NATIONAL INNOVATION AND RESEARCH ACADEMIA
International Journal of Agribusiness and Agricultural Sciences
ISSN: 2713-4670. Volume 7, Issue 1. Pages 01- 17. November, 2022 DOI:5472145227721
Double Blind Peer Reviewed International Research Journal
editornirajournals@gmail.com

Weed Control Efficiency, Nodulation and Yield Response of Groundnut as Affected by Weed Control, Variety, and Season in Bauchi, Nigeria

SHITTU, E.A[1&2]., FAGAM, A.S[2]., GARBA, A.A[2]., SABO, M.U[2]., GWORGWOR, N.A[3]

[1]Department of Agronomy, Bayero University Kano, Nigeria
[2]Department of Crop Production, Abubakar Tafawa Balewa University, Bauchi, Nigeria
[3]Department of Crop Production, University of Jos, Plateau, Nigeria

*Corresponding Authors; Email: seabraham.agr@buk.edu.ng; +2348024695219

Abstract: *Three years (2018-2020) rainy season trials were conducted at Abubakar Tafawa Balewa University Teaching and Research Farm, Gubi, Nigeria to evaluate the weed control efficiency, nodulation and yield attributes of groundnut (Arachis hypogea L.) varieties. The trials consisted of ten weed control treatments and three varieties of groundnut replicated three times in a split plot design. Data were collected on both weed and crop attributes. Results from the study indicated that weed parameters such as weed cover scores, weed density and weed dry weight were significantly lower under the application of pendimethalin at 2.0 kg a.i.ha^{-1} fb 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 were supplemented with hoe weeding at 6 WAS than those that received pre-emergence herbicide alone. Number of nodules, dry matter production, pod yield and kernel yield were significantly higher with the application of hoe weeding at 3 and 6 WAS, pendimethalin at 2.0 and 1.5 kg a.i.ha^{-1} fb SHW at 6 WAS. The SAMNUT 22 variety produced higher nodulation and dry matter while SAMNUT 23 variety produced higher pod and kernel yield, respectively. Findings from the trials revealed that application of pendimethalin at 2.0 and 1.5 kg a.i.ha^{-1} fb SHW at 6 WAS and manual weeding at 3 and 6 WAS with SAMNUT 22 and SAMNUT 23 can be adopted by farmers towards boosting groundnut yield in the study area.*

Keywords: *Weed control efficiency, nodulation, yield, herbicide, variety*

Introduction

Groundnut (*Arachis hypogaea* L.) is a superior source of edible protein, edible oil, energy, vital fatty acids, vitamins, and minerals for human nutrition (Willett *et al*., 2019). The eating of groundnuts has been linked to several health benefits (Sabate *et al*., 2010; Guasch-Ferré *et al*., 2017). Groundnut crop yields are influenced by a variety of agronomic management approaches as well as other factors that contribute to low productivity, such as disease, insects, drought; climate change, deteriorating soil fertility; and weed infestation (Yussif *et al*., 2014; Oppong-Sekyere *et al*., 2015;Kristjanson *et al*., 2017). Weed infestation is the most significant yield-limiting issue. Weeds compete with the crop for available growth resources in the early stages due to the crop's slow growth (Bretagnolle and Gaba, 2015). They interfere with crop growth if not regulated, resulting in a decrease in production and, in severe cases, crop failure (Llewellyn *et al*., 2016). Moreover, several weed species have been reported to serve as reservoirs or alternative weed hosts of plant viruses in nature which are usually transmitted by insect vectors to healthy crops in the fields (Abraham *et al.,* 2020, 2021a and 2021b). Weed competition was directly linked to a decrease in crop output (Kombiok *et al*., 2012). Weeds flourish under drought conditions better than crop plants. According to Prasad *et al*., (2002), and Korav *et al*. (2020), the critical period for crop-weed competition of groundnut is between 40-45 days after sowing, depending on the crop variety and ecology, with yield losses of up to 70 % in groundnut due to weed interference (Prasad *et al*., 2002). Hoe weeding is still the most common method of weed control in the tropics, and while it is effective, it is also time-consuming, expensive, labour-intensive, and scarce during peak periods. As a result, it is ineffective and untrustworthy. Chemical weed management, as opposed to manual hoe weeding, becomes an alternative in this situation due to its simplicity of application, time savings, and affordability (Kalhapure *et al*., 2013). Farmers' preference for varietal features including pod yield, pod size, oil content, drought resilience, and taste are also important determinants in groundnut yield. Others simply care about the haulm yield while others both haulm and pod yield. Choosing a dual-purpose cultivar will help boost groundnut production significantly and smoother growth of weeds (Agostinho *et al*., 2006). As a result, the research was designed to determine the efficacy of pre-emergence herbicides alone or in combination with hoe weeding for season-long weed control in three groundnut varieties for optimal nodulation, dry matter, and yield production.

Materials and Methods

Site description

Three years (2018-2020) rainy season studies were conducted at Abubakar Tafawa Balewa University Teaching and Research Farm, Gubi, (Lat. 10º 45' N and Long. 9º.82' E, 616m above sea level) situated in the Northern Guinea savanna ecological zone of Nigeria to evaluate the weed control efficiency, nodulation and yield attributes of groundnut varieties. The experimental site is characterized by a unimodal rainfall pattern which has a peak in the month of August. The soil of the experimental site is sandy loam with moderate water holding capacity and pH slightly acidic.

Treatments and experimental design

The trial consisted of ten (10) weed control treatments which comprised of 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.iha^{-1} *fb* SHW at 6 WAS, two hoe weeding at 3 and 6 WAS and weedy check and three varieties of maize (SAMNUT 14, SAMNUT 22 & SAMNUT 25). These were laid out in a split plot design and replicated three (3) times. The crop varieties were assigned to the main plots while weed control treatments were assigned to the sub-plots.

Field layout and Crop husbandary

In each year of the trial, the field was harrowed twice to a fine tilth and ridged into 0.75m apart using an ox-drown ridger. It was then marked into the required number of plots each with a 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 1.0m, 0.5m and 1.5m while nutrients at the rate of 20 kg N, 40 kg P_2O_5 and 20 kg K_2O using a compound fertilizer (NPK 15:15:15) and SSP 18%. However, the SSP was applied during land preparation. Sowing was done on the 28th of July 2018, 18th of July 2019 and 26th of July 2020 seasons using treated seeds of groundnut variety of SAMNUT 14, SAMNUT 22 & SAMNUT 23 obtained from Bauchi State Agricultural Development Programme (BSADP), Ministry of Agriculture, Bauchi State. Two seeds were sown along the ridge per hole at a depth of 2 cm and the resultant seedlings were thinned to one plant per stand at 3 weeks after sowing (WAS). 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. Crop varieties were harvested at the physiological maturity stage of the 2018, 2019 and 2020 seasons, respectively.

Data collection and statistical analysis

Data were collected on weed attributes such as weed cover scores, weed density, weed dry weight and weed control efficiency and crop parameters such as the number of nodules plant^{-1}, dry matter production, pod yield and kernel yield were determined using standard agronomic procudure. Data collected were subjected to analysis of variance using Genstat (17th Edition) where the 'F' test shows significance. The treatment means were separated using Duncan's multiple range test (Duncan, 1955).

Weed covers score

The weed cover score was taken at physiological maturity by visual observation on a scale of 0-4 as described by Komboik *et al*. (2003); where 0 = no weed, 1 = moderately weedy, 2 = weedy, 3 = very weedy, 4 = highly weedy.

Weed density (nm^{-2})

The weed samples counted from the 1m^2 quadrant placed randomly in each net plot were summed to obtain the total number of weed species per unit area of the quadrant.

Weed dry matter (Kg ha^{-1})

The weed samples obtained from the weed species composition were cleaned, washed and oven dried at 70^{0} C to a constant weight and weighed using Metlar MT-2000 sensitive weighing scale, the dry weight was extrapolated to a hectare basis (ha^{-1}) and recorded.

Weed control efficiency (WCE) (%)

This was computed from the data obtained in weed dry weight using the equation suggested by Mani *et al.* (1976). Thus, WCE was calculated as follows:

$$WCE\ (\%) = \frac{\text{Weed dry weight in weedy check} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in weedy check}} \times 100$$

RESULTS AND DISCUSSION

1.1 Effect of weed control, variety and season on weeds

1.1.1 Weed cover scores, weed density, weed dry weight and weed control efficiency.

The mean of combined analysis on the effect of weed control and variety on weed cover scores, weed density, weed dry weight and weed control efficiency of groundnuts at Gubi is presented in Table 1. The result indicates that weed cover scores were significantly affected by weed control treatment only. Weedy check significantly ($P \leq 0.05$) resulted in higher weed cover, weed density and weed dry weight compared with the rest of the weed control treatments while weeding twice at 3 and 6 WAS and pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS significantly ($P \leq 0.05$) had lower weed cover scores, weed density and weed dry weight. Uncontrolled weeds, as in the weedy check has the potential of reducing crop performance arising from competition for available growth resources as well as due to the allelopathic effect of the weeds on the crop. These findings are consistent with those of Channappagoudar *et al*. (2013) and Sah *et al*. (2017), who found increased weed count and weed dry weight on weedy check plots compared to treated plots in turmeric. Similarly, Alfonso *et al*. (2013) showed the maximum dry weight of weeds in weedy check followed high weed density and weed cover m^{-2} in faba bean and chickpea in Mediterranian areas. SAMNUT 14 variety significantly resulted in higher weed density than other varieties which was influenced by the genetic make of the variety to develop less canopy and branches capable of suppressing the growth of weeds compared to SAMNUT 22 and SAMNUT 23 which had more features used in suppressing weed growth. Growing groundnut in the 2018 season significantly ($P \leq 0.05$) resulted in higher weed density compared with other seasons which could be attributed to high rainfall received after a few minutes of pre-emergence herbicide application, as well as intermittent drought during the growth period, which gave the weeds an advantage to prosper more than the crops due to their different morphology and survival mechanisms, which in turn was reflected in lower WCE. However, weed density was much lower in the 2019 and 2020 seasons due to suitable environmental conditions that enhanced nutrient uptake for the development of more branches plant^{-1} and canopy expansion, which in turn suppressed weed growth as depicted in higher weed control efficiency. Interaction between weed control and variety on weed density was significant (Table 2) which it indicated that weedy check in SAMNUT 14 resulted significantly ($P \leq 0.05$) in higher weed density compared with the rest of the interaction effects. This was aided by uninterrupted weed growth and the inability of the variety to develop more branches and canopy capable of suppressing weed growth.

The result of weed dry weight shows weedy check consistently produced significantly ($P \leq 0.05$) higher weed dry weight compared with other treatments while hoe weeding twice at 3 and 6 WAS and pendimethalin at 3.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS resulted in lower weed dry weight. Alfonso *et al*. (2013) earlier reported the maximum dry weight of weeds in weedy check due to high weed density and weed cover m^{-2} in faba bean and chickpea in mediterian areas. Sathya Priya *et al*. (2013) found that pre-emergence oxyfluorfen application reduced weed density and weed dry weight in onions. Growing groundnut in the 2018 season significantly ($P \leq 0.05$) resulted in a higher weed dry weight compared with other seasons. Interaction between weed control and season on weed dry weight was significant and is shown in Table 3 where weedy check in the 2018 season significantly produced higher weed dry weight compared with the rest of the interaction effects. Weed control efficiency (WCE) on the other hand was significantly influenced by weed control, variety, season and interaction (Table 1).

Table 1: Mean of combined analysis across seasons on effect of weed control and variety on weed cover scores, weed density, weed dry weight and weed index of groundnut in 2018, 2019 and 2020 cropping seasons at Gubi.

Treatment	Rate (Kg a.i.ha^{-1})	Weed cover scores	Weed density (n m^{-2})	Weed dry weight (kg ha^{-1})	Weed control efficiency (%)
Weed control (W)					
BUTA	2.5	3.16^{b}	186.3^{b}	2120^{b}	46.30^{f}
PENDA	2.5	2.67^{c}	180.5^{c}	1868^{c}	49.44^{e}
BUTA + PENDA	2.0 + 1.0	2.43^{c}	176.3^{d}	1711^{d}	49.77^{e}
PEND + BUTA	2.0 + 1.0	2.15^{d}	167.7^{e}	1458^{e}	51.30^{e}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	2.11^{d}	46.2^{f}	613^{f}	78.59^{d}
BUTA fb SHW at 6 WAS	2.0	1.44^{e}	41.1^{g}	564^{g}	86.96^{c}
PENDA fb SHW at 6 WAS	1.5	1.22^{f}	35.0^{h}	522^{h}	87.61^{bc}
PENDA fb SHW at 6 WAS	2.0	0.89^{g}	28.3^{i}	497^{i}	90.29^{ab}
Weeding at 3 and 6 WAS	-	0.89^{g}	27.8^{i}	496^{i}	91.03^{a}
Weedy check	-	3.78^{a}	399.6^{a}	4558^{a}	-
Level of significance		**	**	**	**
SE (±)		0.193	0.423	8.00	1.059
Variety (V)					
SAMNUT 22		2.27	128.4^{b}	1438	72.03^{a}
SAMNUT 23		2.29	128.9^{b}	1436	69.33^{b}
SAMNUT 14		2.38	130.2^{a}	1448	68.12^{c}
Level of significance		NS	**	NS	**
SE (±)		0.072	0.147	5.83	0.460
Season (Y)					
2018		2.28	133.9^{a}	1631^{a}	67.64^{b}
2019		2.33	124.4^{b}	1340^{b}	71.40^{a}
2020		2.30	126.2^{b}	1345^{b}	71.34^{a}
Level of significance		NS	**	**	*
SE (±)		0.098	0.482	5.46	0.940
Interaction					
W x V		NS	**	NS	**
W x Y		NS	NS	**	NS

V x Y	NS	NS	NS	NS
W x V x Y	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% ($P \leq 0.01$); NS = Not significant.

Table 2: Interaction effect between weed control and variety on weed density of groundnut in 2018, 2019 and 2020 (combine season)

Weed control	Rate (Kg a.i.ha^{-1})	Variety		
		SAMNUT 22	SAMNUT 23	SAMNUT 14
BUTA	2.5	186.0^{e}	184.9^{e}	188.1^{d}
PENDA	2.5	180.0^{f}	180.7^{f}	180.9^{f}
BUTA + PENDA	2.0 + 1.0	175.0^{h}	176.2^{gh}	177.8^{g}
PENDA + BUTA	2.0 + 1.0	168.9^{i}	165.9^{j}	168.4^{i}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	45.4^{l}	44.4^{l}	48.8^{k}
BUTA fb SHW at 6 WAS	2.0	39.6^{m}	39.7^{m}	44.2^{l}
PENDA fb SHW at 6 WAS	1.5	34.9^{n}	35.7^{n}	34.4^{n}
PENDA fb SHW at 6 WAS	2.0	29.4^{o}	26.4^{p}	29.0^{o}
Weeding at 3 and 6 WAS	-	27.7^{op}	25.9^{p}	26.8^{p}
Weedy check	-	396.7^{c}	398.8^{b}	403.4^{a}
Level of significance			**	
SE (±)			0.711	

Table 3: Interaction effect between weed control and season on weed dry weight of groundnut in 2018, 2019 and 2020 (combine season)

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	

Application of weeding twice at 3 and 6 WAS significantly ($P \leq 0.05$) resulted in higher WCE though at par with pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS, pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and butachlor at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS compared with sole application of butachlor at 2.5 kg a.i.ha^{-1} that resulted in lower WCE. Higher WCE values obtained by such treatments might be attributed to the treatments' low weed density, weed dry weight and weed cover score values as a result of season-long weed management. This discovery backs up the findings of Kalhapure and Shete

(2012), who found that two-to-three hoe weeding's resulted in significantly higher weed control efficacy due to reduced weed density and weed dry weight. Furthermore, Mallik *et al*. (2017) and Siddhu *et al*. (2018) found significantly enhanced WCE of garlic due to applications of pendimethalin 30 EC + one hoe weeding at 45 DAT and oxyflourfen 0.150 kg ha^{-1} + quizalofop ethyl 0.05 kg ha^{-1}, respectively. SAMNUT 22 significantly ($P \leq 0.05$) resulted in higher WCE compared with other varieties. Cultivating groundnut in the 2019 and 2020 seasons significantly ($P \leq 0.05$) resulted in higher WCE than 2018 season which recorded lower WCE due to higher weed density arising from heavy rainfall shortly after herbicidal treatments application as well as the intermittent drought observed during the growing season. Higher WCE values in the 2019 and 2020 seasons compared to the previous season could be attributed to favourable environmental circumstances that resulted in higher treatment efficacy in reducing the weed population, letting the crop use the available growth resources for assimilate production. This conclusion supports the findings of Mallik *et al*. (2017) and Siddhu *et al*. (2018) who found that herbicidal treated plots with SHW at intervals had greater weed control efficiency due to the treatments' season-long weed control. Interaction between weed control and variety on WCE of groundnut was significant and is presented in Table 4. The result shows that hoe weeding twice at 3 and 6 WAS and pendimethalin 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 in SAMNUT 22 and SAMNUT 23 and hoe weeding twice in SAMNUT 14 significantly ($P \leq 0.05$) resulted in higher weed control efficiency though at par with butachlor at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and butachlor at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS in SAMNUT 22, SAMNUT 23 and SAMNUT 14 compared with the rest of the interaction effects. This was aided by season-long weed control which reduces crop-weed rivalry for limited growth resources while simultaneously increasing 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 weed control efficiency and weed control index in pigeon pea, cluster bean, onions respectively, due to maximum weed management resulting in yield gain.

Table 4: Interaction effect between weed control and variety on weed control efficiency of groundnut in 2018, 2019 and 2020 (combine season)

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	

1.2 Effect of weed control, variety and season on crop attributes

1.2.1 Number of nodules plant^{-1}, dry matter production, pod yield and kernel yield

The mean of combined analysis on the effect of weed control treatment and variety on the number of nodules plant^{-1}, dry matter production, pod yield and kernel yield of groundnut at Gubi is presented in Table 5. Nodulation in groundnut was significantly influenced by weed control, variety, season and interactions. Hoe weeding twice at 3 and 6 WAS significantly ($P \leq 0.01$) produced higher nodulation compared to the weedy check that had a lower nodulation count. This is possible, however, because herbicides may have a negative impact on nodulation, either directly by affecting Rhizobium or indirectly by reducing photosynthetic allocation to nodules for N fixation, or by limiting root growth and thus the number of root sites available for infection. Weed infestation, on the other hand, may also limit crop root growth due to underground competition for space, nutrients, and moisture, resulting in reduced yield as seen in the weedy check. SAMNUT 22 variety significantly ($P \leq 0.05$) produced a higher number of nodules plant^{-1} compared with other varieties under investigation. The superiority of SAMNUT 22 in producing a higher number of nodules could be attributed to their genetic make-up and environmental interaction, which facilitates the production of more nodules than SAMNUT 23 and SAMNUT 14. Groundnut grown in the 2019 and 2020 seasons significantly ($P \leq 0.01$) produced higher nodulations compared to those grown in 2018. The 2019 and 2020 season's superiority of producing more nodules can be attributed to a sufficient distribution of environmental growth resources combined with effective weed control, which resulted in mutual symbiosis activity between the soil flora and fauna. Studies by Vaziritabar *et al*. (2014) further confirm our result that when herbicides are applied in the field, particularly pendimethalin, they significantly reduced soybean nodulation. However, the herbicide effects varied significantly by location or season, implying that environmental factors are important factors influencing the efficacy of the herbicide. Soil moisture availability, for example, appears to be a key factor influencing plant health, herbicide uptake, and metabolism and ultimately the ability of the plant to recover from the stress of herbicide application as the temperature changes. The interaction between weed control and variety is shown in Table 6. Results indicate that application of hoe weeding at 3 and 6 WAS and pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS significantly ($P \leq 0.01$) resulted in producing a higher number of nodules compared with the rest of the interaction effects. Interaction between weed control and season (Table 7) shows that plots weeded twice at 3 and 6 WAS in the 2019 season significantly ($P \leq 0.01$) resulted in higher nodulation though at par with other weed control treatments in the 2019 and 2020 seasons. Table 8 on the other hand, shows the interaction between variety and season on the number of nodules plant^{-1} where SAMNUT 22 variety in 2019 and 2020 seasons significantly ($P \leq 0.01$) produced higher nodulation compared with other interaction effects. The significant interactions observed could be attributed to less weed-crop competition for available growth resources combined with suitable environmental conditions that influence rhizobia activity. Our findings were corroborated by Ferdous *et al*. (2017), who observed an increase in crop growth and vigour in all seasons due to less weed-crop competition, by reducing the allelopathic effect of weeds on crops. As a result, there is more room for root growth and development. Our result further corroborated with those of Vaziritabar *et al*. (2014) who stated that herbicide efficacy in the field is influenced by factors such as rainfall, temperature, and so on. In the 2019 and 2020 seasons, the favourable environmental conditions might have aided SAMNUT 22 in producing significantly more nodules than other interaction effects. Dry matter production was significantly influenced by weed control, variety and season, where the application of hoe weeding twice at 3 and 6 WAS significantly ($P \leq 0.05$) resulted in higher dry matter production which was also at par with pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and pendimethalin at 1.5 kg a.i.ha^{-1} *fb* 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. Our findings are consistent with those of Sangeetha *et al*. (2012), Smita *et al*. (2014), and Patel *et al*. (2016) who reported separately 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 increased plant heights, number of plant stand^{-1}, LA and LAI, resulting in higher dry matter production. In contrast, the weedy check had significantly less dry matter accumulation, indicating that it was unable to control weeds, which affected dry matter production.

Table 5: Mean of combined analysis across seasons on effect of weed control and variety on number of nodules plant^{-1}, dry matter production, pod yield and kernel yield of Groundnut in 2018, 2019 and 2020 cropping seasons at Gubi.

Treatment	Rate (Kg a.i.ha^{-1})	Number of Nodules plant^{-1}	Dry matter production (Kg ha^{-1})	Pod yield (Kg ha^{-1})	Kernel yield (Kg ha^{-1})
Weed control (W)					
BUTA	2.5	49.81^{h}	311.0^{g}	734.5^{g}	457.1^{e}
PENDA	2.5	49.41^{h}	326.1^{f}	771.9^{f}	494.1^{d}
BUTA + PENDA	2.0 + 1.0	51.89^{g}	330.8^{f}	836.7^{e}	499.2^{d}
PENDA + BUTA	2.0 + 1.0	54.48^{f}	353.1^{e}	894.0^{d}	531.1^{c}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	60.33^{e}	392.2^{d}	1073.7^{c}	575.4^{b}
BUTA fb SHW at 6 WAS	2.0	61.15^{d}	428.7^{c}	1118.7^{b}	591.7^{b}
PENDA fb SHW at 6 WAS	1.5	62.37^{c}	434.5^{b}	1160.4^{a}	628.3^{a}
PENDA fb SHW at 6 WAS	2.0	63.44^{b}	442.9^{ab}	1167.9^{a}	637.3^{a}
Weeding at 3 and 6 WAS	-	64.41^{a}	447.9^{a}	1173.6^{a}	637.6^{a}
Weedy check	-	40.07^{i}	203.7^{h}	465.6^{h}	297.6^{f}
Level of significance		**	**	**	**
SE (±)		0.266	3.72	12.11	5.99
Variety (V)					
SAMNUT 22		62.03^{a}	404.9^{a}	941.5^{b}	540.6^{b}
SAMNUT 23		57.10^{b}	390.6^{b}	986.8^{a}	584.5^{a}
SAMNUT 14		49.28^{c}	315.1^{c}	920.8^{b}	503.7^{b}
Level of significance		**	**	**	**
SE (±)		1.227	2.33	12.85	13.30
Season (Y)					
2018		44.57^{b}	349.3^{b}	787.1^{b}	386.9^{b}
2019		61.92^{a}	380.6^{a}	1031.0^{a}	621.0^{a}

2020	60.12[a]	379.3[a]	1011.0[a]	614.2[a]
Level of significance	**	**	*	**
SE (±)	0.896	3.28	32.88	16.27
Interaction				
W x V	**	NS	NS	**
W x Y	**	NS	NS	**
V x Y	**	NS	NS	NS
W x V x Y	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 ≤ 0.01); .* = significant at 5% (P ≤ 0.05).

Table 6: Interaction effect between weed control and variety on number of nodules plant[1] of groundnut at in 2018, 2019 and 2020 (combine season)

Weed control	Rate (Kg a.i.ha[-1])	Variety		
		SAMNUT 22	SAMNUT 23	SAMNUT 14
BUTA	2.5	53.11[k-n]	51.33 [l-q]	45.00[s]
PENDA	2.5	53.56[k-n]	50.00[npr]	44.67[s]
BUTA + PENDA	2.5 + 1.0	57.33[j]	52.89[l-o]	45.44[s]
PENDA + BUTA	2.5 + 1.0	59.44[h]	55.44[jk]	48.56[qr]
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	66.89[cd]	61.33[i]	52.78[k-p]
BUTA fb SHW at 6 WAS	2.0	67.56[c]	62.89[gh]	53.00[kmn]
PENDA fb SHW at 6 WAS	1.5	70.56[b]	63.56[dfg]	53.00[kmn]
PENDA fb SHW at 6 WAS	2.0	71.89[a]	64.33[cdf]	54.11[j-m]
Weeding at 3 and 6 WAS	-	72.78[a]	65.67[cde]	54.78[jkl]
Weedy check	-	47.22[rs]	43.56[st]	41.44[t]
Level of significance			**	
SE (±)			1.303	

Table 7: Interaction effect between weed control and season on number of nodules plant[-1] of ground nut at in 2018, 2019 and 2020 (combine season)

Weed control	Rate (Kg a.i.ha[-1])	Season		
		2018	2019	2020
BUTA	2.5	45.44[m]	67.78[gi]	52.11[l]
PENDA	2.5	45.44[m]	67.78[gi]	55.78[k]
BUTA + PENDA	2.5 + 1.0	45.22[mn]	55.78[k]	59.56[j]
PENDA + BUTA	2.5 + 1.0	44.33[mn]	59.56[j]	52.11[l]
BUTA fb[1] SHW [2] at 6 WAS[3]	1.5	52.11[l]	67.78[hi]	52.00[l]
BUTA fb SHW at 6 WAS	2.0	52.00[l]	69.11[efg]	69.11[fgh]
PENDA fb SHW at 6 WAS	1.5	44.33[mn]	71.44[cde]	71.44[cde]
PENDA fb SHW at 6 WAS	2.0	44.22[mn]	73.00[bc]	73.00[abc]
Weeding at 3 and 6 WAS	-	44.22[mn]	74.44[a]	74.44[ab]
Weedy check	-	38.00[o]	44.00[mn]	43.11[n]
Level of significance			**	
SE (±)			0.997	

Table 8: Interaction effect between Variety and season on Number of nodules plant[-1] of groundnut at in 2018, 2019 and 2020 (combine seasons)

Season	Variety		
	SAMNUT 22	SAMNUT 23	SAMNUT 14
2018	46.03^{d}	43.90^{d}	43.77^{d}
2019	70.03^{a}	63.70^{b}	52.03^{c}
2020	69.83^{a}	62.83^{b}	50.87^{c}
Level of significance		**	
SE (±)		1.953	

Table 9: Interaction effect between weed control and season on kernel yield of groundnut in 2018, 2019 and 2020 seasons at Gubi

Weed control	Rate (Kg a.i.ha^{-1})	Season		
		2018	2019	2020
BUTA	2.5	381.6^{qr}	526.4^{kmn}	518.4^{kmn}
PENDA	2.5	$381.^{6qr}$	$531.3^{i\text{-}l}$	$524.7^{i\text{-}m}$
BUTA + PENDA	2.5 + 1.0	385.2^{qr}	562.4^{ij}	546.8^{ijk}
PENDA + BUTA	2.5 + 1.0	386.3^{pqr}	575.9^{h}	568.2^{hi}
BUTA fb[1] SHW[2] at 6 WAS[3]	1.5	395.7^{opq}	670.6^{g}	658.7^{g}
BUTA fb SHW at 6 WAS	2.0	414.3^{op}	$694.4^{b\text{-}g}$	$679.7^{b\text{-}g}$
PENDA fb SHW at 6 WAS	1.5	416.0^{o}	$735.2^{a\text{-}e}$	$727.4^{a\text{-}e}$
PENDA fb SHW at 6 WAS	2.0	430.3^{o}	739.2^{abc}	$722.2^{a\text{-}d}$
Weeding at 3 and 6 WAS	-	433.3^{o}	748.4^{a}	729.8^{ab}
Weedy check	-	311.4^{t}	372.7^{qr}	358.4^{qrs}
Level of significance			**	
SE (±)			19.01	

SAMNUT 22 variety significantly (P ≤ 0.05) produced higher dry matter than other varieties. The superiority of SAMNUT 22 in producing a higher dry matter could be attributed to their genetic make-up and environmental interaction, which aided the variety to produce more nodules which in turn may lead to higher dry matter production. Growing groundnut in the 2019 and 2020 seasons, significantly (P ≤ 0.05) resulted in higher dry matter accumulation and production compared with those grown in the 2018 season which could be attributed to a sufficient distribution of environmental growth resources combined with effective weed control, which results in mutual symbiosis activity between the soil flora and fauna. Our 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.

The results on pod yield shows that weed control, variety and season significantly affected the pod yield of groundnut where the application of two hoe weeding's at 3 and 6 WAS, pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and pendimethalin at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS produced significantly (P ≤ 0.01) higher pod yield compared to weedy check that resulted in lower pod yield. However, This demonstrates the treatment's effectiveness in causing less crop-weed competition throughout the crop's growth period, less weed count, and less weed dry weight of weeds enhanced water and food intake, which may have increased the availability of carbohydrates by speeding up photosynthetic activity, led in cell division, multiplication, and elongation, resulting in an increase in cell size for growth and yield production. This current finding is consistent with those of Bhale *et al*. (2012) and Nikhil Reddy *et al*. (2016), who found that effective weed control strategies increased groundnut pod production. Furthermore, Amaregouda *et al*. (2013) also confirm that effective weed control strategies boost soybean growth and pod yield. SAMNUT 23 variety significantly ($P \leq 0.01$) produced higher pod yield compared with other varieties. The dominance of the SAMNUT 23 variety in producing significantly ($P \leq 0.05$) higher pod yield could be related to the variety's genetic composition converting the numerous flowers into pegs and pods might favour larger and heavier pods due to seed size. According to Harrison *et al*. (2014), high producing varieties generate more pegs and convert them into matured pods. The cultivation of groundnut in the 2019 and 2020 seasons significantly ($P \leq 0.05$) produced a higher pod yield than the 2018 season. Similarly, increased pod yields in the 2019 and 2020 seasons might be ascribed to favourable environmental conditions and nutrient uptake, which allowed for the development of a higher number of pods per plant^{-1}, which is directly related to mean pod weight and pod yield, than the previous season. Our current findings corroborate with the assertion of Yadav *et al*., 2011 and 2017), who claim that crops perform better when weeds are efficiently managed. Similarly, Omisore *et al*. (2016) and 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.

Kernel yield on the other hand was significantly influenced by weed control, variety, season and interaction. The application of hoe weeding twice at 3 and 6 WAS, pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and pendimethalin at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS significantly ($P \leq 0.05$) produced higher kernel yield compared to weedy check that resulted in lower kernel yield. This demonstrates the treatment's efficacy in reducing crop-weed competition throughout the crop's growth period, as evidenced by higher weed control efficiency (WCE). Our findings support those of Bhalerao *et al*. (2011) and Olayinka and Etejere (2015), who both reported increased groundnut seed yields as a result of good weed control. Weedy check, on the other hand, had the lowest kernel yield, owing to continuous weed interference. Amaregouda *et al*. (2013) discovered similar results with soybeans. SAMNUT 23 variety produced significantly ($P \leq 0.05$) higher kernel yield compared with other varieties. The cultivation of groundnut in the 2019 and 2020 seasons significantly ($P \leq 0.05$) resulted in a higher kernel yield compared to the 2018 season. The higher kernel yield in the 2019 and 2020 seasons could be attributable to better environmental conditions and nutrient uptake, which allowed for the development of more pods per plant^{-1}, which is directly related to mean pod weight, pod yield, and kernel yield. Our findings corroborate those of Parthipan (2020), who previously found that crops perform better when weeds are efficiently managed. According to Pereira *et al*. (2015), the number of pods produced plant^{-1} favours mean pod weight and pod yield which is impacted by a variety of environmental and management parameters. The interaction between weed control and variety on kernel yield is shown in Table 9. Results reveal that hoe weeding's at 3 and 6 WAS in SAMNUT 23 significantly ($P \leq 0.05$) resulted in producing higher kernel yield which was at par with pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and pendimethalin at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS in SAMNUT 23 and

SAMNUT 22, butachlor at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and butachlor at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS in SAMNUT 23 and SAMNUT 22 compared with the rest of the interaction effects. This could be attributed to the treatments' good weed management, which led to a larger number of pods plant^{-1}, mean pod weight, and pod yield; all of which are favoured by a greater number of branches, canopy spread, CGR and NAR. Table 10 presents the interaction between weed control and season on kernel yield of groundnut where hoe weeded at 3 and 6 WAS in 2019 season produced significantly ($P \leq 0.05$) higher kernel yield which was at par hoe weeded at 3 and 6 WAS in 2020 season, pendimethalin at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and pendimethalin at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS, butachlor at 2.0 kg a.i.ha^{-1} *fb* SHW at 6 WAS and butachlor at 1.5 kg a.i.ha^{-1} *fb* SHW at 6 WAS in 2019 and 2020 seasons compared with the remaining interaction effects demonstrated its potency in enhancing the production of higher kernel yield which was aided by spectrum efficacy of the second hoe weeding to control the second flush of weeds. Due to good weed control strategies and favourable weather conditions that assisted nutrient mobilization to pod and kernel development, the number of branches plant^{-1} and a canopy spread of the crop increased, resulting in each peg being transformed into pods and kernels. Similar data on the number of pods plant^{-1} and pod yield were previously reported by Olayinka and Etejere (2015).

CONCLUSION AND RECOMMENDATIONS

Results from the trials indicated that weed parameters such as weed cover scores, weed density and weed dry weight were significantly lower under the application of pendimethalin at 2.0 kg a.i.ha^{-1} *fb* 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 were supplemented with hoe weeding at 6 WAS than those that received only pre-emergence herbicide alone. Similarly, the number of nodules, dry matter production, pod yield and kernel yield were significantly higher with the application of hoe weeding at 3 and 6 WAS, pendimethalin 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. SAMNUT 22 variety produced higher nodulation and dry matter while SAMNUT 23 variety produced higher pod and kernel yield, respectively. 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 application of pendimethalin 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 and or manual weeding at 3 and 6 WAS with SAMNUT 22 or SAMNUT 23 can be adopted by farmers towards boosting groundnut yield in the study area.

REFERENCES

Abraham, P., Banwo, O. O., David Kashina, B., & Alegbejo, M. D. (2020). Survey for Alternative Weed Hosts of Tomato mosaic virus in Field-Grown Tomato Crops in Sudan Savanna, Nigeria. *Nigerian Journal of Weed Science*, 33 (1),16-30.

Abraham, P., Banwo, O. O., Kashina, B. D., & Alegbejo, M. D. (2021a). Detection of Weed Species Infected by Tomato ring spot virus in Field-grown Tomato in Sudan Savanna, Nigeria. *Nigerian Journal of Plant Protection*, 35 (2), 1-15.

Abraham, P., Banwo, O. O., David Kashina, B., & Alegbejo, M. D. (2021b). Identification of Weed Hosts of Tomato yellow leaf curl virus in Field-Grown Tomato in Sudan Savanna, Nigeria. *International Journal of Horticultural Science and Technology*, 8 (3), 235-246.

Agostinho, F.H., Gravena, R., Alves, P.L.C.A., Salgado, T. P and Mattos, E.D. (2006). The Effect of Cultivar on Critical Periods of Weed control in Peanut. *Peanut Science*, 33(1), 29-35.

Amaregouda A, Jadhav J, Chetti MB, 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.

Alfonso, S., Frenda, Paolo, R., Sergio, S., Benedetto, F., Giuseppe, D., Gaetano, A., & Dario, G. (2013). The critical period of weed control in Faba bean and Chickpea in Mediterranean areas. *Weed Science Society of America*, 61 (3), 452-459. doi:10.1614/WSD-12-00137.1.

Bhale, V. M., Karmore, J.V., Patil, Y.R. and Krishi, P.D. (2012). Integrated weed management in groundnut (*Arachis hypogaea* L.). *Pakistan Journal of Weed Science Research*, 18 (Special Issue), 733-739.

Bretagnolle, V and Gaba, S. (2015) Weeds for bees? A review. *Agronomy and Sustain Development*, 35 (3), 891-909. https:// doi.org/10.1007/s13593-015-0302-5.

Channappagoudar, B. B., Babu, V., Naganagoudar, Y. B. and Rathod, S. 2013. Influence of herbicides on morpho-physiological growth parameters in turmeric (*Curcuma longa* L.). *The Bioscan*, 8(3), 1019-1023.

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

Ferdous, J., M. H. Ali., M. S. Islam., I. F. Chowdhury., M. N. Haque and S. M. Masum. (2017). Growth and yield of soybean as affected by irrigation and weed control methods. *Bangladesh Journal of Weed Science*, 6 (1&2),17-26.

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

Guasch-Ferré, M., Liu, X., Malik, V. S., Sun, Q., Willett, W. C., Manson, J. E., et al. (2017). Nut consumption and risk of cardiovascular disease. *Journal of American College of Cardiology*, 70 (20), 2519-2532. doi: 10.1016/j.jacc.2017.09.035.

Harrison, K. D., Mohammed, I and Awuah, R.Y. (2014). Phenological Development and Yield of Three Groundnut Varieties as Influenced by Plant Density in a Forest-savanna Transition Zone. *International Journal of Agricultural Research*, 9 (2), 87-98. DOI: 10.3923/ijar.2014.87.98

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. DOI: 10.5958/0974-8164.2019.00043.1

Kombiok, J.M., Buah, S.S.J., Dzomeku, I.K., Abdulai, H., (2012). Sources of pod yield losses in Groundnut in the Northern Savanna Zone of Ghana. *West African Journal of Applied Ecology*, 20 (2), 53-63.

Komboik, J. M., Safo, E. Y., Quansah, C. and Ibana, S. (2003). Assessment of Weed Infestation and Economic Returns of Maize/Cowpea Intercrop under Tillage System in Northern Ghana. *Ghana Journal of Agricultural Science*, 36, 107-109.

Korav, S., Ram, V and Ray, L.I.P. (2020). Critical period for crop-weed competition in groundnut (Arachis hypogaea L.) under mid altitude of Meghalaya. *Journal of Crop and Weed*, 16 (1), 217-222. DOI: https://doi.org/10.22271/09746315.2020.v16.i1.1296

Kalhapure, A.H. and Shete, B.T. (2012). Integrated weed management in onion. Indian Journal of Weed Science, 44 (2), 88-91.

Kalhapure, A.H., Shete, B.T. and Bodake, P.S. (2013). Integration of chemical and cultural methods for weed management in groundnut. *Indian Journal of Weed Science*, 45 (2), 116-119.

Kristjanson, P., Bryan, E., Bernier, Q., Twyman, J., Meinzen-Dick, R., Kieran, C., Ringler, C., Jost, C., Doss. C. (2017). Addressing gender in agricultural research for development in the face of a changing climate: where are we and where should we be going? *International Journal of Agricultural Sustainability*, 15 (5),482-500. DOI: 10.1080/14735903.2017.1336411.

Llewellyn, R. S., Ronning, D., Ouzman, J., Walker, S., Mayfield, A., and Clarke, M. (2016). Impact of Weeds on Australian Grain Production: The Cost of Weeds to Australian Grain Growers and the Adoption of Weed Management and Tillage Practices. Report for GRDC. CSIRO, 112.

Mallik, S., Sharangi, A. B. and Datta, N. (2017). Herbicidal option in managing weeds towards growth and yield dynamics of single clove garlic. *International Journal of Agricultural Sciences*, 9 (1), 3627-3630.

Meena, Babulal, Sagarka, B.K. and 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.

Nikhil Reddy, C., Vidyasagar, G. E. Ch and Laxminarayana, P. (2016). Integrated weed management in Rabi Groundnut (*Arachis hypogaea* L.). *International Journal of Current Research*, 8 (11), 40883-40885.

Olayinka, B.U and 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.

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

Oppong-Sekyere, D., Akromah, R., Akpalu, M.M., Ninfaa, A.D., Nyamah, E., Braimah, M.M, Salifu, A.R. (2015). Participatory rural appraisal of constraints to groundnut (*Arachis hypogaea* L.) production in northern Ghana. *International Journal of Current Research and Academic Review*, 3 (10), 54-76.

Patel, R.I., Patel, P.H., Piyush K.S., and Patel N. V. (2016). Weed Management in Field Pea (Pisum sativum L.). *The Bioscan an International Quarterly Journal of Life Sciences*, 11(3),1703-1706.

Parthipan, T. (2020). Weed management strategies for enhanced productivity in groundnut. *Current Journal of Applied Science and Technology*, 39 (29), 15-19. DOI: 10.9734/cjast/2020/v39i2930952

Pereira, G. A. M., Barcellos, J.R, L. H., Jr, Silva, D. V., Braga, R. R., Teixeira, 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.

Prasad, T.V.R., Narsimha, N., Dwarakanath, N. and Krishnamurthy, K. (2002). Efficacy of Oxyfluorfen for weed control in irrigated groundnut. *International Arachis News Letter*, 2, 9-11

Sabate, J., Oda, K., and Ros, E. (2010). Nut consumption and blood lipid levels: a pooled analysis of 25 intervention trials. *Archives of Internal Medicine*, 170 (9), 821-827. doi: 10.1001/archinternmed.2010.79.

Sah, D., Heisnam, P., Mahato, N. K. and Pandey, A. K. (2017). Weed Management in Ginger (Zingiber officinale Roscoe) through Integrated Approaches. *International Journal of Current Microbiology and Applied Science*, 6 (10), 1839-1845.

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.

Sathya Priya Ramalingam., Chinnusamy Chinnagounder., Manickasundaram Perumal., Murali Arthanari Palanisamy (2013). Evaluation of New Formulation of Oxyfluorfen (23.5% EC) for Weed Control Efficacy and Bulb Yield in Onion. *American Journal of Plant Sciences*, 4, 890-895. http://dx.doi.org/10.4236/ajps.2013.44109.

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

Smita, P., K.J. Kubde and 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.

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

Vaziritabar. Y., Vaziritabar, Y., Paknejad, F., Golzardi, F. and Tafty, S. F. (2014). Investigation of bio-fertilizer and selective herbicides application on control of Chenopodium album and Amaranthus retroflexus in soybean. *Journal of Biodiversity and Environmental Science*, 4 (6), 269-277.

Yadav, R., Bhullar, M.S., Kaur, S., Kaur, T. & Jhala, A.J. (2017). Weed control in conventional soybean with pendimethalin followed by imazethapyr + imazamox/quizalofop-p-ethyl. *Canadian Journal of Plant Science*, 97 (4), 654-664. doi.org/10.1139/cjps-2016-0123.

Yadav, S.L., Kaushik, M.K. and 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.

Yussif, I. J., Kwoseh, C., Osman, M., Acheremu, K., Yirzagla, J. (2014). Farmers' perception and farming practices on the effect of early and late leaf spots on groundnut production in northern Ghana. *Journal of Biology, Agriculture and Health*, 4 (19), 22-28.

Willett, W., Rockstrom, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., et al. (2019). Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, 393 (10170), 447-492. doi: 10.1016/S0140-6736(18)31788-4.