.29^{h}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	2.19^{ef}	2.19^{ef}	1.98^{k}	2.51^{bc}	2.53^{bc}	2.06^{e}
BUTA fb SHW at 6 WAS	2.0	2.19^{e}	2.21^{de}	2.12^{h}	2.53^{bc}	2.56^{b}	2.13^{e}
PENDA fb SHW at 6 WAS	1.5	2.22^{bcd}	2.33^{abc}	2.12^{h}	2.67^{a}	2.68^{a}	2.345^{d}
PENDA fb SHW at 6 WAS	2.0	2.38^{abc}	2.38^{abc}	2.29^{c}	2.74^{a}	2.75^{a}	2.44^{cd}
Weeding at 3 and 6 WAS	-	2.34^{ab}	2.35^{a}	2.20^{cd}	2.75^{a}	2.75^{a}	2.45^{c}
Weedy check	-	1.83^{p}	1.82^{p}	1.81^{p}	1.02^{l}	1.03^{kl}	1.00^{l}
Level of significance			**			**	
SE (±)			0.008			0.035	

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability using Duncan Multiple Range Test. BUTA =Butachlor; PENDA = Pendimethalin; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% ($P \leq 0.01$).

Table 11: Mean of combined analysis across seasons on effect of weed control and variety on number of pods plant^{-1}, mean pod weight, 100 seed weight, seed yield and harvest index of groundnut during 2018, 2019 and 2020 cropping seasons

Treatments	Rate (Kg a.i.ha^{-1})	Number of pods plant^{-1}	Mean pod weight plant^{-1} (g)	100 seed weight (g)	Seed yield (Kg ha^{-1})	Harvest index (%)
Weed control (W)						
BUTA	2.5	22.81^{f}	48.10^{h}	29.58^{d}	457.1^{e}	38.07^{e}
PENDA	2.5	25.41^{e}	50.94^{g}	30.01^{cd}	494.1^{d}	38.63^{e}
BUTA + PENDA	2.0 + 1.0	26.81^{d}	53.12^{f}	30.14^{cd}	499.2^{d}	41.63^{d}
PENDA + BUTA	2.0 + 1.0	27.19^{d}	57.49^{e}	30.84^{c}	531.1^{c}	42.59^{d}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	28.67^{c}	59.09^{d}	35.71^{ab}	575.4^{b}	51.07^{c}
BUTA fb SHW at 6 WAS	2.0	30.22^{b}	61.97^{c}	35.92^{ab}	591.7^{b}	51.19^{bc}
PENDA fb SHW at 6 WAS	1.5	30.63^{b}	69.36^{b}	36.14^{ab}	628.3^{a}	52.74^{b}
PENDA fb SHW at 6 WAS	2.0	34.11^{a}	70.03^{ab}	37.10^{a}	637.3^{a}	53.66^{ab}
Weeding at 3 and 6 WAS	-	34.85^{a}	71.02^{a}	37.43^{a}	637.6^{a}	54.67^{a}
Weedy check	-	13.37^{g}	42.56^{i}	19.82^{e}	297.6^{f}	27.00^{f}
Level of significance		**	**	**	**	**
SE (±)		0.347	0.487	0.652	5.99	0.530
Variety (V)						
SAMNUT 22		29.98^{a}	59.09^{a}	30.81^{b}	540.6^{b}	47.83^{a}
SAMNUT 23		30.83^{a}	61.17^{a}	34.71^{a}	584.5^{a}	46.72^{a}
SAMNUT 14		22.61^{b}	54.55^{b}	32.18^{b}	503.7^{b}	40.43^{b}
Level of significance		**	**	**	**	**
SE (±)		0.504	1.104	0.535	13.30	0.675
Season (Y)						
2018		23.51^{b}	50.01^{b}	26.77^{b}	386.9^{b}	32.66^{b}
2019		28.96^{a}	70.90^{a}	37.97^{a}	621.0^{a}	51.17^{a}
2020		27.98^{a}	68.82^{a}	35.78^{a}	614.2^{a}	50.11^{a}
Level of significance		*	**	**	**	**
SE (±)		1.136	1.521	0.684	16.27	3.494
Interaction						
W x V		**	**	NS	**	**
W x Y		**	**	NS	**	**
V x Y		**	**	NS	NS	NS
W x V x Y		NS	NS	NS	NS	NS

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability using Duncan Multiple Range Test. BUTA =Butachlor; PENDA = Pendimethalin.fb[1]= Followed by; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% ($P \leq 0.01$); * = significant at 1% ($P \leq 0.05$).
NS = Not significant.

lin.fb[1]= Followed by; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% (P ≤ 0.01

Table 12: Interaction between weed control and variety on number of pods plant^{-1} and mean pod weight of groundnut in 2018, 2019 and 2020 (combined seasons)

Weed control	Rate (Kg a.i.ha^{-1})	Variety: Number of pods plant^{-1}			Mean pod weight (g)		
		SAMNUT 22	SAMNUT 23	SAMNUT 14	SAMNUT 22	SAMNUT 23	SAMNUT 14
BUTA	2.5	23.56^{lm}	25.78^{jk}	19.44^{o}	49.69^{o-s}	51.54^{m-r}	46.19^{u}
PENDA	2.5	28.44^{fgh}	27.89^{g-j}	19.78^{o}	52.13^{n-q}	52.67^{m-p}	48.74^{p-t}
BUTA + PENDA	2.0 + 1.0	28.56^{efg}	29.33$_{efg}$	22.33^{mn}	54.04^{mn}	55.14^{lm}	49.14^{o-t}
PENDA + BUTA	2.0 + 1.0	28.78^{fg}	30.11^{ef}	23.00^{lm}	58.99^{jkl}	60.82^{ijk}	51.33^{m-s}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	30.56^{de}	32.00^{cd}	23.44^{lm}	60.88^{ijk}	62.36^{g-j}	52.88^{mno}
BUTA fb SHW at 6 WAS	2.0	32.67^{c}	32.78^{c}	24.67^{kl}	62.79^{f-i}	65.23^{e-h}	57.88^{kl}
PENDA fb SHW at 6 WAS	1.5	33.22^{c}	32.89^{c}	26.33^{hjk}	70.21^{bcd}	71.30^{c}	65.97^{efg}
PENDA fb SHW at 6 WAS	2.0	36.67^{b}	37.33^{ab}	27.22^{g-j}	70.39^{bc}	73.90^{ab}	66.38^{def}
Weeding at 3 and 6 WAS	-	38.44^{ab}	39.00^{a}	28.22^{f-i}	70.72^{bc}	74.91^{a}	67.42^{cde}
Weedy check	-	20.67^{no}	19.11^{o}	12.00^{p}	42.88^{u}	43.74^{u}	37.76^{v}
Level of significance			**			**	
SE (±)			0.761			1.363	

Table 13: Interaction between weed control and season on number of pods plant^{-1} and mean pod weight of groundnut in 2018, 2019 and 2020 (combined seasons)

Weed control	Rate (Kg a.i.ha^{-1})	Number of pods plant^{-1} Season			Mean pod weight (g) Season		
		2018	2019	2020	2018	2019	2020
BUTA	2.5	22.89^{no}	25.15^{h-p}	24.71^{h-p}	32.78^{m}	54.51^{j}	54.11^{j}
PENDA	2.5	22.78^{m-q}	25.56^{g-o}	25.16^{g-n}	32.78^{m}	60.34^{hi}	60.84^{hi}
BUTA + PENDA	2.0 + 1.0	25.33^{h-p}	27.44^{f-k}	26.72^{e-l}	32.88^{m}	62.73^{g}	61.99^{g}
PENDA + BUTA	2.0 + 1.0	25.56^{h-p}	27.78^{fgh}	26.68^{e-i}	33.02^{m}	69.99^{f}	69.77^{f}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	26.00^{h-m}	30.33^{cde}	30.13^{c-f}	43.09^{l}	72.20^{ef}	71.60^{ef}
BUTA fb SHW at 6 WAS	2.0	26.67^{e-m}	32.00^{bcd}	31.82^{bcd}	43.89^{l}	75.82^{d}	75.22^{d}
PENDA fb SHW at 6 WAS	1.5	27.44^{e-j}	32.22^{b}	32.01^{bc}	44.26^{l}	87.52^{bc}	85.92^{bc}
PENDA fb SHW at 6 WAS	2.0	27.89^{efg}	37.22^{a}	37.12^{a}	57.46^{k}	88.76^{abc}	88.67^{abc}
Weeding at 3 and 6 WAS	-	28.33^{b-g}	38.11^{a}	37.97^{a}	57.46^{k}	90.02^{a}	89.06^{ab}
Weedy check	-	19.89^{qr}	16.18^{r}	16.11^{r}	30.10^{n}	32.57^{m}	32.50^{m}
Level of significance			**			**	
SE (±)			1.272			1.718	

Table 14: Interaction between variety and season on number of pods plant^{-1} and mean pod weight of groundnut in 2018, 2019 and 2020 seasons

Season	Variety: Number of pods plant^{-1}			Mean pod weight (g)		
	SAMNUT 22	SAMNUT 23	SAMNUT 14	SAMNUT 22	SAMNUT 23	SAMNUT 14
2018	26.53^{bc}	27.37^{b}	20.40^{e}	33.39^{c}	34.97^{c}	32.01^{c}
2019	31.70^{a}	32.57^{a}	22.63^{d}	73.12^{a}	75.24^{a}	64.33^{b}
2020	30.71^{a}	31.77^{a}	22.60^{d}	73.08^{a}	75.18^{a}	64.22^{b}
Level of significance		**			**	
SE (±)		1.341			2.179	

Table 15: Interaction between weed control and variety on seed yield and harvest index of groundnut in 2018, 2019 and 2020 (combined seasons)

Weed control	Rate (Kg a.i.ha^{-1})	Variety: Seed yield (Kg ha^{-1})			Harvest index (%)		
		SAMNUT 22	SAMNUT 23	SAMNUT 14	SAMNUT 22	SAMNUT 23	SAMNUT 14
BUTA	2.5	474.8^{pqr}	522.2^{l-p}	397.7^{s}	37.56^{l}	34.56^{m}	34.00^{m}
PENDA	2.5	491.9^{opq}	546.0^{i-l}	451.4^{r}	39.89^{kl}	40.22^{jkl}	39.56^{kl}
BUTA + PENDA	2.0 + 1.0	503.3^{lnop}	547.6^{h-l}	458.1^{qr}	41.11^{g-k}	43.33^{f-i}	40.33^{i-l}
PENDA + BUTA	2.0 + 1.0	531.1^{k-n}	558.9^{g-k}	461.6^{qr}	44.00^{fgh}	42.80^{fg}	43.11^{f-j}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	616.0^{ef}	621.8^{def}	528.6^{j-o}	55.56^{abc}	53.11^{cd}	44.22^{f}
BUTA fb SHW at 6 WAS	2.0	618.2^{ef}	629.2^{de}	544.8^{j-m}	56.22^{ab}	54.00^{bcd}	44.56^{f}
PENDA fb SHW at 6 WAS	1.5	623.9^{cde}	670.6^{abc}	590.3^{d-i}	56.44^{ab}	54.34^{a-d}	44.89^{f}
PENDA fb SHW at 6 WAS	2.0	635.8^{bcd}	682.1^{ab}	593.9^{d-i}	57.11^{a}	55.11^{abc}	47.56^{e}
Weeding at 3 and 6 WAS	-	633.0^{cd}	684.6^{a}	595.3^{d-h}	57.11^{a}	55.33^{abc}	48.56^{e}
Weedy check	-	387.1st	382.2st	363.4^{t}	27.00^{n}	27.78^{n}	25.22^{o}
Level of significance			**			**	
SE (±)			16.54			1.102	

Table 16: Interaction effect between weed control and season on kernel yield and harvest index of groundnut in 2018, 2019 and 2020 2020 seasons

Weed control	Rate (Kg a.i.ha^{-1})	Season					
		Seed yield (Kg ha^{-1})			Harvest index (%)		
		2018	2019	2020	2018	2019	2020
BUTA	2.5	381.6^{qr}	526.4^{kmn}	518.4^{kmn}	30.33^{j}	41.33^{c-h}	40.12^{c-h}
PENDA	2.5	381.^{6qr}	531.3^{i-l}	524.7^{i-m}	30.33^{j}	41.78^{c-h}	40.98^{c-h}
BUTA + PENDA	2.0 + 1.0	385.2^{qr}	562.4^{ij}	546.8^{ijk}	30.89^{j}	46.00^{def}	44.40^{d-g}
PENDA + BUTA	2.0 + 1.0	386.3^{pqr}	575.9^{h}	568.2^{hi}	30.89^{j}	47.44^{d}	45.84^{d}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	395.7^{opq}	670.6^{g}	658.7^{g}	35.89^{hi}	60.33^{bc}	60.33^{bc}
BUTA fb SHW at 6 WAS	2.0	414.3^{op}	694.4^{b-g}	679.7^{b-g}	36.89^{hi}	60.44^{bc}	58.94^{bc}
PENDA fb SHW at 6 WAS	1.5	416.0^{o}	735.2^{a-c}	727.4^{a-c}	36.89^{hi}	62.11^{bc}	60.18^{bc}
PENDA fb SHW at 6 WAS	2.0	430.3^{o}	739.2^{abc}	722.2^{a-d}	38.89^{hi}	62.67^{bc}	61.88^{bc}
Weeding at 3 and 6 WAS	-	433.3^{o}	748.4^{a}	729.8^{ab}	39.40^{hi}	65.56^{a}	63.76^{ab}
Weedy check	-	311.4^{t}	372.7^{qr}	358.4^{qrs}	25.22^{k}	24.07^{k}	24.00^{k}
Level of significance			**			**	
SE (±)			19.01			3.601	

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability using Duncan Multiple Range Test. BUTA =Butachlor; PENDA = Pendimethalin.fb[1] = Followed by; SHW= Supplementary hoe weeding; WAS= Weeks after sowing. ** = significant at 1% ($P \leq 0.01$

EFERENCES

Adhikary, P., Patra, P.S., & Ghosh, R. (2016). Influence of Weed management on growth and yield of groundnut in Gangetic plains of West Bengal. *Indian Legume Research*, 39 (2), 274-278.

Amaregouda, A., Jadhav, J., Chetti, M.B., & Nawalagatti. (2013). Effect of weedicides on physiological parameters, growth, yield and yield components of soybean (*Glycine max* L.) and weed growth. *Journal of Agriculture and Allied Sciences*, 2 (4), 12-15.

Agasimani, C. A., Shanwad, U. K., Aravndkumar, B. N., Shuvamurth, S. D., Ashork, S., & Jalageri, B. R. (2010). Integrated weed management (IWM): A long time case study in groundnut-wheat cropping system in Northern Karnataka. *Research Journal of Agricultural Sciences*, 1 (3), 196-200.

Chandu, L. T., Shrivastava, G. K., Sreedevi, B., & Thakur, A. K., (2018). Realizing aerobic rice potential in Indian integrated weed management perspective. *International Journal of Current Microbiology Applied Science*, 7 (02), 575-589.

Cosser, N.D., Gooding, M.J., Thompson, A.J., & Froud-Williams, R.J. (1997). Competitive ability and tolerance of organically grown wheat cultivars to natural weed infestations. *Annals of Applied Biology*, 130, 523-535.

Danful,R., Kassim,Y.B., Puozaa,D.K., Oteng-Frimpong,R., Abdul Rasheed,M., Wireko-Kena, A., & Richard Akromah, R. (2019). Genetics of Stay-Green Trait and Its Association with Leaf Spot Tolerance and Pod Yield in Groundnut. *International Journal of Agronomy*, vol. 2019, Article ID 3064026, 11 pages, https://doi.org/10.1155/2019/3064026.

de Vida, F.B., Pérez, L., Emilio, A., Mackill, D.J., Fernández, G.M., & Fischer, A.J (2006). Relating rice traits to weed competitiveness and yield: A path analysis. *Weed Science*, 54,1122-1131

Didon, U.M.E., & Hansson, M.L. (2002). Competition between six spring barley (*Hordeum vulgare* ssp. vulgare L.) cultivars and two weed flora in relation to interception of photosynthetic active radiation. *Biology, Agriculture and Horticulture,* 20, 257-274

Dingkuhn, M., Johnson, D.E., Sow, A., & Audebert, A.Y. (1999). Relationships between upland rice canopy characteristics and weed competitiveness. *Field Crop Research*, 61,79-95

Duncan, D.B., (1955). Multiple Range and Multiple F-tests. Biometrics, 11: 1-42.

Etejere, E. O., Olayinka, B. U., & Wuraola, A. J. (2013). Comparative economic efficacy of different weed control methods in groundnut. *Electronic Journal of Biological Sciences* (EJBS), *7* (2), 10-18

FAO. (2013). Food and Agriculture Organization of United Nations. Available online at: http://faostat.fao.org/DesktopDefault.aspx?PageID=339

Ferdous, J., M. H. Ali., M. S. Islam., I. F. Chowdhury., M. N. Haque., & S. M. Masum. (2017). Growth and yield of soybean as affected by irrigation and weed control methods. *Bangladesh Journal of Weed Science*, 6, 17-26.

Fradgley, N.S., Creissen,H.E., Pearce,H., Howlett, S.A., Pearce,B.D., Döring, T.F., & Girling, R.D. (2017). Weed Suppression and Tolerance in Winter Oats. *Weed Technology*, 31 (5): 740-751

Gardner, F. P., Pearce, R. B. & Mistechell, R. L. (1985). **Physiology of Crop Plants**. Iowa State Univ. Press. Iowa, 500010. p.66.

GenStat (2015). Release 16.3DE. VSN International, 5 The Waterhouse, Waterhouse Street, Hemel Hempstead, Hertfordshire HP1 1ES, UK.

Janila, P., Ramaiah, V., Rathore, A., Upakula, A., Reddy, R. K., Waliyar, F., & Nigam, S. N. (2013). Genetic analysis of resistance to late leaf spot in interspecific groundnuts. *Euphytica*, 193, 13–25.

Janila, P., Variath, M. T., Pandey, M. K., Desmae, H., Motagi, B. N., Okori, P., … Varshney, R. K. (2016). Genomic tools in groundnut breeding program: Status and perspectives. *Frontiers in Plant Science*, 7, 289. https://doi.org/10.3389/fpls.2016.00289

Kashid, N. V., (2019). Integration of post-emergence herbicide application with hand weeding for managing weeds in transplanted rice. *Indian Journal of Weed Science*, 51 (2) 206-208.

Kraehmer, H & Baur, P. (2013). **Weed Anatomy**. Wiley-Blackwell 504 Page

Jat, R.S., Meena, H.N., Singh, A.L., Jaya, N.S., & Misra, J.B. (2011). Weed management in groundnut (*Arachis hypogaea* L.) in India: A review. Agricultural Reviews, 32 (3), 155-171.

Lal, S., Kewat, M.L., & Suryavanshi, T. (2017). Weed indices as influenced by proprquizafop and imazethapyr mixture in soybean. *International Journal of Current Microbiology and Applied Sciences*, 6 (8), 3109-3115.

Mani, V. S., Chakraborty, T. K., & Gautam, K. C. (1976). Double hedge weed killers in peas. *Indian Farm*, 26 (2), 80-83.

Meena, Babulal., Sagarka, B.K., & Pisal, R.R. (2011). Impact of some herbicides and cultural practices on weed and crop parameters in kharif pigeon pea [*Cajanus cajan* (L.) Millsp.]. *Legume Research*, 34 (1), 55-58

Mekonnen, G., Sharma, J. J., Tana, T., & Nigatu, L. (2015). Effect of integrated weed management practices on weeds infestation, yield components and yield of Cowpea [Vigna unguiculata

(L.) Walp.], Eastern Wollo, Northern Ethiopia. *American Journal of Experimental Agriculture*, 7(5), 326-346. doi:10.9734/AJEA/2015/ 14513

Melaku, W. (2008). A preliminary guide to plant collection, identification and herbarium techniques. In The National Herbarium Addis Ababa University, Ethiopia. Addis Ababa University, Faculty of Science, Biology Department.

Mitra, B., Bhattacharya, P.M., Ghosh, A., Patra, K., Chowdhury, A.K., & Gathala, M.K. (2019). Herbicide options for effective weed management in zero-till maize. *Indian Journal of Weed Science*, 50 (2), 137-141.

Olayinka, B.U., & Etejere, E.O. (2015). Growth analysis and yield of two varieties of groundnut (*Arachis hypogaea* L.) as influenced by different weed control methods. *Indian Journal of Plant Physiology*, 20 (2), 130-136.

Olorunmaiye, P. M., & Olorunmaiye, K. S. (2009). Effect of integrated weed management on weed control and yield components of maize and cassava intercrop in a southern Guinea savanna ecology of Nigeria. *Australian Journal of Crop Science*, 3 (3), 129-136

Omisore, J. K., Aboyeji, C. M., & Daramola, O. F. (2016). Comparative evaluation of weed control methods on cowpea (*Vign unguiculata* (L.) Walp) production in the Savanna Agroecological zone of Nigeria. *Scientia Agriculturae*, 14 (3), 279-283.

Pereira, G. A. M., Barcellos, J.R., Silva Jr, L. H., Braga, D.V., Teixeira, R.R., M. M., Silva, A. A., & Ribeiro, J. I., Jr. (2015). Application height in herbicides efficiency in bean crops. *Planta Daninha*, 33 (3), 607–614. doi:10.159.

Prashanth, R., Kalyana Murthy, K. N., Madhu Kumar, V., Murali, M. & Sunil, C. M. (2016), Bispyribac sodium influence on nutrient uptake by weeds and transplanted rice. *Indian Journal of Weed Science*, 48 (2), 217-219.

Priya, R.S., Chinnusamy, C., Manickasundaram, P. & Babu, C. (2013). A review on weed management in groundnut (*Arachis hypogaea* L.). *International Journal of Agricultural Science & Research* (IJASR), 3 (1), 163-171.

Rana, S.S., & Kumar, S. (2014). Practical Manual, Principles and practices of weed management. Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, 55 pages. (DOI:10.13140/RG.2.2.27494.01603).

Rathod, A.D., Solanki, R.M., Modhavadia, J.M. and Padamani, D.R. (2014). Efficacy of pre-and post emergence herbicides in onion and their carry over effect on the succeeding crops. *Annals of Agricultural Research*, 35 (2), 209-16.

Reid, A., Gonzalez, V., Sikkema, P. H., Lee, E. A., Lukens, L., & Swanton, C. J. (2014). Delaying weed control lengthens the anthesis-silking interval in maize delaying weed control lengthens the anthesis-silking interval in maize. *Weed Science*, 62, 326-337. https:// doi.org/10.1614/WS-D-13-00099.1

Rezvani, M., Ahangari, M., & Zaefarian, F. (2012). Effect of cultivars and weeding regimes on soybean yields. *International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering*, 6 (9), 714–716.

Sangeetha, C., Chinnusamy C., & Prabhakaran N.K (2012). Early post-emergence herbicides for weed control in soybean. *Indian Journal of Weed Science*, 45 (2), 140- 142.

Shalu Kumari., Mahua Banerjee., R. K. Raj., Antara Chaudhuri., & Sujay Kumar Paul. (2020). Effect of Weed Management Practices on Growth and Yield of Summer Groundnut (*Arachis hypogaea* L.) in Red and Lateritic Soil. *International Journal of Current Microbiology and Applied Sciences*, 9 (4), 2059-2063. DOI: https://doi.org/10.20546/ijcmas.2020.904.246.

Shittu, E.A., Fagam, A.S., Garba, A.A., and Sabo, M.U. (2021). Evaluating Physiological Growth Parameters of Maize (*Zea mays* L.) as affected by Weed Control Measures and Variety in Bauchi State, Nigeria. *Faman Journal*, 21 (2), 84-99.

Shittu, E.A., & Abdullahi, S.Y. (2022a). Growth Performance of Sorghum (*Sorghum bicolor* L. Moench) as Influenced by Variety and Weed Control Treatment in a Semi-Arid Ecology of Nigeria. International Academic Research Consortium Journals (IARCJ), *International Journal of Agricultural Science and Technology*, 9 (6), 1-16. www.arcnjournals.org.

Shittu, E.A., & Abdullahi, S.Y. (2022b). Yield and Yield Attributes of Sorghum Varieties (*Sorghum bicolor* [L]. Moench) As Influenced by Weed Control in Sudan and Northern Guinea Savanna Ecology of Nigeria. *International Academy Journal of Agribusiness and Agricultural Science Annals*, 6 (2), 1- 14. Academic Science Archives (ASA). DOI: 272142522721621.

Siddhu, G.M., Patil, B.T., Bachkar, C.B., & Handal, B.B. (2018). Weed management in garlic (*Allium sativum* L.). *Journal of Pharmacognosy and Phytochemistry*, 7 (1), 1440 -1444.

Singh, B. (2016). Survey and Indexing of Weeds Growing around Potato Fields for Their Role as an Inoculum Source for Potato leafroll virus (PLRV). Br. *Biotechnology Journal*, 16, 1-8.

Smita, P., K.J. Kubde., & Sujata Bankar. (2014). Effect of Chemical Weed Control on Weed Parameters, Growth, Yield Attributes, Yield and Economics in Soybean (*Glycine max* L.). *American Eurasian Journal of Agriculture & Environmental Science*, 14 (8), 698-701.

Trezzi, M. M., Balbinot, J. A. A., Benin, Debastani, G.F., Patel, F., & Miotto, J.E. (2013). Competitive ability of soybean cultivars with horse weed (*Conyza banariensis*). *Planta Daninha*, Viscosa-MG. 31, 543.550.

Tripathy, P., Sahoo, B.B., Patel, D., & Dash, D.K. (2013). Weed management studies in onion (*Allium cepa* L.). *Journal of Crop and Weed*, 9 (2), 210-12.

Yadav, S.L., Kaushik, M.K., & Mundra, S.L. (2011). Effect of weed control practices on weed dry weight, nutrient uptake and yield of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] under rainfed condition. *Indian Journal of Weed Science*, 43 (1-2), 81-84.

Zerner, M.C., Rebetzke, G.J, & Gill, G.S (2016) Genotypic stability of weed competitive ability for bread wheat (*Triticum aestivum* L.) genotypes in multiple environments. *Crop Pasture Science*, 67 (7), 695-702. https://doi.org/10.1016/j.cropro.2018.08.001