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Assessment of the compatibility of some basic cultural practices in a sustainable bio-intensive garden of green pea

A. M. Petu-Ibikunle* and A. E. Ajiboye

Department of Agricultural Science and Technology, Ramat Polytechnic, Maiduguri, Nigeria

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ABSTRACT: The present study was conducted with the objective of combining some basic agronomic practices for the purpose of intensifying a sustainable organic production of Green Pea. The treatments consisted of practices that could facilitate N-fixation and general improvement of soil fertility through the promotion of microbial activities (from compost manure and seed inoculation with *Rhizobium* spp**).** Mulching was introduced to modify the soil temperature, conserve soil moisture, and trellising was done to facilitate a high capture of photosynthetic active radiation. The cultural/agronomic practices were imposed on one another to get the maximum possible number of combination. In all, ten treatments were obtained. The experiment was laid in a split- plot design with 3 replications. Data were collected on nodule count, pod count, pod weight, percentage crude protein in seed, Relative growth rate and Net assimilation rate. The result showed that Nodulation and protein content of seed correlates positively and was enhanced by compost manure and **Rhizobium** inoculation complements compost manure. The agronomic practices were observed to have favourably modified the subsoil environment for enhanced optimum moisture regime, favourable temperature. Trellising actually increased the capture of photosynthetic active radiation but, the crops yield was significantly ($p \leq 0.05$) high regardless of the contribution from trellising. The control gave the generally lowest result relative to other treatments. It was concluded that an enhanced microbial activity may facilitate a successful food production apart from the fact the organic technology recommended is simple and sustainable.

Keywords: Sustainability, bio-intensity, organic fertilizer, conservation, micro-organism.

Introduction

Farming in Nigeria continues to be dominated by peasant farmers with small holdings (<1ha) using hand tools. This according to Odigboh and Onwalu (1994) has led to a continuous decline in agricultural production with an annual rate of 2.5% against a progressive increase in population which is growing at an average annual rate of 3%. The contribution of agriculture to the Gross Domestic Product (GDP) according to Federal Ministry of Agriculture (1988) has declined from about 60% in 1960 to 20% in 1990.

***** Present Address Department of Crop Production, Kwara State University, Malete.
Email: kpetu@yahoo.com, ibikunle.abiona@kwasu.edu.org

The question then is, what has gone wrong? A number of attempts have been made to answer this question in the past without much success. The effort to find solution must thus continue. Past efforts were focused in bio-chemical approach (which includes plant and animal breeding, fertilizer and feed improvement together with pesticides and veterinary drugs), Engineering approach (which includes improved mechanization for post harvest storage, harvesting erosion control and irrigation) and management approach which include, agricultural policies, extension services and financial facilities/packages and marketing strategies.

The present study is conceptualized from the preliminary view that one major factor responsible for the declining agricultural productivity in Nigeria are poor nutrient status of the soils (Singh *et al* 2004) an insufficient water (Singh 2004). In an attempt to solve these problems, native farmers had recorded an age long record/history of cultural practices that were conceptualized to achieve an efficient capture of these growth enhancing resources by crop roots. Attempts to achieve this was made through the manipulation and intervention of some cultural tillage practices. Mound or ridges were made by gathering together the organic matter –rich top soil and as well simultaneously incorporating the said (green and dry) organic matter (usually weeds and previous crops residue) into the heaps. With this practice, top soils nutrient is gathered to a foci point for easy assess of roots, the incorporated organic matter according to Yusuf (2005) increase the soils physical condition by decreasing soil bulk density; increasing soil porosity and as well enhancing water infiltration rate. This facilitates a high water holding capacity of the soil (i.e high volume of water stored in the heaps.

The incorporation of fresh/green organic material into the soil according to Ayeni and Kayode (2009) may sometimes result to poor germination and seedling establishment. This is because soil plants have allelophatic tendencies. Apart from this, the incorporation of organic matter either from old crop residue or volunteer plants may not be realistic or realizable is the semi arid region. This is because farmers ordinarily have other economic uses for the harvested crop residues. These are either used for shelter materials, fodder for animals and even in making local mattress and pillow. In addition to these, the herbal yield of from the total vegetation in this zone is usually very low due to short period of raining season or prolonged dry season, bush burning and over grazing. As a result of which arable fields are usually left opened (free of organic matter) for incorporation into the soil during seed bed preparation (Singh 2004). The foregoing could be accepted as major contributes to the declining soil fertility in tropical agriculture. While others are low level of biologically fixed N, (Petu-Ibikunle et_al 2009), erosive washing of top soil and generally poor economics of mineral fertilizer and as well adequate knowledge of such importance cultural intervention (Petu-Ibikunle *et al* 2008).

Previous efforts made to improve/sustain arable farm land fertility according to Verteeg and Koudokpon (2003) includes dumping of biodegradable household refuse on farm land, a short season fallow of *Mucuna prurience*, improved perennial tree fallow of *Acacia auriculi formis.* Sort season fallow of pigeonpea an alley cropping system on the basis of alternating heldgrow of *Gliciridia sepium* and *Leuceana leucocephala*. These attempt (of sustaining soil fertility) were either aimed at regenerating a very degrade plot and the other concentrates on stabilizing still moderate fertile soil .(Limon-ortega,*et al, 2009).*

The traditional way of sustaining soil fertility (shifting cultivation and bush fallowing) is nowadays inadequate due to some factors we can refer to as consequences of civilization, that subsequently led to increasing pressure on land resources, which of cause was in fixed supply. The use of mineral fertilizer as an alternative remedy at longrun was more devastating. So generally low agricultural productivity (Baba and Singh 1998) and conflict over land (Pur *et al.,* 2006) thus surfaced as characteristics of tropical agriculture.

The replenishment of soil fertility as an alternative approach in investment of natural resource capital should combine the basic principle of soil science with environmental economics. Shepard and Soule (2000) added that, low land and economically sustained soil management practices requires strategies that would increase the value of farm output, increase high quality of nutrient inputs the value of farm output, increase high quality of nutrient inputs and low cash and labour cost to farmers and as well increase off farm income. The work of Tittonel *et al* (2009) contributed that, to attain a sustainable soil fertility improvement programme, a better understanding is needed of the relative importance of soil and crop management factors in determining small holder crop yield within the farm as being strongly influenced by variations in both crop management, and soil fertility, such as planting date, fertilizer rate, and soil fertility. The later being strongly influenced by farmers past/previous soil and crop management.

Having had a slightly in-depth review of issues of declining soil fertility, and the various suggestions and recommendations for further investigation. The present study is therefore designed/conceptualized with the main objective of developing a simple seed bed technology that would facilitate water and nutrient sustainability.

Objetives of the Study

- Examine the effectiveness of organic farming in the production of garden pea.
- Examine varietal differences of green pea under complete bio-intensive condition.
- Examine the contribution of some cultural interventions to the yield of green pea.
- Examine the role of Micro organism in the improvement of crop productivity.

Materials and Methods

A field experiment was conducted during the cold dry season (Nov-Feb) of year 2008. The Research and Teaching farm of Ramat Polytechnic Maiduguri (the experimental site) was situated at Maiduguri, Borno State Nigeria. A semi-arid zone in the Norhtern guinea savannah (Latitude 11^{o}04' North and Longitude 13^{o}05' East). The average annual rainfall value of the zone is 500mm per annum, erratic in distribution during the 3months of rainfall with its peak during the month of August. The site was previously cropped to millet (Penesetum thyphoides) and cowpea (Vignia unguculata).

Preparation of Compost

Composting started 3 months prior to the use (This period fall with the wet season, during which the vegetation and other biodegradable materials are in abundance). The pit was dug with a dimension of 2m depth and 3x3m wide. The compost heaps was built with a base layer of tree branches, followed by multiple layers of bio-degradable materials such as corn cob, old plant stalk, weeded materials. Another layer (regarded as nitrogenous component) consisting of fresh cow dung, poultry manure feather, intestine of slaughted animals, and remains of dead animals. This layer is the inoculants for bacterial actions to start. Building up the compost heap continues on daily basis with daily deposited of kitchen scraps (including egg shells, bones, yam peels, rotten onions, pepper and tomatoes including leftover food), wood ashes, saw dust and termites mound is also added to supply mineral elements.

Trellis

A light weight tall trellis 1.8m tall was constructed to follow a triped/triangular shape. The peas were trained to twine and climb the support provided by the trellis as they grow.

Experimental Design

The treatment consisted of four basic bio-intensive agronomic/cultural practices which are:

i. Application of compost manure
ii. Inoculation of seeds with IRc 252 Rhizobium strains (R)
iii. Mulching with dry straws (M)
iv. Trellising (T)

The above listed cultural interventions were combined to give all possible combinations. The underlisted combination of treatments was obtained.

1. Control
2. Compost + Rhizobium
3. Compost + Mulching.
4. Compost + Trellising
5. *Rhizobium* + Mulching

6. *Rhizobium* + Trellising
7. *Rhizobium* + Trellising + Mulching
8. *Rhizobium* + Trellising + Composting
9. Mulching + *Rhizobium* + Composting
10. Mulching + *Rhizobium* + Composting + Trellising

Obtaining Rhizobium Inoculants

Peat based *Rhizobium* inoculants were obtained from IITA Ibadan (Prepared according to Williams 1984). The inoculants were used to coat, the green peas with gum Arabic used as the adhesive.

Mulching Material

Grass species (weeds) were gathered in large quantity during the wet season. The material were sun dried into straws for use in the experiment.

The Experimental Crop

Phaseolus vulgaris (Wall smart)

Phaseolus lunatus (Oregon sugar)

Phaseolus vulgaris

The pea takes 8-12 days to germinate with 50-60 days from direct seeding to mature. It grows to a height of 75cm.

Phaseolus lunatus

The pea takes 8-12 days to germinate from direct seeding and 50-60 days from direct seeding to maturity it grows to the height of 75cm. The daily deposition of those material continues. The more you heap the more compost yield you harvest.

A hollow PVC pipe was passed through the centre of the heap to base to enhance ventilation. Water is periodically sprinkled on the heap at least every 3 days to ensure adequately moist condition that is optimum for deposition. A dip stick was inserted into the compost pit to serve as temperature indicator. A warmth on the tip of the dip stick confirms that bacterial action/decomposition is containing.

Procedure for using the compost in the compost treatment seed bed.

The bio-intensive “double digging” seed bed (figure a-d)

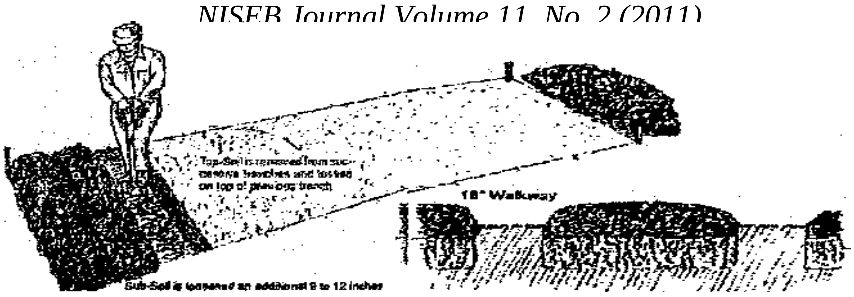
* Mapping out of individual beds by pegging out the required dimensions (1m x 5m). Two seed beds were separated by a boundary of 0.5m.
* A centre trench of 0.5m width was dug along the centre of mapped out plot.
* The trench was lined with a mat of fresh banana leaves (a flat sheet of biodegradable material like cardboard or carton may be used) was in the trench.
* A 15cm thick layer of compost manure was placed in the trench.
* Water was added to the compost in the trench to make it sufficiently wet/moist.
* The ridge was finished up by building up the 1m wide by 15m long beds. The other 0.25m strip left is used to build the adjacent bed in the same manner previously described. (figure a-d)

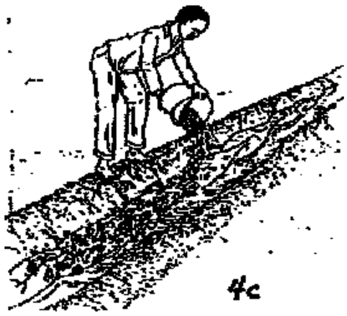
The treatment combinations were laid in a split-plot design. The cowpea varieties (*Phaseolus vulgaris* and *Phaseolus lunatus*) were assigned to the main plot. The resultant combination of cultural practices were assigned to the sub-plots. The experiments were laid in 3 replications. The data collected were subjected to

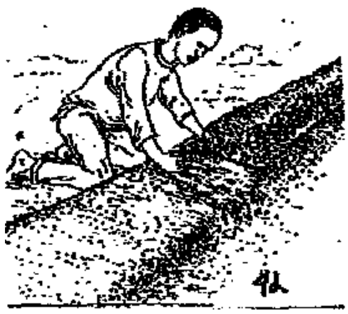
ANOVA, and where the F. ratio was significant at $P \leq 0.05$,the means were separated using least significant difference at $P \leq 0.05$.

Data Collection

1. ***Cumulative pod count over a period of 10days***: pods were regularly picked from 10 randomly selected plants per treatment per replication. The selected plants were the experimental plants from which the cumulative pods harvested were added up after 10days.
2. ***Cumulative pod weight on the number of pods counted and harvested over a period of 10 days:*** The weight of the harvested pods per day were taken using digital electronics scale. The cumulative weight gain was take over the total number of pods counted/harvested after the tenth day.
3. ***Nodule count:*** Ten plants were randomly selected per treatment/replication and carefully dug out. The soil was washed off the roots and the number of visible nodules counted
4. ***Protein yield (content of seed):*** The crude protein content of the seed sample from each treatment was determined using Micro-kjedahl method (Bremner 1965)







1. The manure trench

2. The completed seed bed with drip tapes laid

Plant Growth Analysis

Dry matter yield of Green pea was estimated by taking the mean oven dried weight of 10 plants at 4 and 6 weeks after sowing. The dry matter weight were recorded as W_1 and W_2 respectively for 4 weeks (t_1) and 6 weeks (t_2) after sowing.

The leaf area of Green pea per each treatment was determined from the mean of 10 randomly selected plants. The plainmetry method described by Bleasdale (1973) was used. The leaf area was at (L1) and (L2) respectively for 4 weeks (t_1) and 6 weeks (t_2)

5a. Relative growth rate(g/g/day)

$$RGR = \frac{Log_2 W_2 - Log_2 W_1}{t_2 - t_1}$$ ………(Hunt 1978)

5b. Net assimilation rate (g/cm^2/day)

$$NAR = \frac{W_2 - W_1}{L_1 - L_2} \times \frac{Log_e L_2 - Log_e L_1}{t_2 - t_1}$$ …….. (Watson 1947)

Results

Crude Protein

The green pea varieties did not exhibit a significantly different ($P \leq 0.05$) protein content. This ordinarily means that the 2 varieties of green pea (wall smart and Oregon sugar) regardless of the cultural interventions (i.e treatments) contain the same level of crude protein.

Cultural practices significantly ($P \leq 0.05$) increased the crude protein content in green pea. The control, compost + mulching, and compost+ trellising recorded the lowest crude protein, that were not significantly different ($P \leq 0.05$) from one another.

The highest crude protein % was common to compost + mulching, Rhizobium inoculation + mulching, compost + Rhizobium inoculation+ Trellising and compost + Rhizobium inoculation + mulching + Trellising. 3.06% was recorded as the lowest and 4.53% was recorded as the lowest.

Interaction of variety and cultural practices did not significantly ($P \leq 0.05$) affect/increase the protein content of green pea.

Nodulation

There was varietal difference ($P \leq 0.05$) in green pea nodule count. The variety Oregon sugar recorded the higher nodulation of 14.77. The 2 varieties probably differ in their ability to nodulate.

Cultural practices significantly ($P \leq 0.05$) increased nodulation in green pea. The lowest nodulation (4.83) was recorded from the control, composting + Rhizobium + Mulching, Composting + Rhizobium + Trellising and Composting + Rhizobium + Mulching + Trellising recorded an average of 22.5 nodule count. The 2 treatments recorded the highest nodulation that were significantly similar.

Variety x cultural practices (figure 1) recorded a significantly ($P \leq 0.05$) difference in cowpea nodulation. The result showed that at the highest combination of the cultural practices, (Composting + Rhizobium inoculation + Mulching, Compost + Rhizobium inoculation + Trellising and Composting + Rhizobium inoculation + Mulching + Trellising). Nodulation in green pea was highest in wall smart variety in all the possible interaction obtained.

Pod Count

Varieties of green pea(Table 1) were not significantly ($P \leq 0.05$) different in their pod count. The cultural practices also did not significantly ($P \leq 0.05$) resulted in increase in green pea pod yield. Variety x cultural practices did not create a significantly ($P \leq 0.05$) differences in green pea pod yield.

Table 1: Growth, yield and development of green pea in response to some agronomic practices

		Crude protein(%)	Nodule count	Pod Count	Pod Wt(kg)	NARx10^{-3}	RGR x10^{-4}
A)	**Green Pea Variety**						
	Wall smart	4.15^{a}	13.22^{b}	28.67^{a}	36.19^{a}	0.39^{a}	1.51^{a}
	Oregon sugar	4.05^{a}	14.77^{a}	29.70^{a}	41.19^{b}	0.41^{a}	0.35^{a}
	SE±	5.02	0.29	0.15	4.83	4.40	3.30
	LSD (P≤0.05)	-	1.26	-	-	-	-
B)	**Cultural Practices**						
	Control	3.06^{c}	4.83^{c}	29.33^{b}	27.33^{b}	0.31^{cd}	0.030a
	Compost + Rhizobium	4.60^{a}	16.50^{b}	28.17^{b}	49.33^{a}	0.35^{cd}	0.038^{a}
	Compost + Mulching	3.22^{c}	9.00^{c}	28.83^{b}	49.33^{a}	0.35^{cd}	0.038^{a}
	Compost + Trellising	3.25^{c}	6.67^{c}	28.66^{b}	30.83^{b}	0.44^{ab}	0.036^{a}
	Rhizobium + Mulching	4.10^{b}	6.60^{c}	28.50^{b}	30.67^{b}	0.42^{abc}	0.039^{a}
	Rhizobium + Trellising	4.55^{b}	17.00^{b}	28.66^{ab}	32.00^{b}	0.40^{bc}	0.034^{a}
	Comp+Rhizo+Mulching	4.78^{a}	21.17^{a}	28.83^{a}	30.00^{b}	0.43^{ab}	0.038^{a}
	Comp+Rhizo+Trellising	4.81^{a}	22.17^{a}	31.83^{a}	48.00^{a}	0.40^{bc}	0.034^{a}
	Mulching+Rhizo+Threll	4.15^{b}	17.55^{b}	20.00^{a}	33.00	0.40	0
	Comp+Rhizo+Mulch+Threll	4.53^{a}	22.50^{a}	30.50^{a}	51.00^{a}	0.48^{a}	0.037^{a}
	SE±	0.35	2.24	1.58	1.05	4.87	3.14
	LSD (P≤0.05)	1.20	4.55	-	2.37	-	-
C)	**AXB**	**NS**	*	**NS**	**NS**	**NS**	**NS**

***** = LSD (P≤0.05)

Pod Weight

Green pea varieties did not significantly (P≤0.05) differ in pod yield in the present experiment. The control was amongst the treatment that recorded the significantly (P≤0.05) lowest pod weight of 27.33. The significantly highest (P≤0.05) pod weight was an average of 51.00 recorded from about four different treatments including Compost + Rhizobium + Mulching + Trellising, Compost + Rhizobium +Trellising, Compost + Mulching, and Compost + Trellising. The interaction of variety and cultural practices did not significantly (P≤0.05) increase the pod weight green pea.

Net assimilation Rate.

Green pea varieties did not significantly (P≤0.05) differ in Net assimilation rate. The cultural interventions significantly (P≤0.05) increase the NAR in green pea. The control with $0.39x10^{-3}$ was significantly (P≤0.05) amongst the lowest NAR yielder. The highest NAR was $0.48x10^{-3}$ recorded from Compost + Rhizobium + Mulching + Trellising. This was however significantly not differ NAR from Rhizobium + Mulching, Compost + Trellising and Compost + Rhzizobium + Mulching.

Relative Growth Rate;

Green pea variety did not exhibit a significantly (P≤0.05) difference in their relative growth. Cultural practices did not significantly (P≤0.05) increased the RGR, neither did the variety x cultural practices significantly (P≤0.05) influence the RGR of green pea. Cultural x treatment interaction showed that nodulation was more specific to other cultivars that a particular one.

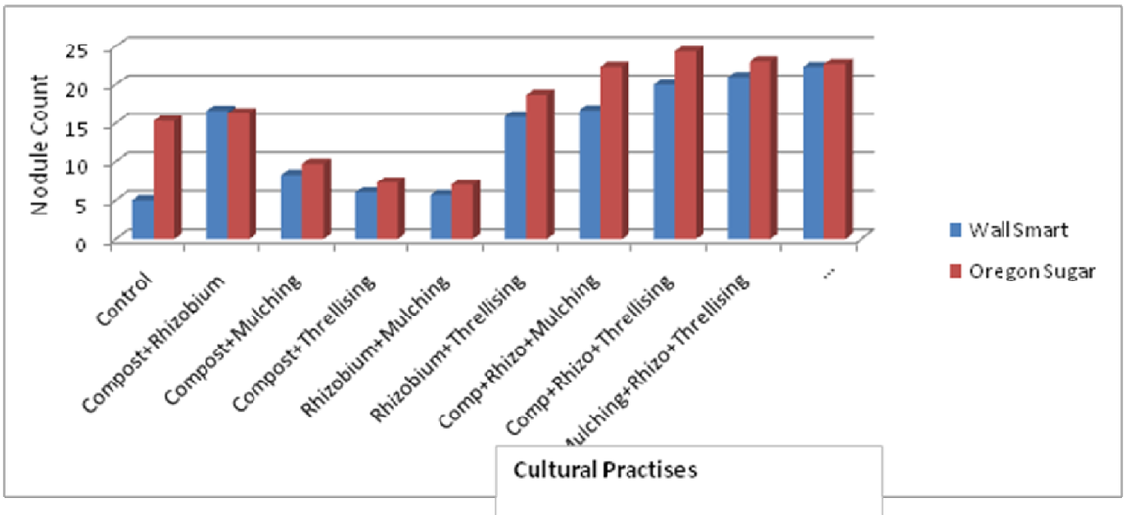


Fig 1: Effect of Cultural Practices x Variety on Green Pea Nodulation.

Discussion

Most combinations that include Compost and Rhizobium inoculants showed a superior result in most of the parameters observed. It is logical to accept the explanation according to Dom Mergue (1990). Compost was analysed to contain a large population of bacteria and fungi species. These species can significantly improve plant nutrition and water uptake. Phosphorus solubulization may occur when elemental sulphur enables Thiobacilli to thrive. While Azospirillum increases mineral-water uptake.

The explanation of Dobereiner and Padrosa (1987) is also an issue to explain the performance recorded from the use of compost. Compost may contain Rhizospheres non-symbiotic nitrogen fixing rhizobacteria such as Azospirillum promote root growth and thus plant growth (RGR via hormonal action (Hegazi *et al., 1984*) reported that a group of free living bacteria called Azotovbacter chroocuccum which grow readily on degradable plant residue can fix enough nitrogen to improve soil fertility. In general, about 300 different strains of plant growth promoting bacteria is found in compost.

Even though pathological parameters were not taken, it is also reasonable to assume that growth was enhanced because compost contains antibiotics that can enable plant to resist pest and disease so such as actidione, azaserine, altenaric acid and polymyxin are potent metabolic inhibitors and pathogen neutralizers {Barbara and Deborah (2008)}.

Nodulation was enhanced probably the compost invigorated the soils food web by providing nutrient, moisture and habital for wide range of beneficial life form soil texture, drainage and fertility is improved. With these, the possibility of water stress depression of O_2 uptake and reduction in available metabolite such as ATP occurring was likely to have been overcome. Thus nodulation and N-fixation is likely to be enhanced. This is according to Siverding (1981) explanation. The increase in maize yield due to level of mulching according to Adeoye (1990) also explain and agrees with this findings.

Seed inoculation has the ability to increase soot dry weight and growth rate and increase yield. Olufajo and Adu, (1992), Adu and Nnandi (1990) and Luyindula and Haque (1990). The varietal x Rhizobium strain gained a significantly different in Michin *et al.,* (1978).

The protein content of cassava increased with increase in Nitrogen from intercropped groundnut (IITA 1987). Adu and Nnadi and Petu-Ibikunle *et al.,* 2009 also reported increase in cowpea protein content as a consequence of increase in Nitrogen via biological fixation and nodulation.

Increase in the capture of PAR was facilitated by trellising. Leaf expansion is facilitated by increase in solar income thus increase in RGR and NAR. The higher the RGR the greater the contribution to N-Fixation. Kirimi ad Siddiqie (1991) and leaf emergence is enhanced by increase in utilization of solar income, Kirby (1995).

IITA (1987) NAR and RGR may increase due to pest and diseases reduction Balliue *et al.,* 2004 reported that RGR will increase due to increase Nitrogen concentration and production of high leaf ratio. Lower leaves shaded when not trellised, parasitism on upper ones may occur not trellised, Yoshuo (1975).

Conclusion

Crops' (Green pea) environment can be manipulated to favourably enhance growth, development and biological yield. The environment referred to are the basic cultural interventions. In this case, conservation and not exploitation in an attempt to increase the entire crop productivity. When moisture is adequately conserved (mulching), capture of PAR enhanced (trellising) soil nutrient and microbial activities (supplied via composting). Artificial seed inoculation may not be necessary being a more costly and sophisticated technology relative to the composting. Composting is discovered to be capable of providing more species of microbes that will not only facilitate Nitrogen fixation, but afford many other benefits. The basic advantages of artificial seed inoculation may be simultaneously achieved via the use of compost, thus seed inoculation may not be necessary if compost is added. In addition to this, the soil physio-chemical quality is improved. In general, bio-intensity (the combination of some basic cultural practices) is convincingly a conservative measure of utilizing the renewable and non renewable resources via the promotion of microbial activities in the soil.

Recommendations

* The combination of mulching and compost manure with or without trellising is recommended for improving nodulation and protein content in green pea.
* Wall smart variety of Green pea is recommended for production in the study area based on its better nodulating ability.

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