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RESEARCH ARTICLE

EFFECTS OF PLANT POPULATION AND DIFFERENT LEVELS OF PHOSPHOROUS ON SEED YIELD OF SPIDER PLANTS (*CLEOME GYNANDRA*) IN VIHIGA COUNTY.

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Abstract

Cleome gynandra has common names as African cabbage, spider flower, spider wisp, cat's whiskers. It is an erect herbaceous biannual herb with hairy, often stems color ranging from purple to cream and many branches growing to a height of about one meter. It is propagated by seeds through sowing directly and thinning done four weeks after planting. It's an African leafy vegetable and a medicinal plant. It's known to play a key role in providing necessary nutrients such as iron, calcium, zinc, potassium, iodine, and Magnesium for human development. It requires well-drained loamy soils with an average rainfall of 1700 mm per year; the mean monthly maximum and minimum temperature requirement are 23.8^0C and 12.4^0C respectively. Farmers producing it, often face the challenge of spacing, fertilizer use, land fragmentation and declining soil fertility. There are various recommendations on spacing and phosphorous nutrients required; thus, prompting the need to study the effects of spacing/ P levels on seed yield of spider plant in Vihiga County. From the results obtained, the two parameters affect plant height, number of branches, number of pods and seed yield significantly.

Introduction:-

Cleome gynandra is a bi-annual ALV, commonly referred to as spider plant/spider weed or spider flower. It is native to Africa, Asia, and the Middle East.

In Africa, it is grown extensively in the lowlands and mid-latitude regions, particularly in the dry savannah sometimes, as a sole crop, but more often intercropped with bananas, coffee, and any other ALV like amaranth, cowpea and corchorus spp.

In Kenya, the crop is grown in mid and high altitude areas although it tolerates drought, survives well in low altitude regions, but early flowering occurs. Compared to other food crops, the spider plant is not produced for commercial purposes. However, it is a major source of dietary calcium, protein, and iron in many. Due to its multiple uses, it is important as a vegetable for humans. It is estimated that the annual world spider plant crop is grown on 2 Million ha and the total grain production is 30,000 tons although only a small proportion enters the international trade (Ahmed, et al., 2012)

The plant has the ability to regenerate if there are several buds left (Ayana, et al, 2013).

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Spider plant is a quick growing crop and is characterized by a long tap root and a wide vegetative spread, making it an excellent plant for soil erosion prevention and weed suppression. It is known to have allelopathic compounds that suppress weeds. However, it is less successful at suppressing perennial grasses, so cultivation between rows is vital.

The crop is intercropped easily with cotton and as a ground cover in orchards. Also, it finds its use in the rearing of birds, including wild turkeys as they are fed on seeds and as a cover for quails, with other varieties specifically being used for wildlife purposes (Clark, 2007)

Spider plant continues to blossom and produce seed for an extended period, not exceeding 3 months. Early flowering occurs during water stress conditions.

Spider plant leaves and soft stems can play an important role towards meeting the food needs of the resource poor. The production of spider plant as a leafy-vegetable, however, appears to have increased markedly in many areas in recent years as farmers shift to more drought tolerant species. Additionally, fresh, immature pods and flowers are eaten as veges by man and poultry respectively. Other uses of spider plant include; its stems used as a mulch/manure and cover crops controlling soil erosion.

The plant's ability to withstand drought, short growing period (3months) and multipurpose use makes it an attractive alternative for farmers in marginal drought-prone areas with low rainfall and less developed irrigation systems (Said, Itulya & Ehler, 2007).

African leafy vegetables (ALVs) are reputed to play a key role in providing necessary micronutrients for balanced diets (Kipkosgei, 2004). In western Kenya, where increasing food insecurity continues to ravage most people living in rural areas or slum areas in urban centers, there is urgent need to address issues relating to hidden hunger. The low-income levels of these marginalized groups disqualify them from accessing benefits from exotic vegetables that require high levels of inputs.

The ALVs, though neglected over the years by scientists, farmers, and policymakers, offer a possibly cheaper and more readily available source of micronutrients (Tagwira, Piha & Mugwira, 1992). Some of the important micronutrients obtained from ALVs include iron, calcium, zinc, potassium, iodine, and magnesium for human development. For instance, Iron is essential for the formation of hemoglobin and myoglobin and its deficiency leads to anemia, a condition of low hemoglobin. Growing children, pregnant and breastfeeding mothers and heavy-duty workers require large amounts of calcium strong bone and teeth formation. Problems associated with calcium deficiency in diets such as bone mineral loss, leading to rickets in children and osteomalacia in adults, are increasingly being recognized in Africa as important contributing factors to fractures in old age among women (FAO, 1997). Zinc is another mineral recognized as necessary for normal growth, resistance to infectious diseases and reduction of incidences of still-births and possibly impaired cognitive development.

The main sources of micronutrients such as iron and calcium are meats, milk, and supplements. Among the third world countries, however, and especially among marginalized communities, these rich sources are expensive and beyond the reach of many. Edible green leafy vegetables, some of which grow in the wild or are semi-cultivated, such as ALVs, could, therefore, provide a potentially cheaper and readily available alternative source among the resource-poor and marginalized groups, especially women, children and the elderly.

Available literature on nutrient composition of ALVs varies greatly with agro-ecological zones, as well as mineral availability from the soil (Mengel, 1979; Gomez, 1982; OnisandOnyango, 2000). The expansion of production and promotion of the consumption of ALVs in Kenya is hampered by poor crop management, particularly, spacing and fertilizer use; hence, declining soil fertility levels, and necessitating supplemental fertilization (OkokoandOdera, 1997). Apparently, there has been no study on the relationship between plant density and nutrient levels in western Kenya, Vihiga County. *Cleome gynandra* is used as an indigenous vegetable plant and can be found all over the world, growing as a weed in roadsides and in open grasslands. In western Kenya, it is cultivated and grows spontaneously everywhere. The plant is used for medicinal purposes as described in Ayurvedic pharmacopeia of India and in other ancient medical texts. It is a chief constituent in Narayana Churna, where it is used as an Anthelmentic, in-ear diseases, pruritis and several other diseases such as gastrointestinal disorders and infections (Mishra, Singh & Dagenais, 2011*)*. The main objective of the study was, therefore, to determine the effects of plant population and different levels of phosphorus on seed yield of spider plant (*Cleome gynandra)*, in western Kenya, Vihiga County.

Methodology:-

Site Description:-

The experiment was carried out in Gisambai location, Hamisi District, Vihiga County, on a two farmers' fields. The study site lies at an altitude of1685 m above sea level and is within latitude 0^o20'N and longitude $35^0$40'E. The site receives an average rainfall of 1700 mm per year, with long rains starting from March/April and ending in June/July, while short rains fall between September and December. The mean monthly maximum and minimum temperature are 23.8^0C and 12.4^0C respectively. The site is under eutricnitisol units according to FAO/UNESCO classification (FAO/UNESCO, 1974). These soils are deep, well drained and have a dark reddish-brown color. This area was chosen based on the popularity and levels of utilization of Cleomegynandra, by the community residing thSoil samples from the site were taken from a depth of 0-20 and 20-40 cm. The samples were air-dried and ground to pass through a 2 mm sieve and analyzed for total P by the Mehlich method; pH using a ratio of 1:2.5 soil water. The soil reaction (pH) was moderately acidic in both sites and requires dolomitic lime. Levels of soil phosphorus, nitrogen, Potassium, calcium, magnesium, and carbon (organic matter contents) were very deficient in soils from both sites too (Appendices I and II).

Climatology:-

Hamisi is in the Eastern part of the County, where rainfall is bimodal, conventional in nature. Long rains occur in March and April and short rains occur in September and December. April is the wettest month while the driest period is December to January. The mean annual rainfall range is 1700 mm. The County is warm and wet. The average annual temperature is 18^oC. The temperatures are highest in the months of December and January (which top 20^oC to23.8^oC in some instances) while lowest Temperatures occur around March and April (12.4^0C) before the long rains.

Soils:-

Soils in the study area are reddish brown sandy loam (eutric). They have low to moderate fertility. The soils of the experimental area were sampled and analyzed in the month of June 2014. Samples were taken from the top (0-15 cm). The samples were labeled and sent for analysis at MEAltd, Nakuru. The results indicated that Nitrogen, phosphorus, and zinc are deficient (Appendices I and II).

Land Preparation and Plant Establishment:-

The seeds of Cleome were obtained from a certified seed company. The seeds were pregerminated to test its viability.provision for bucket irrigation in times of drought. First, the germination test was carried out and the germinationresults were above 90% germination, and the seeds were accepted as viable. Demarcation of blocks and plots wasdone before the seeds were then subjected to the specific treatment and then planted manually on the seed beds that were prepared to a fine tilth byLand that was cleared and cultivation is done one month earlier by jembe. After leveling off the field, ridging followed at the spacing of 45 x 15 cm, 30 x 15 cm as per the plot layout and treatments and treatment combinations.

Experimental Design:-

The experimental design used was Randomized Complete Block Design (RCBD) with factorial arrangements. Plot sizes were 2 x 2 m with paths of 1m between blocks and 0.5m between the plots with a spacing of broadcasting as a control, 30 x15cm and 45 x 15cm subjected to 5 different levels of P_20_5 at a rate of 0, 20kg/ha, 30kg/ha,40kg/ha and 50kg/ha. Four ridges were made for subplots where a spacing of 45 x 15 cm was being applied and 6 lines or ridges for those of 30 x 15 cm spacing where on broadcasting subplots there were no ridging done 15 treatments and treatment combinations were replicated in three blocks (table 3.1 and figure 3.1). The experiment was conducted in Amulavu's and Musimbi's farms which were 3km apart.

Treatments and Treatment Combinations:-

Treatments-:-

Treatments consisted of three spacing at Broadcasting, 30 x15 cm, 45 x 15cm and five Triple Super Phosphate application rates at planting. The fertilizer rates applied were 50 kg P/ha, 40 kg P/ha, 30 kg P/ha and 20 kg P/ha and zero rates.

Spider plantspacing:-
Broadcasting (S_1),
30x 15 cm (S_2),
45 x 15 cm (S_3)
Triple super phosphate (TSP) - 5 levels of P_2O_5
F_1=0kg/ha
F_2=20 kg/ha
F_3=30 kg/ha
F_4=40 kg/ha
F_5=50 kg/ha

Treatments and Treatment combinations:-
The treatment combinations were as indicated in table 3.1

Table 3:-Treatment and treatment combinations

SPACINGS FERTILIZER LEVELS	S_1 (Broadcasting)	S_2 (30 x 15cm)	S_3 (45 x 15cm)
F_1 (0 kg/ha)	F_1S_1	F_1S_2	F_1S_3
F_2 (20 kg/ha)	F_2S_1	F_2S_2	F_2S_3
F_3 (30 kg/ha)	F_3S_1	F_3S_2	F_3S_3
F_4 (40kg/ha)	F_4S_1	F_4S_2	F_4S_3
F_5 (50kg/ha)	F_5S_1	F_5S_2	F_5S_3

Data Collection:-
Ten (10) plants were randomly selected using a table of random numbers in every plot and marked appropriately. During the random selection of the plants, the outer rows were avoided so as to get accurate results. These were used to sample data from the plots and the respective averages recorded for later analysis. Data collection was done weekly others fortnightly from planting to harvesting. The following data was collected:

1. Date of planting.
2. Stand count after one week
3. Plant height(weekly)
4. Number of branches per plant fortnightly
5. Time of 50% flowering
6. Number of pods per plant (start at the 8th week, and done weekly)
7. Date of harvesting at the 12th week.
8. The weight of seeds at the 14th week

All the data was recorded and sorted for final analysis as below:-

Data Analysis:-
Data were collected from the field and summarized in excel and subjected to analysis of Variance ANOVA using the SPSS version 20, and the Analysis of Variance (ANOVA) at 5% level of significance. Where there were significant differences, the means were compared using the least significant difference (LSD) and Duncan multiple ranges at $p \leq 0.05$.

Results and Discussion:-
Effects of Plant Population and P Levels on Plant Height of SpiderPlant:-
Figure 4.1shows the data on the effect of plant population and P-levels on plant height for the two sites. It shows that spacing had a major effect on plant height with a spacing of 45 x 15 cm having a more effective in almost all plots than other spacing. P levels also had a significant effect on plant height by a P level of 50kg/ha having a greater effect on plant height than P levels of 0 kg/ha, 20kg/ha, 30kg/ha, and 40 kg/ha. This is in line with Nandekar and Sawarkar (1990) and Naik, Karrim, and Han (1996); who observed that increasing Phosphorous application significantly increased plant height of spider plant. A similar observation was made by Carsky & Iwuafor (1999).

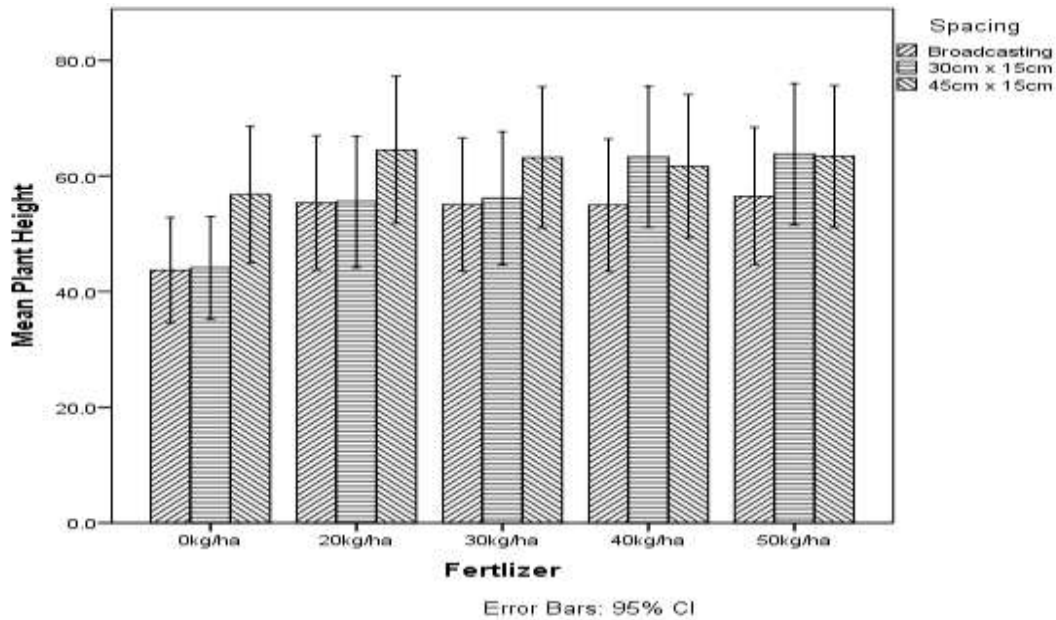

Figure4:-Effects of Plant Population and P-Levels on Plant Height

The Anova was done on the effects of plant population and P levels on plant height for the two sites(Appendix IV). The results indicate that there was a significant difference between the heights of plants with $p \leq 0.05$ for both spacings and for P levels. The blocks revealed to have no significant difference on plant heights drawn from different blocks with p-value =0.463.

The interaction effects between spacing and fertilizer were also found to be significant at $p \leq 0.05$. It indicates that there was the statistically significant difference between the interaction levels with F5S3 showing the tallest plant height with (p-value 0.000).

The post hoc test was done to investigate the factor that caused a significant difference, from table 4.1 and 4.2 showed that there were significant differences on means of plant height caused by different spacing and P levels. The test whether the difference was caused by either plant population or P-levels shows that there was significant difference effect of plant population and p-levels on plant height with lower plant population i.e.45x 15 cm having taller plants than higher plant population (broadcasting) at (P-value=0.000) and higher P-levels i.e. 50kg/ha registered taller plants than 0kg/ha P-value ≤ 0.000. The LSD and Duncan results showed that there was a significant difference on the effect of spacing and P-levels on plant height respectively. This agrees with Plaster, 1985; Memon 2003, as cited by Ahmed, Fandullahand Hussain, 2003 who observed that P is essential for the general health and vigor of plants, and it stimulates root development, increase stalk and stem strength and improves flower formation, fruiting and seed production.

Table 4:-LSDtest on the effects of spacing on plant height

	Broadcasting	30 x 15 cm	45 x 15 cm
Broadcasting		-1.466667*	-12.460000*
30 x 15 cm			-10.993333*
45 x 15 cm			

*. The mean difference is significant at the 0.05 level.

Table 5:-DMRTon effects of P-levels on plant height

P- levels	Plant height
0kg/ha	97.66[a]
20kg/ha	114.14[b]
30kg/ha	115.52[c]
40kg/ha	117.83[d]
50kg/ha	120.55[e]

Effects of Plant Population and P Levels on Number of Branches:-

Figure 4.2shows effects of spacing and P-levels on the number of branches. It clearly shows that spacing had an effect on the number of branches on each plant and plot, with a spacing of 45 x 15 cm having a much effective than a spacing of 30x 15cm and broadcasting. Phosphorous had an effect too on the number of branches whereby as the levels of P increased while the number of plants /plant population reduced, it had a positive effect/ increment on the number of branches and in the general growth of spider plant. This implies that phosphorous increases stalk and stem strength of plants.

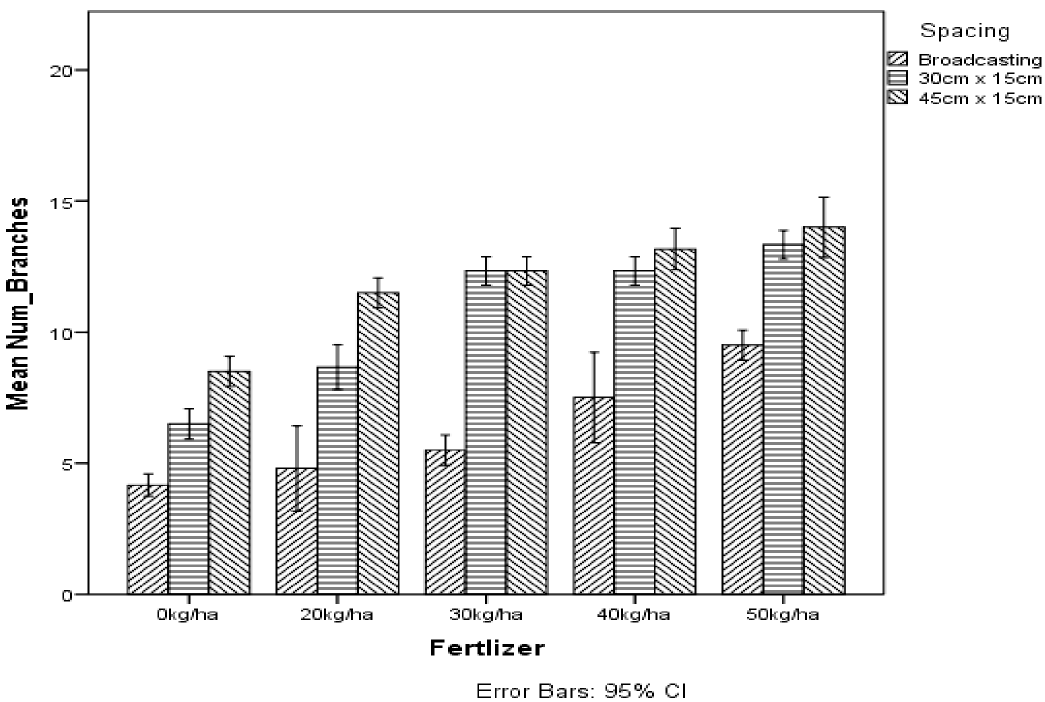

Figure 5:-Effects of Spacing and P-levels on Number of Branches

The ANOVA was done on the effects of plant population and P levels on the number of branches for the two sites. The results proved that there was a significant difference between the number of branches with $p \leq 0.05$, for both spacing and P levels. The blocks too revealed to have no significant difference on the number of branches from different blocks with p-value = 0.312.

The interaction effect between spacing and fertilizer was also found to be significant(0.000). It indicates that there was a significant difference between the interaction levels with F5S3 (P level of 50kg/ha and a spacing of 45x 15cm) showing the highest number of branches with p-value = 0.000.

The post hoc test was done to investigate the factor that caused a significant difference. In table 4.3 and 4.4, showed that there was a significant difference on the means of the number of branches caused by different spacing and P levels. The test whether the difference was caused by either plant population or P levels shows that there was significant difference between plant population and between P levels on number of branches with a spacing of 45x

15 cm having many branches than 30x 15cm and broadcasting at p≤0.05 and higher P levels of 50kg/ha registering highest number of branches than other P levels.

Table4:-LSD test on plant population effects on the number of branches

	Broadcasting	30 x 15 cm	45 x 15 cm
Broadcasting		-4.33*	-5.60*
30 x 15 cm			-1.27*
45 x 15 cm			

*. The mean difference is significant at the 0.05 level.

Table 4.1: DMRT on effects of P-levels on number of branches

P- levels	Number of branches
0 kg/ha	6.39[a]
20 kg/ha	8.33[b]
30kg/ha	10.06[c]
40 kg/ha	11[d]
50 kg/ha	12.28[e]

Table 4:-DMRT on effects of P-levels on number of branches

Effects of Plant Population and P Levels on Number of Pods Formed:-

Figure 4.3shows the effects of Spacing and P-levels on Pods formation for the spider plant. The figure clearly illustrates that as P levels increased with a decrease in the number of plants per plot, there was a significant increase in the number of pods per plant. This indicates that both spacing and P levels had an effect on pods formation in spider plant. This agrees with the findings of the study on effects of planting distances on tomato by Bustelaar and Elhart (1986), Pyzik & Dabrowska (1989) and Saggam & Yazgan (1995) who observed separately that wider spacing gave more fruits per plant and heavier fruits than closer spacing but yield per unit area increased with closer spacing. Similar results were obtained by Ahmed (1984), Met Wally, Al-Habib, and Murtan (1987), Leskovar andCantliffe (1992), Petreuska (1993), Decoteau and Graham (1994). Also, it is in line with Plaster (1985), who discovered that P is essential for the general health and vigor of plants. Adequate availability of P stimulates root development, increases stalk and stem strength and improves flower formation, fruiting and seed production. It also enhances uniform and early crop maturity increases the nitrogen-fixing capacity of legumes, improves crop quality and increases resistance to plant diseases.

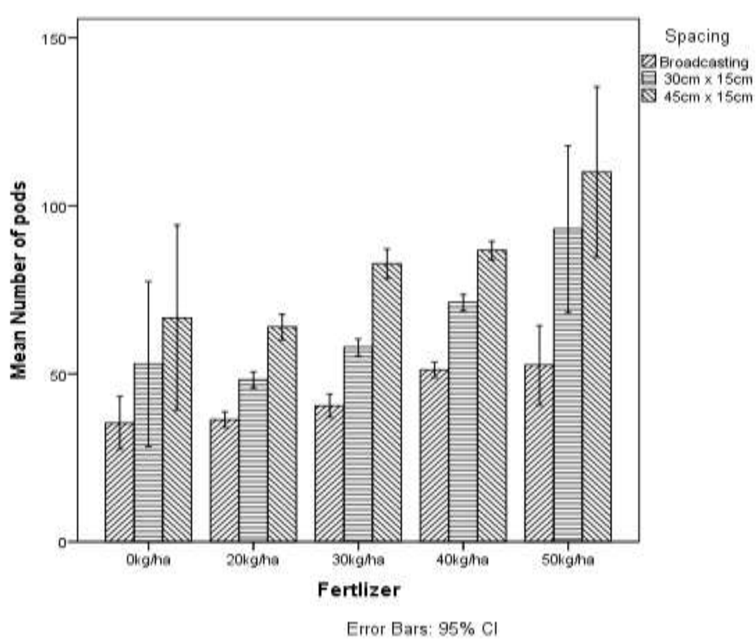

Figure 4:-Effect of Spacing and P-Levels on Number of Pods Formed

The significance test on the effect of Spacing and P levels on pods formation was done by ANOVA(AppendixVI). The results show that there were no significant differences on pods formation at 5% levels of significance for both site and blocks (p values 0.269 and 0.315 respectively) but Spacing, P-levels, and interaction showed significant differences(P-value=0.00) at 5% level of significance. Further, an LSD and Duncan test was conducted to investigate the differences between the factors i.e. Spacing and P-levels respectively. The results indicated that there was significant difference between the means of pods formed at 5% level of significance (Table 4.5) while for the Duncan there was too significant difference between effects of P levels on means of pods formed by P level of 50kg/ha registering high number of pods than the other levels (table 4.6).

Table 4.2: LSD test on spacing effects on the number of pods

Dependent Variable: Number of Pods			
Spacing	Broadcasting	30 x 15 cm	45 x 15 cm
Broadcasting		-21.43*	-36.93*
30 x 15 cm			-15.50*
45 x 15 cm			

Table4.3: DMRT on the effect of P- levels on the number of pods

P- levels	No. of pods
0 kg/ha	44.17[a]
20 kg/ha	49.44[b]
30kg/ha	60.33[c]
40 kg/ha	69.67[d]
50 kg/ha	89.50[e]

Effects of Plant Population and P Levels on Seed Yield:-

Figure 4.4 shows the effects of plant population and P-levels on seed yield. It's clear that spacing and P levels had a positive effect on the number of seeds formed per pod per plant. This implies that as space of planting increased this resulted into an increase in the amount of seed development in pods by a spacing of 45x 15cm registering highest amount of seeds than the spacing of 30x 15cm and broadcasting. P levels too had a significant effect on the amount of seed development in spider where a rate of 50kg/ha registered a higher amount of seed than control to rates of 20, 30, and 40kg/ha. This agrees with Ahmed, Fadlallah and Hussain (2003) that P is essential for the general health and vigor of plants, and it stimulates root development, increase stalk and stem strength and improves flower formation, fruiting and seed production and with Pyzik and Dabrowska (1989) and Saggam and Yazgan (1995) who observed separately that wider spacing gave more fruits per plant and heavier fruits than closer spacing but yield per unit area increased with closer spacing.

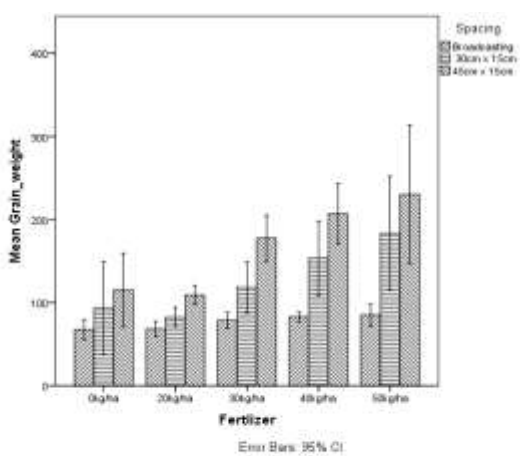

Figure 4:-Effects of Plant Population and P Levels on Seed Yield of Spider Plant

Analysis of variance was conducted to test the significant effect of Spacing and p-levels on the seed yield of the spider plant. The results in appendix VII show that Spacing and P-levels had a significant effect on the final yield of the spider plant with p≤0.05. The output for the sites was not statistically significantly different at 0.05 level of significance (P-value= 0.116). In conclusion, the spacing and use of increased level of phosphorus has an influence on the seed yield of spider plant and in-fact on all aspects of growth for the plant including height, branches, and pods. The blocks registered a significant effect on the seed yield of spider plant at 5% levels of significance. The influence was witnessed more on wider spacing (S3) and phosphorus level of 50kg/ha (F5). Interaction effects indicated that there was a significant difference between the plant population and levels of phosphorus with more yield at interaction F5S3 i.e. Spacing at 45x15cm and 50kg/ha respectively (P-value=0.000). In determining the differences in factor i.e. spacing and P-levels, a posthoc analysis was conducted. The results (Table 4.7 and 4.8 respectively) show that Spacing had significant influence in determining the seed yield for the spider plant by 45x 15cm registering the highest output followed by 30x15cm spacing then broadcasting. P-levels showed a significant difference too where 50kg/ha showing a significant influence on the amount of seed produced than 0,20 kg/ha,30 kg/ha and40kg/ha.

Table 4:-LSD test on the effects of spacing on seed yield Dependent Variable: Seed Yield

Spacing	Broadcasting	30 x 15 cm	45x 15 cm
Broadcasting		-49.70*	-91.23*
30 x 15 cm			-41.53*
45 x 15 cm			..
*. The mean difference is significant at the 0.05 level.			

Table4:-Duncan test on effects of P-levels on seed yield

P- levels	**Grain weight**
0 kg/ha	81.67[a]
20 Kg/ha	92.50[b]
30 Kg/ha	147.50[c]
40 Kg/ha	177.50[d]
50 kg/ha	205.00[e]

Conclusion:-

The study found out that plant population/ spacing has got an effect on the general growth (height, number of branches), Pods formation and subsequent seed yield/grain development in spider plant with the widest spacing of 45 x 15 cm registering tallest plants, a higher number of branches, pods and seed yield. The same applies to Phosphorous levels where P levels having an effect on the general growth of the plant, pods formation and seed yield with the highest rate of P level(50 kg/ha) registering highest results. This conforms with Carsky & Iwuafor (1999) that increased application of phosphorous leads to increased plant height.

The results indicated that plant population and P levels had a remarkable influence on the general growth of spider plant and seed yield/ grain weight of spider plant.
In this experiment it is being concluded that;

1. There was an increase in growth and seed yield parameters with an increase in fertilizer (P) rates application. Lower seed yields and growth were observed at 0 kg P/ha application rate and higher yields recorded at 50 kg P/ha application rate. Thus, application of phosphorus fertilizer at the rate of 50 kg P/ha is appropriate for the sites
2. There was an increase in growth and seed yield parameters with an increase in the spacing interval. Lower seed yields and growth were observed at broadcasting and at 30 x 15 cm spacing interval, and higher yields recorded at 45 x 15 cm spacing interval. Therefore the appropriate spacing for increased yield was 45 x 15 cm.

Recommendations:-

In this study the recommendations are:

1. Triple Super Phosphate application at the rate of 50kg P/ha is recommended for improved growth and seed yield spider plant.
2. The spacing interval of 45x 15 cm is recommended as appropriate for improved growth and seed yield of spider plant.
3. Regular soil testing should be done so that Trip Super Phosphate is applied according to soil analysis results.

4. More research work should be done using different spacing intervals and different spider plant species/varieties at different fertilizer application rates to determine the most appropriate spacing, variety, and fertilizer rates.

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