# EFFECT OF PLANTING PATTERN AND FERTILIZER RATES ON ONION *(ALLIUM CERA* L.) AND PEPPER *(CAPSICUM ANNUML.)* MIXED CROP

**BY**

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# DECLARATION

I hereby declare that this thesis has been written by me and that it is record of my own research work. It has not been presented before in any previous application for a higher degree.

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The above declaration is confirmed

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**CERTIFICATION**

This thesis entitled "EFFECT OF PLANTING PATTERN AND FERTILIZER RATES ON ONION (*Allium Cepa L.)* AND PEPPER (*Capsicum Annum L.*) MIXED CROP" by Aliyu A. Samaila meets the regulations governing the degree of Master of Science (Agronomy) of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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## DEDICATION

This work is dedicated to my wife, Khadija Modupe, who took the chance against all odds and remained steadfast thereafter; and to Kamal'deen and Sa'adatu for just being there.

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**Aliyu Sama'ila.**

# ABSTRACT

Field experiments were conducted during 1996/97 and 1997/98 dry seasons at the Irrigation Research farm of the Institute for Agricultural, Samaru (11 1 l'N, 7° $38^{1}$ E 686m) to study the effect of different rates of fertilizer (NPK) and planting pattern on the performance of onion/pepper mixtures. The treatments consisted of four rates of NPK - 20:10:10 compound fertilizer: (0, 250, 500 and 750 kg/ha) and six planting patterns (Sole pepper, Sole onion, 1:1 alternate onion and pepper stands, 1:2 alternate pepper and onion stands, 1:1 alternate rows onion/pepper and 1:2 alternate rows onion/pepper). These were arranged in factorial combinations and replicated three limes in a randomized complete block design. Planting pattern significantly influenced total yield of onion on one hand, with 1:2 alternate row giving the highest yield: also the number of leaves/plant, fresh weight of fruits and total yield of Pepper. Fertilizer application of up to 500kg/ha significantly increased plant height, leaf number, bulb diameter marketable bulb yield and total yield of onion as well as fruit length leaf number, plant height and total fruit yield of pepper. The higher rate of 750kg/ha NPK significantly depressed plant height, reduced fruit diameter, fresh weight and total yields of both crops. The 1:2 alternate row planting pattern gave the highest land equivalent ratio (LER) amongst the patterns considered. A significant positive correlation was observed between yield of onion and bulb fresh weight, bulb diameter, number of leaves/plant and plant height, and between the yield pepper and number of leaves, plant height, fruit diameter and fresh weight of fruits; while a significantly negative correlation was observed between days to flowering and yield of pepper.

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## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| Kg | = | Kilogramme |
| *Et al* | = | and others |
| g | = | gramme |
| $^{O}C$ | = | Degree celcius |
| % | = | Percentage |
| m | = | Metre(s) |
| $m^2$ | = | metre square |
| Ha | = | hectare |
| N | = | Nitrogen |
| P | = | elemental Phosphorus |
| K | = | Elemental Potassium |
| t/ha | = | Tonnes per hectare |
| WAT | = | Weeks after transplanting |
| NS | = | Not significant |
| mt | = | Metric tonnes |

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# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Onion

Onion (*Allium cepa* L.) belongs to the family Alliaceae to which many cultivated bulbs like garlic (*Allium sativum)* and Leek (*A. ampeloprasum*) belong. It has been associated with the ancient middle and South-East Asia, Persia, Turkey and the Mediterranean regions (Shoemaker, 1947). Onion cultivars range from short-day to long-day types thereby making their spread through most of the world possible (Purseglove, 1972). In terms of economic importance, onion comes second only to tomatoes (*Lycopersicum esculentum*) as the most important cultivated vegetable (Grubben, 1977). World production stood at 35.6 million metric tonnes in 1996 (F.A.O , 1996 ). Major onion producers in Africa include : Egypt (448,000 MT), Morocco (360,000 MT), South Africa (308,000 MT) , Niger (178,000 MT) and Senegal (40,000 MT), F.A.O.(1996). Onion is mainly used as a complementary condiment where its paste is blended with pepper and tomatoes in making stew, or as a spice in frying and curing of meat. Onion is also used for medicinal purposes of flavouring or as a linctus for cold remedies because of its high content of organic sulphur and allyl oils (Jones and Mann, 1963). In Nigeria, onion is grown mainly in the sudan and Northern Guinea savanna ecological zones. It is mainly grown in the dry season on fadama soils or under irrigation. It is also grown as a rainfed crop but, with smaller bulbs and consequently lower yields because of high relative humidity associated with wet season that harbour pests and diseases and also accelerates rooting (Inyang, 1966). Onion yield obtained by farmers in northern Nigeria is about 15 to 20t/ha. Insufficient use of fertilizers and low planting densities have been identified as two major constraints to high yields (Amans *et al*, 1982).

### 1.2 Pepper

Pepper (*Capsicum spp*) belongs to the family Solanaceae that include sweet pepper (*Capsicum annum*) Bird chillies (*C. frutescens*)and *Capsicum pubescens* (Thomson and Kelly, 1957). It originated from Peru and is closely linked with the Incas and Aztec civilizations of South America (Thomson and Kelly, 1957). It was first introduced to Europe by Columbus in 1492 and from where it got distributed to other countries in the first part of the 16th century (Purseglove, 1969). Pepper ranks fourth among world vegetable production exceeded only by Tomato (*Lycopersicum esculentum*), Onion (*Allium cepa*) and Potato (*Solanum tuberosum*). World annual production reached 14 million metric tonnes in 1996 (F.A.O., 1996). In Nigeria, production was about 970,000 metric tonnes in 1996 (F.A.O., 1996). Pepper is an important vegetable crop constituting about 40% of the total vegetables consumed in Nigeria. It is used both as a condiment and a spice while the sweet green types are used as salad dressings (Purseglove, 1972). It is used in paste or puree or ground with other vegetables in preparation of stew and soup. Capsicum frutescens contains high level of Capsaicin - a pungent material used in industries as a stimulant (Purseglove, 1972). Pepper contains high levels of vitamins and other nutrients. 500gm of pepper contains 112 calories, 4.6gm protein, 0.8gm fat, 21.7gm carbohydrate, 42mg Calcium and 85mg phosphorus. It also contains Iron, carotene and amino acids like riboflavin, thiamine and niacin (Thomson and Kelly, 1957).

Pepper grows well in areas with relatively warm climates, well - distributed rainfall (about 50-100mm) and a temperature range of $18^0C$ - $26^0C$ at blossom setting (Ware and McCallum, 1975). The crop does well under varying soil conditions but does best in sandy loams with good water holding capacity, good quantity of organic matter and a pH range of 5.5-7.0 (Ware and McCallum, 1975). In Nigeria, it is usually grown as a dry season crop mostly in the savanna ecological zones; but some rainfed pepper is also grown. It grows better during periods of long sunshine.

## 1.3 Cropping System

The popular cropping system for vegetable crops in the Nigerian savanna is mixed cropping with cereals, legumes or with other vegetables (Onochie 1976). A lot of study has been done on pepper and onion as sole crops or in association with cereals like maize or sorghum but, there is no reported work on the two crops grown in mixture. However, it is increasingly becoming more common to see onion and pepper grown in mixture. The current trend in agricultural research emphasizes the judicious use of space and inputs that will positively influence the largest proportion of farmers.

## 1.4 Objective of Study

The majority of vegetable farmers in Nigeria grow their crops in mixtures and on small plots. But these mixtures vary greatly in their relative crop proportions and spacings. In addition little is known about optimum fertilizer needs in these mixtures. Most of the soils are relatively poor in nutrients, therefore the aspect of nutrition and fertilizer use becomes very important. It is in this respect that the study was conducted with the following objectives:

a) To determine the planting pattern that will give the best output for an onion / pepper mixture.

b) To determine the optimum fertilizer level for the onion / pepper mixture.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Effect of fertilizers on Onion

Onion responds well to fertilizer application. Nitrogen, in particular has been found to have a profound influence on the plants' vegetative growth even though high levels (over 180kg/ha) have been found to have a detrimental effect on crop growth and yield (Singh and Kumar, 1969). Excessive nitrogen application may result in the production of large bulbs but of poor curing ability and susceptible to bulb rot (Vaughan, 1960). Pande *et al*, (1969) reported increase in total yield and marketable grade of onion in response to increasing nitrogen level from 0 to 160kg/ha.

Amans *et al*., (1982) reported no significant difference in the number of leaves of onion with the application of 40, 80 and 120kg N/ha. But the application of 40kg N/ha doubled the yield when compared with the control while a further increase in N level above 80kgN/ha led to a significantly increased bulb yield. Application of 120kg N/ha however, gave yields that are significantly not different from those obtained by the application of either 40 or 80kg N/ha.

A significant interaction between nitrogen and spacing was reported by Das and Dhyani (1956) in which the maximum yield was obtained with the application of 72kg N/ha and 10cm plant spacing. The same quantity of nitrogen at a wider spacing of 20cm produced the best marketable grade yield. The combination a spacing of 30cm and 96kg N/ha produced very large size bulb.

Henriksen (1987) working in Denmark, reported that the yield of marketable grade bulbs increased with increasing nitrogen application up to 120kg/ha. At 180kg N/ha, there was a correlation between the time of top bending and nitrogen supply. On the average, bulbs supplied with 120kg N/ha matured 9 days earlier than in control. Verma *et al.*, (1972) reported onion crop yield and bulb size were increased in response to 200kg N/ha which also reduced bolting. Higher rates of N above 200kgN/ha were not economical. Itagi *et al.*, (1958) also reported that growth and yield were correlated with nitrogen application.

The need to supply a balance of fertilizer nutrients was also demonstrated. Bottcher and Kolbe (1975) reported that 80kg N/ha with moderate P and K levels produced the maximum total and marketable onion yields. Very high N levels (160 and 320kg/ha) without adequate P or K delayed plant development in the early stages after seedling emergence, reduced number of plants per unit area, and subsequently the yield. Amans *et al.*, (1982) reported no significant difference in the application of 20 and 40kgP. Both rates increased the number of leaves per plant and total bulb yield in combination with nitrogen.

Singh (1978) however, reported a significant response to N and P but not to K. The highest yield was obtained with the combination of N and P at 112.5 and 196.9kg/ha respectively.

Pande *et al.*, (1969) reported that the highest yield and maximum bulb size were obtained in response to N-level of 112kg at 56kg and $K_20$ at 28kg/ha. This treatment was also the most profitable in terms of the net returns/ha. This agreed with the findings of Haggag *et al.*, (1986) who reported that overall best yield was obtained with NPK at 250kg/ha. In another trial, Onion yields were increased by the application of 70kgN/ha plus 45kg/ha $P_20_5$ but there was no response to 45kg/haK alone (Narang and Dastane 1971). Another report indicated that increasing NPK levels from 75:60:60 to 120:120:90kg/ha still resulted in increase in yield of onion bulbs from 20-35t/ha (Khvatov *et al.*, 1973).

## 2.2 Effect of fertilizer on Pepper

The essential elements of N, P and K have significant effects on the growth and yield of pepper. Bangash and Shaik (1972) reported 109% increase in pepper yield above the control when 100:100:100/NPK/ha was applied. In a similar work, Lal and Pundrik (1971) obtained the highest yield of chilli pepper when the crop was supplied with 80:90:50kg NPK/ha.

Saga (1972) reported that a deficiency of N in pepper crop grown in Sand culture reduced top growth and leaf colours while the lack of P and K, depressed root growth. The Capsicin content was also low in crops without adequate P or P plus K.

Jasa *et al.*, (1973) reported that combined fertilizer which included Urea, plant matter and phosphate significantly improved plant growth, leaf area, plant dry matter and photosynthetic productivity and yields. Zayed *et al.*, (1985) in Egypt reported that NPK at the rates of 80 and 120kgha increased plant height, plant dry weight, fruit number and total yield but had no significant effect on chemical composition.

Cerna (1980) reported no marked effect on pepper yield by increasing N from 120kg/ha to 180kg/ha but there was a significant difference in the yield of plots that were supplied with 120kg N/ha from those that have no fertilizer. Batal and Smittle (1981) reported that the maximum marketable yield was attained only when sufficient N was added to maintain soil nitrate levels between 20 - 30ppm.

## 2.3 Effect of inter cropping

Intercropping is the simultaneous growing of two or more crops on the same land (Beets, 1979). Mixed cropping otherwise known as intercropping is popular with the small-scale farming system in less developed, warm tropical countries like Nigeria (Yunusa, 1985). The popularity of intercropping may be partly due to the advantages the farmer gains culturally, agronomically and socially since inter cropping is considered as a balanced system in which human resources (Labour, finance and social structure) are in equilibrium with available natural resources (climate, soil and crop species) (Yunusa, 1985). Intercropping, also provide an insurance against total crop failure under natural adversity. For example, it may ensure a modest yield of one of the component crop, even if other component crop(s) fail. This is because crops have different resistance levels to adverse conditions as well as requirements as compared to sole crops (Onochie, 1975).

Some crops in mixtures provide complementary physical and nutritional support to each other. For example in Maize/Yam mixtures and Maize/Cowpea mixtures where in the former mixture, the maize provides physical support for the yam tendrils while in the latter, the maize makes use of the nitrogen fixed by the bacterial species in the nodules of legume roots. (Agboola and Fayemi, 1971).

### 2.4 Effect of planting arrangement in intercropping

Planting arrangement is the distribution pattern of plants over the ground which determines the shape of the area available to individual plants (Abaver, 1983). Planting arrangement could be in any form but single alternate row, double rows, 1:2 alternate rows, triple or quadruple rows or alternate holes are more popular. Whatever arrangement used, total yield from mixtures consistently showed relative advantage over sole cropping (Abaver 1983). Disadvantages of the various patterns may be seen when comparing the different types of arrangement (Anon, 1974).

### 2.5 Fertilizer in Intercrops

The main factor to be considered in fertilizing intercrops is that the component crops may have different nutritional needs and that the period of maximum need or demand for one crop may differ from that of the associated crop (Abaver, 1983) Also, the rate, time and method of fertilizer application for one crop may not be conducive to one of the components .

Fertilizer responses are governed perhaps as much by differences among crop species as by the variability among soils. (Oesligle et al 1976). It is therefore important to know about the nutritional requirements and growth characteristics of the crops which are to be grown in a specific cropping pattern.

Rooting habit which is manifested in differences in nutrient needs and differences in the period of maximum need or demand to the extent that post-planting application of fertilizer may be hindered (Abaver, 1984). Moreso, the root distribution system is not only a characteristic of each specie but also it may be strongly influenced by some soil properties, (hardpan, ground water level or toxic substances) that may hinder nutrient absorption by roots (Anon, 1982).

# CHAPTER THREE

## 3.0 Materials And Method

### 3.1 Experimental Site:

Field trials were conducted during the 1996/97 and 1997/98 dry seasons at the Irrigation research field of the Institute for Agricultural Research (IAR) Samaru ($11^0 11'$N $7^0 38'$E, 686m above sea level) in the Northern Guinea ecological zone of Nigeria. The soil of the site in both seasons was loamy. Meteorological records and details of soil analysis are presented in Appendices I - IV.

### 3.2 Treatment And Experimental Design:

The treatment evaluated consisted of intercropping Onion variety "D77" which has low bolting characteristics and a local sweet pepper variety (Tattasai) under the following six planting patterns:

i. Sole onion

ii. Sole pepper

iii. 1:1 alternate stands (one onion stand alternating with one pepper stand on the same row)

iv. 1:2 alternate stands (one pepper stand alternating with two onion stands on the same row)

v. 1:1 alternate rows (one row of onion alternating with a row pepper)

vi. 1:2 alternate rows (one row of pepper alternating with two row of onion).

These six planting patterns were factorially combined with four rates of NPK compound fertilizer (20:10:10) 0, 250, 500 and 750kg/ha. The treatments were laid out in a randomized complete block design with three replications.

## 3.3 Cultural Practices:

### 3.3.1 Nursery preparation and management

Nursery beds of 1.0m width were prepared on which seeds of onions and pepper were sown. Farmyard manure plus 50gm of NPK/m2 were incorporated into the soil. Onion seeds were sown two weeks earlier than pepper because the onion seedlings require longer period to reach transplanting size than pepper. Onion seeds were drilled on 13$^{th}$ and 17$^{th}$ October for the 1996/97 and the 1997/98 trial respectively, while pepper seeds were sown on 27$^{th}$ and 31$^{st}$ October for the 1996/97 and the 1997/98 trial respectively.

### 3.3.2 Land preparation and transplanting

The experimental fields were ploughed and harrowed and prepared into sunken plot beds of 1.5 x 4m sizes. Transplanting of both pepper and onion seedlings based on the various planting patterns, was done on 14$^{th}$ and 18$^{th}$ December for the 1996/97 and 1997/98 trials respectively. Spacing used for sole onion were 20 x 15cm while that of sole pepper was 60 x 45cm. The 1:1 alternate stand arrangement had one onion stand alternating with one pepper stand while the 1:2 alternate stand had two onion stands alternating with one pepper stand in equal spaces.

### 3.3.3. Irrigation

Irrigation water was applied by controlled surface flooding of individual plots at 3 – day intervals. At each irrigation, the plots were watered until they flooded.

3.3.4. **Weed control**

Manual hoe weeding was carried out at 3,6 and 9 weeks after transplanting to control weeds. The prominent weeds on the field were *Cyperus Spp* and *Tridax Procumbens.*

3.3.5. **Pests and disease control**

A light incidence of white flies and aphids was observed in both seasons. They were effectively controlled by the application of Cymbush (Cypermethrin) EC at the rate of 100ml in 20 litres of water. There were no serious disease incidence in the two seasons to warrant special control measures.

3.3.6. **Harvesting**

**(Pepper)**

Harvesting was done by hand picking of mature pepper fruits at weekly intervals for a period of three weeks. At each harvest the fruits / plot were weighed. Maturity of fruits was indicated by color change from green to red.

**(Onion)**

Onion was harvested in one single harvest by handpulling the bulbs, when the leaf tops began to wither and collapse (an indication of maturity). The harvested onion bulbs were cured in the sun for one week before counting and weighing.

3.4 **Observations**

A random sample of plants, three each for onion and pepper were tagged per plot for non-destructive measurements of growth parameters at two weeks interval.

For pepper, the growth parameters determined were the plant height, number of leaves/plant, days to 50% flowering and number of branches/plant. For onion, these were the plant height and number of leaves/plant. Other data recorded at harvest for onion were bulb fresh and dry weight, bulb diameter and yield/ha; and for pepper the fruit fresh and dry weights, fruit length and diameter as well as yield/ha.

### 3.4.1. <u>Number of leaves/plant</u>

The number of leaves/plant for both pepper and onion were counted and the average for the three selected samples recorded per plot at two weeks interval.

### 3.4.2 <u>Plant height</u>

The height of plants where measured from the ground level to the terminal bud of the main stem in case of pepper or to the tip of the tallest leaf in case of onion. Both heights were measured with a meter rule every two weeks.

### 3.4.3 <u>Diameter of onion bulb and pepper fruit</u>

The diameter of onion and pepper fruit were measured with the aid of a Vernier calipers after harvest. A sample of five onion bulbs or pepper fruit per plot was used and means recorded.

### 3.4.4 Pepper fruit length

Average fruit length of pepper was determined by taking the lengths of five fruits samples.

### 3.4.5. Mean fresh weight of onion bulb and pepper fruit

The fresh weights of harvested onion bulbs and pepper fruits per plot were determined immediately after harvest using a metler balance. The mean weights per bulb or fruit were calculated by dividing the total weight of harvest number of units per plot.

### 3.4.6 Dry weight of onion bulb and pepper fruit

A sample of four bulbs of onion or fruits of pepper were over-dried at $70^0$c to a constant weight. The mean dry weights per bulb of onion or fruit of pepper was recorded per treatment plot.

### 3.4.7. Total yield (t/ha)

Total yields per plot of pepper fruit and onion bulb were each converted to tonne/hectare using the appropriate conversion factor. The onion bulbs were first air-cured for one week before the weights were recorded.

### 3.4.8 Land equivalent ratio (LER)

A sole crop is assumed to have a land equivalent ratio of 1.00. For crop in mixtures however, the LER was calculated using the formula:

$$LER = \frac{A_1}{M_1} + \frac{A_2}{M_2}$$

$A_1$ = Onion in mixture.

$A_2$ = Pepper in mixture.

$M_1$ = Onion sole.

$M_2$ = Pepper sole.

### 3.4.9 Statistical analysis of data

The data collected were subjected to statistical analysis of variance to test the significance of treatment effects as described by Snedecor and Cochran (1967). Where treatment means were different, the means were then compared using Duncan's multiple range test DMRT (Duncan ,1955).

## CHAPTER FOUR

## 4.0 RESULTS

### 4.1 Onion

#### 4.1.1 Number of leaves per plant

The effect of treatments on number of leaves of onion was significant at 5 and 11 WAT of 1996 (Table 1). At 5 WAT, the number of leaves of onion grown as sole crop or in 1:1 alternate stand arrangement were significantly lower than 1:1 row or 1:2 row arrangement. At 11 WAT, sole onion produced significantly lower number of leaves than all other planting patterns which recorded similar leaf number.

Fertilizer significantly influenced leaf number. The 500kg / ha rate gave the highest leaf number at all sampling periods while the highest rate 750kg/ha depressed leaf number at 5,7 and 9WAT in both years. At 11 WAT of 1997 however, the 750kg/ha rate recorded similar leaf number with 500kg/ha rate. There was no significant planting pattern x fertilizer interaction.

#### 4.1.2 Plant height

Planting pattern significantly affected plant height of onion only at 5 and 9 WAT of 1996/97 season (Table 2). At 5 WAT, 1:1 alternate stand significantly produced shorter plants than all other planting patterns which produced significantly similar heights. But at 9 WAT, the sole crop produced significantly taller plants than the intercrop plant arrangement except the 1:1 alternate stand treatment with which it was similar.

Fertilizer application increased plant height at 5, 7 and 9 WAT only. Fertilizer rate of 500kg/ha produced the tallest plants at 5 and 7 WAT. The height observed for plants applied with 750kg/ha NPK/ha was similar to those applied with 500kg/ha at 7 WAT. At 9

WAT however, the tallest plants were observed in plots with no fertilizer but, their height was significantly similar to those that received 250kgNPK/ha.

No significant planting pattern x fertilizer interaction was recorded.

**TABLE 1: The effect of Planting and Fertilizer rates on number of leaves / Plant of onion in onion/Pepper mixture during the 1996/97 and 1997/98 dry season and mean of the two seasons.**

| | WEEKS AFTER TRANSPLANTING | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | | | 7 | | | 9 | | | 11 | | |
| **Treatment** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** |
| **Planting Pattern (P)** | | | | | | | | | | | | |
| Sole Crop | 4.7b | 4.7 | 4.7 | 6.6 | 7.1 | 6.9 | 8.6 | 8.4 | 8.5 | 12.5b | 11.7 | 12.1 |
| 1:1 Alternate Stand | 4.8b | 4.3 | 4.5 | 6.5 | 7.2 | 6.8 | 8.6 | 8.6 | 8.6 | 12.6a | 12.4 | 13.5 |
| 1:2 Alternate Stand | 5.0ab | 5.1 | 5.0 | 6.4 | 7.3 | 6.9 | 8.6 | 9.1 | 8.9 | 14.6a | 10.8 | 12.7 |
| 1:1 Alternate Row | 5.2a | 4.8 | 5.0 | 6.4 | 7.1 | 6.8 | 8.7 | 8.5 | 8.9 | 14.8a | 11.7 | 13.2 |
| 1:2 Alternate Row | 5.1a | 4.7 | 4.9 | 6.5 | 7.2 | 6.8 | 8.6 | 9.3 | 8.9 | 14.6a | 10.6 | 12.6 |
| SE ± | 0.11 | 0.25 | 0.15 | 0.10 | 0.23 | 0.12 | 0.12 | 0.54 | 0.27 | 0.23 | 0.91 | 0.46 |
| **Fertilizer Rate (F)** | | | | | | | | | | | | |
| **(20:10:10)** | | | | | | | | | | | | |
| 0 | 3.3d | 3.4c | 3.3c | 4.0c | 5.2c | 4.9c | 1.4d | 6.3b | 6.9c | 10.5d | 8.3c | 9.4c |
| 250 | 4.9c | 5.1ab | 5.0b | 7.0b | 8.1a | 7.6ab | 8.9b | 9.2a | 9.1b | 14.7c | 10.7b | 12.7b |
| 500 | 6.0a | 5.8ab | 5.9a | 7.6a | 8.1a | 7.8a | 9.4a | 10.3a | 9.9a | 16.1a | 13.8a | 15.0a |
| 750 | 5.7b | 4.7b | 5.2b | 7.2b | 7.5b | 7.3b | 8.6c | 9.4a | 9.0b | 15.5b | 12.9ab | 14.2a |
| SE± | 0.09 | 0.23 | 0.13 | 0.09 | 0.21 | 0.11 | 0.10 | 0.48 | 0.24 | 0.21 | 0.81 | 0.42 |
| **Interaction** | | | | | | | | | | | | |
| P x F NS | NS | NS | NS NS | NS | NS | | NS | NS | NS | NS | NS | |

Means followed the same letter(s) within column and treatment set are not significantly different using DMRT (P = 0.05)

NS = Not Significant

TABLE 2: The effect of Planting and Fertilizer rates on Plant height of onion in onion/Pepper mixture during the 1996/97 and 1997/98 dry season and mean of the two seasons.

| | WEEKS AFTER TRANSPLANTING | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | | | 7 | | | 9 | | | 11 | | |
| **Treatment** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** |
| **Planting Pattern (P)** | | | | | | | | | | | | |
| Sole Crop | 15.8a | 15.1 | 15.4 | 24.6 | 29.2 | 26.9 | 33.7a | 33.1 | 33.4 | 40.6 | 39.4 | 40.0 |
| 1:1 Alternate Stand | 14.6b | 13.9 | 14.3 | 24.8 | 30.0 | 27.4 | 32.0ab | 38.1 | 35.0 | 40.9 | 39.9 | 40.4 |
| 1:2 Alternate Stand | 15.8a | 13.6 | 14.7 | 24.7 | 26.8 | 25.7 | 30.7b | 37.9 | 34.3 | 40.2 | 40.9 | 40.2 |
| 1:1 Alternate Row | 15.2a | 13.8 | 14.5 | 24.3 | 28.2 | 24.3 | 31.8b | 33.1 | 32.4 | 41.2 | 40.3 | 40.7 |
| 1:2 Alternate Row | 15.6a | 14.7 | 15.1 | 25.1 | 24.0 | 24.7 | 31.3b | 33.3 | 32.3 | 40.7 | 41.0 | 40.9 |
| SE ± | 0.30 | 0.95 | 0.51 | 0.60 | 1.50 | 0.78 | 0.60 | 1.78 | 1.02 | 0.60 | 1.62 | 0.85 |
| **Fertilizer Rate (F) (20:10:10)** | | | | | | | | | | | | |
| 0 | 10.2c | 9.2c | 9.7c | 17.4c | 21.4b | 19.4b | 23.1b | 26.7b | 24.9b | 36.8c | 31.9c | 34.4c |
| 250 | 16.5b | 15.7ab | 16.1ab | 26.2b | 31.3a | 28.7a | 32.0a | 36.7a | 34.9a | 41.3b | 44.2a | 42.7a |
| 500 | 18.0a | 17.8a | 17.9a | 27.9a | 29.9a | 28.9a | 30.7a | 38.1a | 37.2a | 44.5a | 45.0a | 44.8a |
| 750 | 17.0b | 14.2b | 15.6b | 27.5a | 28.2a | 27.9a | 31.8a | 38.9a | 37.0a | 40.3b | 39.4a | 39.9b |
| SE± | 0.85 | 0.85 | 0.45 | 0.32 | 1.34 | 0.70 | 0.56 | 1.59 | 0.91 | 0.53 | 1.45 | 0.76 |
| **Interaction** | | | | | | | | | | | | |
| P x F | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Means followed the same letter(s) within column and treatment set are not significantly different using DMRT (P = 0.05)

NS = Not Significant

4.1.3 **Diameter of bulb**

The influence of planting pattern on bulb diameter in both seasons and their combined analysis is not significant (Table 3). Fertilizer application significantly influenced bulb diameter with rates up to 500kg/ha. The highest rate of 750kg/ha reduced bulb diameter in 1996 and combined analysis.

No planting pattern x fertilizer rate interaction was significant.

4.1.4 **Fresh weight of bulb**

There was no significant planting pattern effect on fresh bulb weight of onion on (Table 4). Fertilizer application significantly influenced fresh weight where all the three rates of applied fertilizer produced statistically similar weight of fresh bulbs; however, bulbs produced by plots applied with 500kg/ha and 750kg/ha were not statistically different from those produced by plots that received no fertilizer. In 1997/98, all the three fertilizer rates produced similar fresh weight of bulb that were however significantly higher than those produced by plots without fertilizer. No planting pattern x fertilizer rate interaction was significant.

4.1.5 **Dry weight of onion**

Table 5 shows the effect of treatments on dry weight of onion. 1:1 alternate stand planting pattern produced the heaviest dry weight of onion bulbs while all other patterns recorded statistically similar dry weights except in 1996 when 1:2 alternate row recorded the least dry weight among planting patterns. Sole crop recorded lower dry weight than intercrops in both years and the average of the two years.

Fertilizer significantly influenced dry weight of onion. Response to fertilizer was up to the highest rate of 750kg/ha with the exception of 1996 when the rate depressed dry weight.

No planting pattern x fertilizer rate interaction was significant.

Table 3: Effect of planting patterns and fertilizer rates on diameter of onion bulb at Samaru during the 1996/97, 1997/98 seasons mean of the two years.

| | Bulb diameter at harvest (cm) | | |
|---|---|---|---|
| Treatment | 1996/97 | 1997/98 | Mean |
| **PLANTING PATTERNS (P)** | | | |
| Sole crop | 7.1 | 5.6 | 6.3 |
| 1:1 alternate stand | 7.3 | 5.6 | 6.4 |
| 1:2 alternate stand | 7.3 | 5.1 | 6.2 |
| 1:1 alternate row | 7.0 | 4.8 | 5.9 |
| 1:2 alternate row | 7.0 | 5.3 | 6.1 |
| SE $\pm$ | 0.16 | 0.29 | 0.17 |
| **FERTILIZER RATES (F)** | | | |
| (20:10:10) | | | |
| 0 | 5.7c | 4.0b | 4.9c |
| 250 | 7.4b | 5.7a | 6.5ab |
| 500 | 8.1a | 5.9a | 7.0a |
| 750 | 7.3b | 5.6a | 6.4b |
| SE $\pm$ | 0.14 | 0.26 | 0.16 |
| **INTERACTION** | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).
NS = Not Significant.

Table 4: Effect of planting patterns and fertilizer rates on fresh wt. of onion bulb at Samaru during 1996/97, 1997/98 dry seasons and mean of the two years.

| | Mean bulb wt (g) | | |
|---|---|---|---|
| Treatment | 1996/97 | 1997/98 | Mean |
| **PLANTING PATTERNS (P)** | | | |
| Sole | 104 | 97.2 | 100.5 |
| 1:1 alternate stand | 143 | 99.9 | 121.4 |
| 1:2 alternate stand | 130 | 78.2 | 104.1 |
| 1:1 alternate row | 117 | 70.2 | 93.7 |
| 1:2 alternate row | 202 | 83.4 | 142.8 |
| SE± | 39.30 | 8.67 | 20.41 |
| **FERTILIZER RATES (F)** | | | |
| (20:10:10) | | | |
| 0 | 86.0 | 61.0b | 73.5b |
| 250 | 200.0a | 90.1a | 144.9a |
| 500 | 149.0ab | 101.9a | 125.2ab |
| 750 | 123.0ab | 90.1a | 106.5ab |
| SE± | 35.21 | 7.75 | 8.30 |
| INTERACTION | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).

NS = Not significant.

Table 5: Effect of planting patterns and fertilizer rates on oven dry weight/bulb of onion at Samaru during 1996/97, 1997/98 dry seasons mean of the two years.

| Treatment | Dry weight of onion bulb (g) | | |
|---|---|---|---|
| | 1996/97 | 1997/98 | Mean |
| **PLANTING PATTERN (P)** | | | |
| Sole | 14.2d | 10.0b | 12.1c |
| 1:1 alternate stand | 22.3a | 14.7a | 18.5a |
| 1:2 alternate stand | 20.2b | 8.94b | 15.6b |
| 1:1 alternate row | 19.1bc | 7.5b | 15.3bc |
| 1:2 alternate row | 18.4c | 10.5b | 14.5b |
| SE ± | 0.52 | 1.39 | 0.76 |
| **FERTILIZER RATE (F)** | | | |
| (20:10:10) | | | |
| 0 | 13.8c | 7.2b | 10.5b |
| 250 | 20.3b | 10.4ab | 15.4a |
| 500 | 22.2a | 11.1a | 16.7a |
| 750 | 19.0b | 12.5a | 15.8a |
| SE ± | 0.47 | 1.24 | 0.68 |
| **INTERACTION** | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).

NS = Not significant.

### 4.1.6 **Dry matter of onion**

Planting pattern significantly affected the dry matter content of onion in 1996/97 only (Table 6). The different planting patterns under study recorded statistically similar dry matter that was significantly higher than the one recorded by sole crop. Fertilizer application had no significant effect on the dry matter content of onion. No planting patterns x fertilizer rate interaction was significant.

### 4.1.7 **Marketable bulb yield**

Planting pattern effect was significant on marketable bulb yield (Table 7). In 1996/97 the highest marketable bulb yield was obtained by the sole crop followed by 1:1 alternate stand arrangement and 1:1 alternate row. The least marketable bulb yield was obtained by 1:2 alternate row pattern. In 1997/98, the sole crop, 1:1 alternate row pattern and 1:2 alternate row pattern all had statistically similar but higher marketable bulb yield than 1:1 and 1:2 alternate stands. The average of the two years had sole crop and 1:1 alternate stand and role patterns producing statistically similar marketable bulb yields. The marketable bulb yields of all treatments in the intercrop were statistically similar.

Fertilizer application significantly affected marketable bulb yield, but increase was with rates up to 500kg/ha. Higher rate of 750kg/ha decreased marketable bulb yield. No planting pattern x fertilizer rate interaction was significant.

Table 6 Effect of planting pattern and fertilizer rates on dry matter content of Onion in Onion/Pepper mixture during the 1996/97, 199798 dry seasons and mean of the two years.

| | (DM% of Onion) | | |
|---|---|---|---|
| Treatment | 1996/97 | 1997/98 | Mean |
| **PLANTING PATTERNS (P)** | | | |
| Sole | 13.8b | 10.7 | 12.3 |
| 1:1 alternate stands | 16.2a | 12.5 | 14.3 |
| 1:2 alternate stand | 15.8a | 10.7 | 13.3 |
| 1:1 alternate row | 16.2a | 12.0 | 14.1 |
| 1:2 alternate row | 16.0a | 13.8 | 14.9 |
| SE $\pm$ | 0.54 | 1.60 | 0.83 |
| **FERTILIZER RATES (F)** | | | |
| (20:10:10) | | | |
| 0 | 16.1 | 11.6 | 13.8 |
| 250 | 15.7 | 12.9 | 14.3 |
| 500 | 15.1 | 10.4 | 12.7 |
| 750 | 15.6 | 13.0 | 14.3 |
| SE $\pm$ | 0.48 | 1.43 | 0.74 |
| **INTERACTION** | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).

NS = Not significant

#### 4.1.8 Total yield of onion (t/ha)

Planting pattern significantly influenced total yield of onion in both years and their combined analysis (Table 8). Sole crop out yielded all the other planting patterns. Among mixtures, 1:2 alternate row pattern out - yielded all other patterns but recorded similar yield with 1;1 alternate row in 1997/98 and the combine analysis. The least yields were obtained by 1:1 and 1:2 alternate stand patterns.

Increase in the rate of fertilizer application significantly increased yield of onion up to 500kgNPK/ha but decreased at rate higher than this. The control plot gave the lowest yield in both years.

Planting pattern x fertilizer interaction was observed in both years. In 1996/97 (Table 9) sole crop that received 500kg/ha of fertilizer had the highest yield while the yields of sole crop that received either 750 or 250kg/ha were similar. Among the inter-crops 1:2 alternate row that received 500kg/ha out yielded all other patterns. The least yield was obtained by 1:1 alternate stand that received no fertilizer. In 1997/98 and the average of the two years (Table 10 and 11), sole crop out yielded mixtures even where fertilizer was not applied. The highest yield was obtained by sole crop applied with 500kg/ha of fertilizer. Among the mixtures 1:1 and 1:2 alternate row patterns recorded similar yields that were statistically higher than those of other patterns. The least yield was obtained by 1:1 alternate stand that received no fertilizer.

Table 7: Effect of planting patterns and fertilizer rates on Marketable bulb yield of Onion (t/ha) at Samaru during the 1996/97, 1997/98 seasons and mean of the two years.

| | Marketable bulb yield (t/ha) | | |
|---|---|---|---|
| Treatment | 1996/97 | 1997/98 | Mean |
| **PLANTING PATTERNS (P)** | | | |
| Sole | 13.2a | 10.3ab | 11.6a |
| 1:1 alternate stands | 9.5b | 10.2b | 9.7ab |
| 1:2 alternate stands | 4.9d | 10.2b | 7.4b |
| 1:1 alternate row | 8.5c | 10.4a | 9.2ab |
| 1:2 alternate row | 4.1d | 10.3ab | 7.1b |
| SE $\pm$ | 0.24 | 0.062 | 0.92 |
| **F0ERTILIZER RATE (F)** | | | |
| (20:10:10) | | | |
| 0 | 6.0c | 3.9b | 4.5b |
| 250 | 8.5b | 5.1a | 6.8ab |
| 500 | 9.6a | 5.4a | 7.5a |
| 750 | 8.6b | 5.0b | 6.8ab |
| SE $\pm$ | 0.22 | 0.05 | 0.82 |
| **INTERACTION** | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).

NS = Not significant.

Table 8: Effect of planting patterns and fertilizer rates on Total bulb yield (t/ha) onion at Samaru during the 1996/97, 1997/98 dry seasons and mean of the two years.

| | Total bulb yield (t/ha) | | |
|---|---|---|---|
| Treatment | 1996/97 | 1997/98 | Mean |
| **PLANTING PATTERNS (P)** | | | |
| Sole | 14.5a | 12.5a | 13.5a |
| 1:1 alternate stands | 4.7d | 2.6c | 3.6d |
| 1:2 alternate stands | 5.3d | 4.6bc | 4.7c |
| 1:1 alternate rows | 8.6c | 4.6b | 6.6b |
| 1:2 alternate rows | 9.5b | 4.5b | 7.0b |
| SE ± | 0.26 | 0.54 | 0.30 |
| **FERTILIZER RATES(F)** | | | |
| (20:10:10) | | | |
| 0 | 5.7c | 2.5c | 4.1c |
| 250 | 9.2b | 5.9b | 7.6b |
| 500 | 10.5a | 8.2a | 9.3a |
| 750 | 8.7b | 6.0b | 7.4b |
| SE ± | 0.24 | 0.47 | 0.27 |
| **INTERACTION** | | | |
| P x F | ** | ** | ** |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).

** = Highly Significant

Table 9: Interaction of planting patterns and fertilizer rates on Total bulb yield (t/ha) at Samaru during the 1996/97 dry season.

| | FERTILIZER RATE (kg/ha | | | |
|---|---|---|---|---|
| Treatment | 0 | 250 | 500 | 750 |
| **PLANTING PATTERNS (P)** | | | | |
| Sole | 9.5def | 15.1b | 17.7a | 15.6b |
| 1:1 alternate stand | 2.8j | 5.2j | 9.9cd | 4.9i |
| 1:2 alternate stands | 3.2j | 5.8i | 6.2hi | 5.7i |
| 1:1 alternate row | 5.4i | 9.8de | 11.1cd | 8.1fg |
| 1:2alternate rows | 7.4gh | 10.0cde | 11.3c | 9.2efg |
| SE $\pm$ | | 0.53 | | |

Table 10: Interaction of patterns and fertilizer rates on Total bulb yield (t/ha) of onion at Samaru during the 1997/98 dry seasons.

| | FERTILIZER RATE (kg/ha) | | | |
|---|---|---|---|---|
| Treatment | 0 | 250 | 500 | 750 |
| **PLANTING PATTERNS (P)** | | | | |
| Sole | 6.0c | 13.2b | 18.9a | 12.0b |
| 1:1 alternate stand | 0.6i | 2.7f-i | 3.4d-i | 3.6c-i |
| 1:2 alternate stands | 1.4hi | 4.3c-h | 6.0cde | 4.6cg |
| 1:1 alternate row | 1.6ghi | 5.4c-f | 6.6c | 4.9c-f |
| 1:2 alternate rows | 2.9e-i | 4.0c-h | 6.2cd | 5.0c-f |
| SE $\pm$ | 0.06 | | | |

Table 11: Mean interaction analysis of the effect of planting patterns and fertilizer rate on total bulb yield (combined analysis).

| | FERTILIZER RATE (kg/ha) | | | |
|---|---|---|---|---|
| Treatment | 0 | 250 | 500 | 750 |
| **PLANTING PATTERNS (P)** | | | | |
| Sole | 7.8cde | 14.1b | 18.3a | 13.8b |
| 1:1 alternate stand | 1.7j | 4.0hi | 4.6gh | 4.3h |
| 1:2 alternate stands | 2.3ij | 5.1fg | 6.1efg | 5.2fgh |
| 1:1 alternate row | 3.5hij | 7.6cde | 8.9c | 6.5ef |
| 1:2 rows | 5.2fg | 7.0de | 8.8cd | 7.1cde |
| SE ± | | 0.60 | | |

Means followed by the same letter(s) within columns and treatment set are not significant when using DMRT (P=0.05).

### 4.1.9 Correlation matrices between growth and yield variables of onion at Samaru during 1996/96, 1997/98 and mean of the two years

The relationships that existed between growth and yield attributes of onion crop are shown on Tables 12, 13 and 14. All the growth and yield attributes recorded positive and significant correlation except the one between total bulb yield and bulb fresh weight, total bulb yield and leaf number and bulbs dry weight and bulb fresh weight in 1998/97; total bulb yield and bulb dry weight in 1997/98 and total bulb yield and bulb fresh or dry bulb yield and bulb fresh weight bulb dry weight was significantly negative.

Table 12: Correlation matrix between growth and yield characters of onion during 1996/97 season

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 1. | **Total bulb yield** | 1.00 | | | | | |
| 2. | **Bulb DW** | -0.2* | 1.00 | | | | |
| 3. | **Bulb FW** | 0.02 | 0.02 | 1.00 | | | |
| 4. | **Bulb diameter** | 0.3** | 0.7** | 0.2** | 1.00 | | |
| 5. | **Number of leaves** | 0.1 | 0.8** | 0.2** | 0.7** | 1.00 | |
| 6. | **Plant height** | 0.4** | 0.5** | 0.2** | 0.7** | 0.6** | 1.00 |

* = **Significant at 5% level of significance**

** = **Significant at 1% level of significance**

Table 13: Correlation matrix between growth and yield characters of onion during 1997/98 season.

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 1. | **Total bulb yield** | 1.00 | | | | | |
| 2. | **Bulb DW** | 0.1 | 1.00 | | | | |
| 3. | **Bulb FW** | 0.4** | 0.3* | 1.00 | | | |
| 4. | **Bulb diameter** | 0.4** | 0.3** | 0.8** | .00 | | |
| 5. | **Number of leaves** | 0.3** | 0.3** | 0.3** | 0.5** | 1.00 | |
| 6. | **Plant height** | 0.3** | 0.2* | 0.4** | 0.4** | 0.4** | 1.00 |

* = **Significant at 5% level of significance**

** = **Significant at 1% level of significance**

Table 14: Mean correlation matrix between growth and yield characters of onion during (1996/97 and 1997/98 seasons)

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 1. | Total bulb yield | 1.00 | | | | | |
| 2. | Bulb DW | 0.2* | 1.00 | | | | |
| 3. | Bulb FW | 0.2* | 0.3** | 1.00 | | | |
| 4. | Bulb diameter | 0.5** | 0.7** | 0.4** | 1.00 | | |
| 5. | Number of leaves | 0.3** | 0.6** | 0.3** | 0.7** | 1.00 | |
| 6. | Plant height | 0.3** | 0.2* | 0.2* | 0.4** | 0.4** | 1.00 |

* = Significant at 5% level of significance

** = Significant at 1% level of significance

## 4.2 Pepper

### 4.2.1 Number of leaves/plant

Significant response due to planting pattern on number of leaves per plant of pepper was recorded at 7, 9, 11 and 13 WAT (Table 15). At 7 WAT, 1:1 alternate stand arrangement had the highest leaf number followed by 1:1 alternate row. Pepper grown sole produced the least number of leaves per plant although not significantly different from those of the 1:2 alternate stand and 1:2 alternate row arrangements. At 9 WAT, all the mixed crop planting patterns recorded significantly similar leaf number that was higher than that of sole crop. At 11 WAT, 1:1 alternate stand significantly produced more leaves than other planting patterns which were statistically similar. At 13 WAT, all the mixed crop planting arrangements gave significantly similar but higher number of leaves than sole crop.

In 1997/98, planting pattern effect was significant at 7, 11 and 13 WAT. At 7WAT 1:1 alternate stand gave the highest leaf number that was similar to the one produced by 1:1 alternate row but the leaf number produced by 1:1 alternate row was similar to those produced by other planting patterns including sole. At 11 WAT 1:1 alternate stand also produced the highest leaf number while all other planting patterns produced similar leaf number. At 13 WAT however, all the plants in mixtures produced significantly higher leaf number than sole crop.

When the two years were averaged, leaf number was significant only at 13 WAT where the crop mixtures produced higher leaf than sole crop.

Fertilizer application significantly influenced number of leaves per plant at all sampling periods. Fertilizer rates of 500KgNPK/ha gave the highest leaf number during all sampling periods. This was similar to the one obtained by the application of 750kg at 5,7,9 and 13 WAT. The least leaf number was obtained by plots with no fertilizer at all periods of sampling was recorded. At 9 and 11 WAT of 1996 250kg/ha also gave a statistically similar leaf number with the higher applied rate. There was no significant planting pattern x fertilizer rate interaction on the number of leaves.

In the average of the two years, fertilizer rates of up to 750kg/ha increased leaf number except at 5 and 9 WAT of the two years had no significant differences due to planting pattern except at 13 WAT. Increasing fertilizer rates up to 500kgNPK/ha had significant influence on number of leaves at all periods of sampling. Further increase to 750kg/ha had no significant effect except at 5 and 9 WAT when it significantly depressed leaf number. No significant planting pattern x fertilizer rate interaction was recorded.

**TABLE 15: Effect of Planting Pattern and Fertilizer rates on number of leaves / Plant of Pepper in onion/Pepper mixture during the 1996/97 and 1997/98 dry season and mean of the two seasons.**

| | WEEKS AFTER TRANSPLANTING | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | | | 7 | | | 9 | | | 11 | | | 13 | | |
| Treatment | 96/97 | 97/98 | mean | 96/97 | 97/98 | mean | 96/97 | 97/98 | mean | 96/97 | 97/98 | mean | 96/97 | 97/97 | mean |
| **Planting Pattern (P)** | | | | | | | | | | | | | | | |
| Sole Crop | 10.8 | 9.5 | 10.2 | 26.1 | 19.3b | 22.7 | 26.0c | 30.1 | 28.0 | 38.8ab | 39.0b | 38.9 | 139.7 | 132.2b | 136.4b |
| 1:1 Alternate Stand | 12.7 | 9.5 | 11.1 | 31.6 | 22.3a | 26.9 | 34.6a | 28.5 | 31.6 | 33.0 | 44.6a | 41.9 | 176.3 | 157.2a | 168.8a |
| 1:2 Alternate Stand | 12.3 | 9.8 | 11.0 | 31.2 | 20.5b | 25.8 | 32.2ab | 29.7 | 30.9 | 49.8a | 38.6b | 44.2 | 148.7 | 157.8a | 153.8a |
| 1:1 Alternate Row | 11.1 | 9.4 | 10.2 | 31.4 | 21.0ab | 25.7 | 34.8ab | 30.3 | 32.6 | 47.3a | 39.1b | 43.2 | 158.3 | 170.5a | 164.1a |
| 1:2 Alternate Row | 11.6 | 9.6 | 10.6 | 26.1 | 20.6b | 23.4 | 32.2ab | 28.6 | 30.9 | 40.7a | 38.6b | 39.6 | 151.2 | 167.1a | 159.1a |
| SE ± | 0.88 | 0.14 | 0.45 | 2.48 | 0.46 | 1.28 | 2.18 | 0.62 | 1.14 | 3.72 | 0.48 | 1.86 | 9.93 | 5.65 | 5.74 |
| 1.00 | | | | | | | | | | | | | | | |
| **Fertilizer Rate (F)** | | | | | | | | | | | | | | | |
| 0 | 8.0c | 8.9c | 8.4c | 19.4b | 15.0c | 17.2c | 25.2b | 19.3c | 22.3c | 28.3b | 25.9c | 27.1c | 85.3c | 68.9c | 77.1c |
| 250 | 11.9b | 9.5b | 10.7b | 29.7b | 20.1b | 24.9b | 32.9a | 31.6b | 32.3b | 39.8a | 41.8b | 40.8b | 141.1b | 152.1b | 149.6b |
| 500 | 14.6a | 10.0a | 12.3a | 34.4a | 24.1a | 29.2a | 37.4a | 34.7a | 36.0a | 51.6a | 46.2a | 48.9ab | 191.5a | 210.1a | 200.8a |
| 750 | 12.3ab | 9.8ab | 11.0b | 32.9a | 23.8a | 28.3a | 32.3a | 35.0ab | 32.7b | 56.1a | 43.0b | 49.6a | 195.3a | 197.6a | 196.4a |
| SE± | 0.79 | 0.12 | 0.40 | 2.22 | 0.41 | 1.14 | 1.95 | 0.55 | 1.02 | 3.32 | 0.43 | 1.66 | 8.88 | 5.05 | 5.14 |
| **Interaction** | | | | | | | | | | | | | | | |
| P x F | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Means followed the same letter(s) within column and treatment set are not significantly different using DMRT (P = 0.05)
NS = Not Significant

4.2.2 **Plant height**

Influence of planting pattern on the height of pepper at various sampling periods in 1996/97 was significant except at 7 WAT (Table 16). At 5 WAT, 1:1 alternate row recorded significantly taller plants than 1:1 alternate and 1:2 alternate row treatments. But there was no significant difference between 1:1 alternate row and the 1:2 alternate stand or the sole crop treatment. At 9 WAT, it was the sole crop that had the plants that were significantly taller than other planting patterns except 1:1 alternate stand treatment. At 11 WAT, the 1:1 and 1:2 alternate stand crop pattern gave significantly similar but taller plants than those produced by sole crop and 1:1 alternate row.

Similar plant heights were however observed for 1:1 and 1:2 alternate rows which also produced taller plants than the sole crop. At 13 WAT, the 1:1 alternate row produced significantly taller plants than other treatments except the sole crop with which it was similar. Significant response to fertilizer was up to 750kg/ha except at 5 and 13 WAT of 1996 where the rate reduced plant height.

TABLE 16: The effect of Planting and Fertilizer rates on Plant height of Pepper in onion/Pepper mixture during the 1996/97 and 1997/98 dry season and mean of the two seasons.

| | WEEKS AFTER TRANSPLANTING | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | | | 7 | | | 9 | | | 11 | | | 13 | | |
| **Treatment** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/97** | **mean** |
| **Planting Pattern (P)** | | | | | | | | | | | | | | | |
| Sole Crop | 6.2ab | 5.9 | 6.1 | 9.9 | 7.9 | 8.9 | 13.6a | 17.0 | 15.3 | 19.4c | 21.6 | 20.5 | 38.2ab | 36.5 | 37.3 |
| 1:1 Alternate Stand | 6.0b | 5.8 | 5.9 | 8.8 | 8.5 | 8.7 | 12.8ab | 22.5 | 17.6 | 22.0a | 23.8 | 22.0 | 36.2c | 39.6 | 37.3 |
| 1:2 Alternate Stand | 6.3ab | 6.3 | 6.3 | 9.3 | 8.6 | 8.9 | 12.4b | 21.1 | 16.3 | 22.5a | 23.4 | 37.0 | 37.6bc | 37.3 | 22.1 |
| 1:1 Alternate Row | 6.6a | 6.3 | 6.5 | 9.4 | 8.5 | 8.9 | 12.7b | 20.5 | 16.6 | 20.5bc | 23.4 | 22.0 | 39.9a | 37.3 | 38.6 |
| 1:2 Alternate Row | 5.8b | 6.3 | 6.1 | 9.5 | 7.9 | 8.7 | 12.4b | 18.3 | 15.4 | 21.7ab | 20.9 | 21.3 | 37.0bc | 36.3 | 36.7 |
| SE ± | 0.20 | 0.30 | 0.20 | 0.30 | 0.40 | 0.30 | 0.30 | 1.90 | 1.00 | 0.40 | 1.60 | 0.80 | 0.70 | 1.90 | 1.00 |
| **Fertilizer Rate (F)** | | | | | | | | | | | | | | | |
| 0 | 5.2C | 5.0c | 5.1c | 7.1b | 6.6b | 6.9c | 10.6d | 13.8b | 12.2c | 16.2c | 18.0c | 17.1c | 23.7c | 22.5b | 23.1c |
| 250 | 6.2b | 6.1b | 6.2b | 9.4a | 8.6a | 9.0b | 13.2b | 20.0a | 16.6b | 21.4b | 21.2bc | 21.3b | 40.9b | 38.6a | 39.7b |
| 500 | 6.8a | 6.9a | 6.8a | 10.8a | 9.2a | 10.0a | 14.8a | 24.1a | 19.5a | 23.9a | 27.2a | 25.6a | 44.3a | 43.2a | 43.7a |
| 750 | 5.6c | 6.6ab | 6.6ab | 10.2a | 8.8a | 9.5ab | 12.4a | 21.6a | 17.0ab | 23.4a | 23.7ab | 23.5a | 42.3b | 45.0a | 43.7a |
| SE± | 0.20 | 0.20 | 0.10 | 0.30 | 0.40 | 0.20 | 0.30 | 1.20 | 0.90 | 0.40 | 1.40 | 0.70 | 0.60 | 1.20 | 0.90 |
| **Interaction** | | | | | | | | | | | | | | | |
| P x F | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Means followed the same letter(s) within column and treatment set are not significantly different using DMRT (P = 0.05)

NS = Not Significant

### 4.2.3. <u>Number of branches/plant</u>

Planting pattern effect on the number of branches per plant was significant at 5 and 7 WAT of the mean (Table 17). At 5 WAT the treatments in mixture had a statistically similar number of branches per plant but, the number of branches per plant produced by sole crop was at par with all the other planting patterns except 1:1 alternate stand which had the highest number of branches. At 7 WAT 1:2 alternate row produced the highest number of branches that were statistically similar to those produced by 1:1 alternate row. The least number of branches were produced by sole crop and 1:1 alternate stand. Fertilizer application significantly affected the number of branches. Response to fertilizer was up to 750kg/ha except at 9, 11 and 13 WAT of 1996 and at 9 WAT of the mean where it depressed branch number. No planting pattern x fertilizer rate interaction was significant.

**TABLE 17:** The effect of Planting Pattern and Fertilizer rates on number of branches / Plant of Pepper in onion/Pepper mixture during the 1996/97 and 1997/98 dry season and mean of the two seasons.

| | WEEKS AFTER TRANSPLANTING | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | | | 7 | | | 9 | | | 11 | | | 13 | | |
| **Treatment** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/98** | **mean** | **96/97** | **97/97** | **mean** |
| **Planting Pattern (P)** | | | | | | | | | | | | | | | |
| Sole Crop | 1.9 | 2.4 | 2.1b | 5.6b | 8.5 | 7.0c | 12.3 | 15.1 | 13.9 | 22.5 | 13.6b | 21.2 | 34.0 | 40.4 | 37.1 |
| 1:1 Alternate Stand | 2.2 | 2.8 | 2.5a | 6.6a | 7.7 | 7.2c | 11.3 | 13.6 | 12.4 | 23.0 | 16.2b | 19.6 | 35.7 | 43.3 | 39.5 |
| 1:2 Alternate Stand | 2.1 | 2.7 | 2.4ab | 5.9b | 9.4 | 7.7bc | 10.6b | 14.3 | 12.5 | 22.7 | 20.0ab | 21.4 | 35.4 | 35.4 | 35.0 |
| 1:1 Alternate Row | 2.1 | 2.7 | 2.4ab | 7.0a | 9.6 | 8.3ab | 11.3 | 15.3 | 13.3 | 23.1 | 19.4ab | 20.2 | 37.4 | 35.8 | 36.6 |
| 1:2 Alternate Row | 2.1 | 2.4 | 2.2ab | 7.1a | 10.4 | 8.7a | 11.0 | 13.7 | 12.4 | 21.6 | 22.4a | 22.0 | 37.7 | 45.0 | 41.4 |
| SE ± | 0.12 | 0.17 | 0.11 | 0.17 | 0.65 | 0.34 | 0.46 | 0.93 | 0.51 | 0.53 | 1.28 | 0.69 | 2.20 | 2.88 | 1.86 |
| **Fertilizer Rate (F)** | | | | | | | | | | | | | | | |
| 0 | 1.8b | 2.1b | 1.9b | 3.6c | 6.2c | 5.0c | 8.7c | 9.5b | 9.1c | 15.0d | 13.7b | 14.0c | 22.0c | 18.3c | 20.1c |
| 250 | 2.0ab | 2.7ab | 2.4a | 6.9b | 9.0b | 8.0b | 11.7b | 13.8a | 13.7b | 22.7c | 21.3a | 22.0b | 35.6b | 37.8b | 36.7b |
| 500 | 2.2a | 3.0a | 2.6a | 8.0a | 10.3ab | 9.2a | 14.2a | 17.1a | 15.6a | 27.0a | 21.8a | 24.4a | 48.0a | 48.9a | 48.5a |
| 750 | 2.2a | 2.6ab | 2.4a | 7.2ab | 10.8a | 9.0a | 10.6b | 15.3a | 13.0b | 24.1b | 21.9a | 23.0ab | 37.7b | 54.9a | 46.3a |
| SE± | 0.11 | 0.15 | 0.11 | 0.15 | 0.58 | 0.30 | 0.41 | 0.83 | 0.53 | 0.47 | 1.15 | 0.62 | 2.03 | 2.58 | 1.66 |
| **Interaction** | | | | | | | | | | | | | | | |
| P x F | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Means followed the same letter(s) within column and treatment set are not significantly different using DMRT (P = 0.05)
NS = Not Significant

4.2.4 **Days to flowering**

The effect of treatments on number of days to flowering in both years and their mean is shown on Table 18. Planting pattern influence was significant only in 1996/97 where 1:2 alternate row significantly recorded more days to flowering than all other planting patterns except 1:1 alternate row which recorded similar number of days to flowering. There was no significant difference in the number of days to flowering between 1:1 and 1:2 alternate stands. Fertilizer had no influence on days to flowering in both seasons and their mean. Likewise, there was no significant planting pattern x fertilizer rate interaction on number of days to flowering.

4.2.5 **Fruit length**

Response of fruit length of pepper to treatments in both seasons and the mean of the two years is shown on Table 19. In 1996/97, sole pepper significantly produced longer fruits than 1:1 alternate rows. There was however no significant difference between sole crop or 1:1 alternate stands and 1:2 alternate row. In 1997/98 season, sole crop significantly produced longer fruits than all the other planting patterns except 1:1 alternate stand which had statistically, similar fruits with sole crop. 1:1 alternate stand on the other hand, had fruits that were statistically similar with all the planting patterns. The two year average showed that sole crop produced longer fruits than all other treatments which were statistically similar.

The influence of fertilizer on fruit length showed that in 1996/97 and the combined analysis, application of 500kg/ha produced significantly longer fruits. Higher doses of 750kg/ha reduced fruit length in both cases. In 1997/98, there was no significant difference in fruit length as a result of varying fertilizer rates even though treatments applied fertilizer had longer fruits than those without fertilizer. No significant planting pattern x fertilizer rates interaction was observed.

### 4.2.6 **Fruit diameter**

Planting pattern had no significant effect on the diameter of pepper in both seasons and their average (Table 20). Fertilizer rates of 500kg/ha significantly increased fruit diameter. Higher rates of 750kg/ha decreased diameter.

### 4.2.7 **Fresh weight of fruits**

The effect of treatment on mean fresh weight of fruits in both years and their mean is shown on Table 21. In 1996/97, sole crop significantly had heavier fresh fruits than 1:1 alternate stand and 1:2 alternate row. 1:2 alternate stand and 1:1 alternate row were statistically similar with sole crop on one hand, and similar with 1:1 alternate stand and 1:2 alternate row on the other. In 1997/98, 1:1 alternate stand significantly had higher fresh weight than sole crop but; was statistically similar with 1:1 alternate row and 1:2 alternate row. These two were similar with 1:2 alternate stand. Average of the two years showed no significant influence of treatments on fresh weight of fruits.

Fertilizer rates of 500kg/ha significantly gave a higher fresh weight of pepper in 1996/97 while the higher rate of 750kg/ha reduced fruit fresh weight. In 1997/98, all the three applied fertilizer rates produced fresh weights that were significantly higher than zero fertilizer plots but statistically similar. The two year average showed no significant influence of fertilizer on fruit fresh weight.

No significant planting pattern and fertilizer interaction was recorded.

**Table 18: Effect of planting patterns and fertilizer rates on days to 50% flowering on pepper at Samaru during the 1996/97, 97/98 seasons and mean of the two years.**

| Treatment | Days to 50% flowering | | |
|---|---|---|---|
| | 1996/97 | 1997/98 | Mean |
| PLANTING PATTERNS (P) | | | |
| Sole | 71.9b | 82.7 | 77.3 |
| 1:1 Alternate Stand | 72.8b | 80.7 | 76.8 |
| 1:2 Alternate Stand | 70.6b | 72.6 | 71.6 |
| 1:1 Alternate Row | 73.6ab | 78.2 | 75.9 |
| 1:2 Alternate Row | 78.9a | 79.8 | 79.4 |
| SE ± | 1.93 | 3.48 | 1.99 |
| FERTILIZER RATE (F) (20:10:10) | | | |
| 0 | 76.3 | 79.9 | 78.1 |
| 250 | 73.2 | 79.9 | 76.5 |
| 500 | 72.9 | 81.9 | 77.4 |
| 750 | 71.9 | 73.5 | 72.7 |
| SE ± | 1.73 | 3.11 | 1.78 |
| INTERACTION | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).
NS = Not Significant.

**Table 19: Effect of planting patterns and fertilizer rates on fruit length of pepper at Samaru during the 1996/97, 97/98 seasons and mean of the two years.**

| Treatment | Fruit length (cm) | | |
|---|---|---|---|
| | 1996/97 | 1997/98 | Mean |
| PLANTING PATTERNS (P) | | | |
| Sole | 5.6a | 5.6a | 5.6a |
| 1:1 Alternate Stand | 5.3ab | 4.9ab | 5.1b |
| 1:2 Alternate Stand | 5.5ab | 4.3b | 4.9b |
| 1:1 Alternate Row | 5.2b | 4.6b | 4.9b |
| 1:2 Alternate Row | 5.3ab | 4.4b | 4.8b |
| SE ± | 0.12 | 0.28 | 0.16 |
| FERTILIZER RATE (F) (20:10:10) | | | |
| 0 | 4.6c | 3.3b | 4.0c |
| 250 | 5.4b | 5.2a | 5.3b |
| 500 | 6.1a | 5.5a | 5.8a |
| 150:75:75 | 5.4b | 5.0a | 5.2b |
| SE ± | 0.11 | 0.25 | 0.14 |
| INTERACTION | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).

NS = Not Significant.

Table 20: Effect of planting patterns and fertilizer rates on diameter of pepper at Samaru during the 1996/97, 1997/98 dry seasons and mean of the two seasons.

| Treatment | Fruit diameter at harvest(cm) | | |
|---|---|---|---|
| | 1996/97 | 1997/98 | Mean |
| PLANTING PATTERNS (P) | | | |
| Sole | 3.0 | 3.3 | 3.2 |
| 1:1 Alternate Stand | 3.0 | 3.1 | 3.0 |
| 1:2 Alternate Stand | 3.0 | 3.2 | 3.1 |
| 1:1 Alternate Row | 3.1 | 2.9 | 3.0 |
| 1:2 Alternate Row | 2.9 | 3.1 | 3.0 |
| SE ± | 0.05 | 0.12 | 0.08 |
| FERTILIZER RATE (F) (20:10:10) | | | |
| 0 | 2.3c | 2.3c | 2.5c |
| 250 | 3.0b | 3.2b | 3.1b |
| 500 | 3.3a | 3.7a | 3.5a |
| 750 | 2.9b | 3.3b | 3.1b |
| SE ± | 0.05 | 0.11 | 0.06 |
| INTERACTION | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).

NS = Not Significant

**Table 21: Effect of planting patterns and fertilizer rates on Mean fresh weight/fruit of pepper at Samaru during the 1996/97, 19997/98 dry seasons and mean of the two years.**

| | Mean fresh weight/fruit (g) | | |
|---|---|---|---|
| Treatment | 1996/97 | 1997/98 | Means |
| PLANTING PATTERNS | | | |
| Sole | 10.8a | 9.2c | 10.0 |
| 1:1 Alternate Stand | 9.2b | 12.6a | 10.9 |
| 1:2 Alternate Stand | 10.1ab | 10.1bc | 10.1 |
| 1:1 Alternate Row | 9.7ab | 11.6ab | 10.7 |
| 1:2 Alternate Row | 8.8b | 11.4ab | 10.1 |
| SE ± | 0.43 | 0.81 | 0.46 |
| FERTILIZER RATE (F) (20:10:10) | | | |
| 0 | 7.5c | 6.5b | 11.0 |
| 250 | 9.9b | 12.3a | 11.1 |
| 500 | 11.6a | 13.1a | 12.4 |
| 750 | 9.8b | 12.1a | 11.0 |
| SE ± | 0.39 | 0.72 | 0.41 |
| INTERACTION | | | |
| P x F | NS | NS | NS |

**Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).**
**NS = Not Significant.**

#### 4.2.8 Dry weight of fruits

The effect of treatments on dry weight of fruits in 1996/97, 1997/98 seasons and their average is shown on Table 22. Planting pattern significantly affected dry weight only in 1996/97 season. Sole crop had a significantly higher dry weight than all the other planting patterns except 1:2 alternate stand with which it is similar. 1:1 alternate row on the other hand was statistically similar with 1:2 alternate row. No significant influence due to planting pattern was recorded in 1997/98 and the average.

Fertilizer application significantly influenced dry weight in both years and the combined analysis. Application of up to 750kg/ha produced significantly higher dry weight except in the two year average where it significantly decreased dry weight.

No fertilizer x planting pattern interaction was recorded.

#### 4.2.9 Dry Matter Percentage

Planting pattern had no significant influence on dry matter percentage of pepper in both seasons and their average over both years (Table 23). Fertilizer on the other hand significantly affected dry matter percentage in 1996/97 season only. Fruits that received no fertilizer and those with 250kg/ha had statistically similar but higher dry matter percentage. Higher NPK rates of 500 and 750 depressed the dry matter percentage. No significant planting pattern x fertilizer rate interaction was observed.

**Table 22: Effect of planting patterns and fertilizer rates on Dry weight of pepper fruits at Samaru during the 1996/97, 1997/98 dry seasons and mean of the two years.**

| | Dry weight of fruits (g) | | |
|---|---|---|---|
| **Treatment** | **1996/97** | **1997/98** | **Mean** |
| PLANTING PATTERNS (P) | | | |
| Sole | 2.0a | 1.7 | 1.9 |
| 1:1 Alternate Stand | 1.8b | 2.6 | 2.2 |
| 1:2 Alternate Stand | 1.9ab | 2.1 | 2.0 |
| 1:1 Alternate Row | 1.7bc | 2.3 | 2.0 |
| 1:2 Alternate Row | 1.5c | 2.1 | 1.8 |
| SE $\pm$ | 0.06 | 0.25 | 0.13 |
| FERTILIZER RATE (F) (20:10:10) | | | |
| 0 | 1.5c | 1.5b | 1.5c |
| 250 | 1.9b | 2.3a | 2.1ab |
| 500 | 2.0a | 2.7a | 2.4a |
| 750 | 1.7a | 2.2a | 2.0b |
| SE $\pm$ | 0.47 | 1.24 | 0.11 |
| INTERACTION | | | |
| P x F | NS | NS | NS |

**Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).**
**NS = Not Significant.**

**Table 23: Effect of planting patterns and fertilizer rates on dry matter percentage of Pepper fruit at Samaru during the 1996/97, 1997/98 dry seasons and mean of the two years.**

| | Percentage dry matter (DM%) | | |
|---|---|---|---|
| Treatment | 1996/97 | 1997/98 | Mean |
| PLANTING PATTERNS (P) | | | |
| Sole | 18.8 | 19.3 | 19.0 |
| 1:1 Alternate Stand | 20.1 | 20.0 | 20.0 |
| 1:2 Alternate Stand | 19.3 | 20.7 | 20.0 |
| 1:1 Alternate Row | 18.4 | 20.9 | 20.7 |
| 1:2 Alternate Row | 18.4 | 17.0 | 17.7 |
| SE ± | 0.88 | 2.12 | 1.18 |
| FERTILIZER RATE (F) (20:10:10) | | | |
| 0 | 20.9a | 21.9 | 21.4 |
| 250 | 19.3ab | 19.4 | 19.4 |
| 500 | 17.9b | 19.0 | 18.4 |
| 750 | 17.8b | 19.6 | 18.8 |
| SE ± | 0.79 | 1.90 | 1.02 |
| INTERACTION | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significant when using DMRT (P=0.05).
NS = Not Significant.

#### 4.2.10 Total yield

The effect of treatments on total yield of pepper during both seasons and their mean is shown on Table 24. Planting pattern significantly influenced total yield where sole crop out yielded crop mixture ;in both seasons and the combined analysis. Also, in both seasons and their combined analysis, 1:1 alternate stand, 1:2 alternate stand and 1:1 alternate row all had yields that were statistically similar with each other but significantly higher than 1:2 alternate row; except in 1996/97 when 1:1 alternate row had a significantly lower yield ;than 1:1 alternate stand.

Fertilizer application of 500kg/ha gave a significantly higher yield than the other rates which recorded statistically similar yields with each other.

Planting pattern x fertilizer rate interaction was significant in 1997/98 and the mean of the two years (Tables 25 and 26). Sole crop that received 500kg/ha produced the significantly highest yield, but increasing fertilizer rates to 750kg/ha decreased the yield. The lowest yield was obtained by 1:1 and 1:2 alternate stand treatments and 1:2 alternate row treatment that received no fertilizer.

**Table 24: Effect of planting patterns and fertilizer rates on yield of pepper (t/ha) in an onion / pepper mixed crop at Samaru during the 1996/97, 1997/98 seasons and mean of the two seasons.**

| | Pepper yield (t/ha) at harvest | | |
|---|---|---|---|
| **Treatment** | 1996/97 | 1997/98 | **Mean** |
| **PLANTING PATTERNS (P)** | | | |
| **Sole** | **2.3a** | **3.7a** | **3.0a** |
| **1:1 alternate stand** | **1.6b** | **1.9b** | **1.7b** |
| **1:2 alternate stands** | **1.3bc** | **1.8b** | **1.5b** |
| **1:1 alternate row** | **1.3c** | **1.8b** | **1.6b** |
| **1:2 alternate row** | **0.8d** | **1.3c** | **1.1c** |
| **SE ±** | **0.09** | **0.09** | **0.06** |
| **FERTILIZER RATE (F)** | | | |
| (20:10:10) | | | |
| **0** | **0.9c** | **1.2c** | **1.5c** |
| **250** | **1.4b** | **2.1b** | **1.8b** |
| **500** | **2.0a** | **2.9a** | **2.4a** |
| **750** | **1.55b** | **2.2b** | **1.9b** |
| **SE ±** | **0.08** | **0.08** | **0.06** |
| **INTERACTION** | | | |
| **P x F** | **NS** | ** | ** |

**Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).**
**NS = Not Significant.**
**** = Highly significant**

Table 25: Interaction of planting patterns and fertilizer rates on Total fruit yield/ha) of pepper in an onion/pepper mixed crop at Samaru during 1997/98 dry season.

| Treatment | Fertilizer rates (kg/ha) | | | |
|---|---|---|---|---|
| | 0 | 500 | 500 | 750 |
| PLANTING PATTERNS (P) | | | | |
| Sole | 2.3def | 3.2c | 5.9a | 4.4b |
| 1:1 Alternate Stand | 1.1hi | 1.9fg | 2.7cd | 1.8fg |
| 1:2 Alternate Stand | 1.1hi | 1.8fg | 2.6de | 1.6gh |
| 1:1 Alternate Row | 0.9ij | 2.0efg | 2.5de | 1.8gh |
| 1:2 Alternate Row | 0.5j | 1.5gh | 1.8fg | 1.5gh |
| SE ± | | 0.20 | | |

Means followed by the same letter(s) within columns and treatment set are not significant when using DMRT (P=0.05).

Table 26: Interaction of planting patterns and fertilizer rates on Total fruit yield of pepper fruit/ha (t/ha) at Samaru (mean of the two season).

| Treatment | Fertilizer rates (kg/ha) | | | |
|---|---|---|---|---|
| | 0 | 250 | 500 | 750 |
| PLANTING PATTERNS (P) | | | | |
| Sole | 1.9fg | 2.7c | 3.9a | 3.4b |
| 1:1 Alternate Stand | 1.1j | 1.7fgh | 2.6cd | 1.6ghi |
| 1:2 Alternate Stand | 1.1jk | 1.7fgh | 2.0ef | 1.4hij |
| 1:1 Alternate Row | 0.7kl | 1.6hi | 3.2de | 1.7fgh |
| 1:2 Alternate Row | 0.4l | 1.2g | 1.4hij | 1.2j |
| SE ± | | 0.13 | | |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).

4.2.11 **Correlation Analysis**

There was significant correlation between various growth and yield parameters of pepper during 1996/97, 1997/98 and mean of the two years (Tables 27, 28 and 29). The only exception recorded was the negative and non-significant correlation between days to flowering and all other parameters in 1997/98 and the mean. While in 1996/97 dry season, days to flowering was significantly and negatively correlated only total fruit yield, fruit dry weight and plant height. The average of the two years also showed a positive but non significant correlation between total fruit fresh and dry weights and number of leaves.

Table 27: Correlation matrix showing relationship between growth and yield characters of pepper during 1996/97 season.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Fruit yield | 1.00 | | | | | | | | |
| 2. Fruit dry weight | 0.74** | 1.00 | | | | | | | |
| 3. Fruit fresh wt. | 0.56** | 0.63** | 1.00 | | | | | | |
| 4. Fruit diameter | 0.52** | 0.52** | 0.55** | 1.00 | | | | | |
| 5. Fruit length | 0.53** | 0.67** | 0.80** | 0.52** | 1.00 | | | | |
| 6. Days to flowering | -0.31* | -0.42 | **-0.15 | -0.14 | -0.23 | 1.00 | | | |
| 7. No, of branch (13 WAS) | 0.33** | 0.44** | 0.43** | 0.49** | -0.60** | -0.04 | 1.00 | | |
| 8. No. of leaves (13 WAS) | 0.36** | 0.32* | 0.60** | 0.59** | 0.63** | 0.12 | 0.63 | 1.00 | |
| 9. Plant height | 0.50** | 0.52** | 0.60** | 0.56** | 0.70** | 0.26* | 0.71** | 0.81** | 1.00 |

* = Significant at 5% level of significance.

**= Significant at 1% level of significance.

Table 28: Correlation matrix showing relationship between growth and yield characters of pepper during 1997 dry season.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Fruit yield | 1.00 | | | | | | | | |
| 2. Fruit dry weight | 0.1 | 1.00 | | | | | | | |
| 3. Fruit fresh wt. | 0.2 | 0.6** | 1.00 | | | | | | |
| 4. Fruit diameter | 0.5** | 0.3** | 0.5** | 1.00 | | | | | |
| 5. Fruit length | 0.6** | 0.3** | 0.5** | 0.6** | 1.00 | | | | |
| 6. Days to flowe-ring | -0.2 | -0.03 | -0.1 | -0.1 | -0.02 | 1.00 | | | |
| 7. No, of branch (13 WAS) | 0.4** | 0.4** | 0.5** | 0.6** | 0.6** | -0.2 | 1.00 | | |
| 8. No. of leaves (13 WAS) | 0.3 | 0.3* | 0.5** | 0.5** | 0.4** | 0.1 | 0.7* | 1.00 | |
| 9. Plant height | 0.4** | 0.4** | 0.5** | 0.6** | 0.6** | 0.1 | 0.8* | 0.7 | 1.00 |

* = Significant at 5% level of significance.

** = Significant at 1% level of significance.

Table 29: Correlation matrix showing relationship among growth and yield Characters of pepper (mean of two years).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Totl fruit yield | 1.00 | | | | | | | | |
| 2. Fruit DW | 0.3** | 1.00 | | | | | | | |
| 3. Fruit fresh wt. | 0.3** | 0.6** | 1.00 | | | | | | |
| 4. Fruit diameter | 0.5** | 0.3** | 0.5** | 1.00 | | | | | |
| 5. Fruit length | 0.4** | 0.2** | 0.4* | 0.5** | 1.00 | | | | |
| 6. Days to 50% flowering | 0.2 | -0.02 | -0.02 | -0.1 | -0.1 | 1.00 | | | |
| 7. Number of branch (13 WAS) | 0.4** | 0.4** | 0.5** | 0.5** | 0.5** | 0.15 | 1.00 | | |
| 8. No. of leaves (13 WAS) | 0.3** | 0.3** | 0.5** | 0.5** | 0.5** | 0.01 | 0.7* | 1.00 | |
| 9. Plant height(13WAS) | 0.4** | 0.4** | 0.5** | 0.6** | 0.6**- | 0.01 | 0.7** | 0.8** | 1.00 |

** = Significant at 1% level of significance (0.24).

DF = 118.

4.3 **Land Equivalent Ratio (LER)**

The calculation of LER during the two seasons and their mean is shown on Table 30. In 1996/97, 1:1 and 1:2 alternate row significantly gave similar but higher LER than any of the cropping patterns. This was followed by sole crop and finally 1:1 and 1:2 alternate stand treatments. However, in 1997/98, sole crop had a higher LER than mixtures. All the planting patterns recorded statistically similar LER. Average over the two years sole crop, 1:1 alternate row and 1:2 alternate row all recorded significantly similar but higher LER than 1:1 alternate stand and 1:2 alternate stand which recorded similar LER with each other.

The effect of different rates of fertilizer on LER was significant only in 1997/98. Increasing NPK rates up to 750kg/ha significantly increased LER. Similar LER was produced by 0, 250 and 500kgNPK/ha.

Table 30: Effect of planting patterns and fertilizer rates on Land equivalent (LER) (Onion) in an onion/pepper mixture at Samaru during the 1996/97, 1999/98 seasons and the mean of the two years.

| | LER at harvest | | |
|---|---|---|---|
| Treatment | 1996/97 | 1997/98 | Mean |
| **PLANTING PATTERN (P)** | | | |
| Sole | 1.0b | 1.0a | 1.0a |
| 1:1 alternate stand | 0.7c | 0.6b | 0.7b |
| 1:2 alternate stands | 0.8c | 0.6b | 0.7b |
| 1:1 alternate row | 1.2a | 0.7b | 0.9a |
| 1:2 alternate rows | 1.3a | 0.7b | 1.0a |
| SE ± | 0.10 | 0.10 | 0.10 |
| **FERTILIZER RATE (F)** | | | |
| (20:10:10) | | | |
| 0 | 1.0 | 0.6b | 0.8 |
| 250 | 1.0 | 0.7b | 0.8 |
| 500 | 1.0 | 0.7b | 0.9 |
| 750 | 1.0 | 0.9a | 0.9 |
| SE ± | 0.03 | 0.09 | 0.04 |
| **INTERACTION** | | | |
| P x F | NS | NS | NS |

Means followed by the same letter(s) within columns and treatment set are not significantly different when using DMRT (P=0.05).
NS = Not Significant.

# CHAPTER FIVE

## 5.0 DISCUSSION

### 5.1 *Effect of Fertilizer Application*

#### 5.1.1 **Onion growth and yield**

The application of fertilizers affected the growth and development of onion. The essential elements of NP and K have been found to have a profound influence on growth and yield characters of onion (Singh and Kumar, 1969). From the results obtained in this study, growth characters such as the number of leaves per plant, plant height and bulb diameter responded significantly to applied NPK fertilizer. In 1996/97, the application of 250 to 500kg/ha NPK significantly increased most growth parameters but the highest dose of 750kg/ha depressed plant height at 5 and 11 WAT. This negative response of height to excess fertilizer rate could be as a result of high N content (150kgN). The high level of N might have depressed the nutrition of other nutrients such as P (Amans and Slangen, 1988). Similar observations were reported by Bottcher and Kolbe (1975) and Singh and Kumar (1969) who reported that very high levels of fertilizer delayed plant development, reduced number of plants per unit area, increased percentage of bolting and natural injury and also delayed ripening in onion.

In 1997/98 however, the maximum increase in plant growth parameters was recorded with a lower rate of 250 kg NPK/ha. At higher rates the effect on growth was not significant; and as observed in 1996/97, the highest rate of NPK depressed plant height.

Fertilizer application increased bulb diameter and dry matter content as well as the total yield/ha of onion. There was a progressive and significant increase in total yield with increase in applied NPK rates up to 500 kg/ha. Similar significant response of onion to fertilizer application was reported by Binkley and Lorenz (1938) and Amans *et al* (1982).

The highest rate of NPK application (750kg/ha) was found to depress yield. This observation is in agreement with Singh and Kumar (1969) who reported that high levels of fertilizer may have a detrimental effect on onion growth and yield.

5.1.2 **Pepper growth and yield**

Growth of pepper responded to fertilizer application in both years. Number of branches per plant, number of leaves per plant, plant height and fruit diameter all significantly responded to fertilizer application up to 500 kg/ha particularly during the later growth stages. At the early growth stage (5 WAT) the optimum rate of growth as exemplified by number of branches was with the 250kg/ha rate. This was most likely because at this early stage, the crop demand for nutrients was relatively low because rates beyond 500kg/ha was found to significantly reduce the number of branches in one year. A similar finding has been reported on pepper where high rate of fertilizer was detrimental to growth (Saga, 1972). Cerna (1980) also reported that increasing N from 120 to 180kg/ha, P from 28 to 42kg/ha and K from 84 to 126kg/ha had no further significant effect on growth and yield compare to a lower rate.

Fruit diameter also increased with the application of fertilizers. The largest fruits were obtained with the application of 500kg NPK/ha and the smallest fruits were from the non-fertilized plots.

Fertilizer application increased the yield and yield components of pepper in both trails with optimum rates at 500kg/ha. The highest rate of NPK used (750kg/ha) had no significant effect on the final yield of pepper. This agreed with the findings of Cerna (1980) who reported that higher NPK rates of 180 - 42 - 126 had no marked effect on the yield of pepper.

## 5.2 Effect of planting patterns

### 5.2.1 Onion growth and Yield

Pepper and onion are known to be quite compatible in mixture under an appropriate spacing (Amans, 1987). Planting pattern significantly affected plant height and number of leaves of onion plant in 1996 only when 1:1 alternate stand produced the shortest plants compared with the other cropping patterns. The 1:1 pattern was the one which place the two crops much close to each other, this may have created a higher degree of competition for light and soil resources (Amans and Ado, 1994). This higher degree of competition had more effect on the onion plants whose canopy was overshadowed by the larger pepper plants.

Number of leaves per plant was also affected by planting pattern in 1996/97. The growth of Onion in early stages is normally slow (Amans and Slangen, 1988) and those plants in mixture with pepper using the 1:1 planting pattern registered significantly shorter heights. The 1:1 planting pattern placed the two crops much closer to each other compared with other patterns. Thus, the slow growth of the onion at this stage, coupled with the shading effect of the closely associated pepper may have adversely influenced Onion growth at 5 WAT . But at the latter stage of growth, despite the shading effect from pepper, the growth of the onion plant improved even under the 1:1 planting pattern such that the difference between the height of onion was not different from those of other planting patterns. It has been reported that the upright nature of onion leaves gives the plant some advantage in escaping severe mutual shading effect (Amans, 1987). This may have explained in part why the vegetative growth of the onion plant did not suffer significantly from inter cropping with pepper once the crop was at its active growing stage (when pepper canopies were formed). Planting pattern influenced total yield where sole crop out-yielded all the other planting patterns. This is because the sole crop plot has the highest number of plants. Among the mixed crop treatments, the maximum yield of onion was recorded by 1:2 alternate row planting pattern these was also because of the higher Onion population in the pattern which gave a higher bulb yield. The 1:1 and 1:2 alternate stand treatments gave the lowest yield in both seasons because of a reduced plant population of component crops in the crop mixture when compared to sole crop (Bayei, 1985).

### 5.2.2 Pepper growth and yield

Pepper growth parameters of plant height, number of branch per plant days to 50% flowering and fruit length were significantly affected by planting pattern the height was significantly taller but the number of branches per plant fewer in the sole and 1:1 alternate row plating pattern compare with other patterns. This two planting patterns had similarly spaced pepper plants (60 x 45cm) which was the closes compared with other treatments. This spacing was probably too close for optimum growth of the pepper variety used, since the general recommendation for pepper ranges between 60 x 45cm - 60 x 60cm (Amans, 1987). In this case, the closely spaced pepper plants had higher degree of mutual shading resulting in plants been taller but with lesser number of branches compared with plants at wider spacing used in the other planting patterns. The number of days to 50% flowering was longer in the 1:2 alternate row plating pattern. This pattern, had the least level of interplant competition and thus experienced a longer period of pre-flowering growth (Amans, 1987).

Planting pattern significantly affected fresh and dry weights of pepper, the dry matter contents and the total yield. The fresh fruit yield was highest in sole crop where the plant population was relatively more than in other treatments. This was followed by the 1:1 and 1:2 alternate stands which also had higher population of pepper plants compared with 1:1 and 1:2 alternate rows with least yield/ha.

## 5.3 Aggregate crop output

In 1996/97, aggregate yield outputs from 1:1 and 1:2 alternate row (LER 1.2 and 1.3 respectively) were higher than those of sole crop (LER 1.0). When the two years were averaged, sole crops LER (1.0) was significantly at par with that of 1:1 and 1:2 alternate rows (LER 0.9 and 1.0 respectively). This agreed with the findings of Abaver (1983) who reported that what ever arrangement used, mixtures consistently showed relative advantage over sole cropping.

# CHAPTER SIX

## SUMMARY AND CONCLUSION

Trials were conducted at the Irrigation Research farm of the Institute for Agricultural Research (IAR) Samaru during the 1996/97 and 1997/98 to study the effect of different planting patterns and fertilizer rates in an Onion/pepper mixed crop.

Onion variety D-77 and a local variety of Pepper (tattasai) were used for the study. The following patterns were compared: Sole pepper, Sole Onion,1:1 alternate stand,1:2 alternate stand, 1:1 alternate row 1:2 alternate row. Four rates of compound fertilizer (NPK- 20:10:10) 0, 250, 500 and 750kg were applied in two equal split doses: one half at one week after transplanting and the other half at six weeks after transplanting.

Fertilizer application significantly increased growth and yield characters. Vegetative growth characters of number of branches, number of leaves, plant height and yield characters of bulb diameter of onion, fruit length of pepper, dry matter content, fresh and dry weights and the total yield with the application of fertilizer rates of up to 500kg/ha.

The highest yield was obtained by sole crop x 500kg NPK/ha and was followed by 1:1 and 1:2 alternate rows receiving the same quantity of fertilizers. Also the highest LER was obtained by both 1:1 and 1:2 alternate row patterns that received 500 kg NPK/ha.

From the results of this study, it could be concluded that a planting pattern of 1:1 or 1:2 alternate rows and NPK rates of 500kg/ha is the best combination for a pepper/onion mixture under similar soil and weather conditions that prevailed during the study.

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## Appendix I

Physical and chemical properties of the soil at the experiment site

| **Soil characteristic** | **Soil depth(0-30cm)** |
|---|---|
| PH in water (1:2:5) | 4.70 |
| PH in Cacl2 (1:2:5) | 5.20 |
| Organic carbon (%) | 0.60 |
| Total Nitrogen (%) | 5.47 |
| Available phosphorus (ppm) | 3.10 |
| | |
| Exchange bases (meg /g of soil) | |
| Ca | 1.38 |
| Mg | 0.31 |
| K | 0.31 |
| Na | 0.14 |
| Cec | 5.94 |
| | |
| Particle size distribution | |
| Sand % | 42% |
| Silt % | 45% |
| Clay % | 13% |
| Textural class | Loam |

**Appendix II**

Physiochemical properties of the soil experimented site in 1997/98

| Soil composition | Depth (0-30cm) |
|---|---|
| Particle size | |
| % sand | 36% |
| % Silt | 44% |
| % clay | 20% |
| Textural class | Loam |
| | |
| Chemical Properties | |
| Ph in water | 6.50 |
| Ph in $Cal_2$ | 6.10 |
| Organic carbon | 0.55 |
| Residual N. | 0.069 |
| Available P (ppm) | .224 |
| Exchangeable cations Meg/of soil | |
| Ca | 1.42 |
| Mg | 0.86 |
| K | 0.46 |
| Na | 0.18 |
| CEC | 5.6 |

## Appendix III

Total rainfall, minimum and maximum temperature, relative humidity and sunshine hours at 10 days interval during the 1996/97 experiment

| Month | Rainfall | T°C | | Relative humidity | | Sunshine 10am-4p.m |
|---|---|---|---|---|---|---|
| | | Min | Max | 10am to | 4pm | |
| 1/10 | 0 | 13.6 | 28.7 | 27.6 | 22.2 | 6.7 |
| 11-20 | 0 | 13.5 | 31.2 | 25.6 | 23.1 | 7.1 |
| 21-30 | 0 | 12.0 | 13.1 | 21.6 | 21.9 | 6.0 |
| **Dec. '96** | | | | | | |
| 1-10 | 0 | 13.2 | 32.1 | 19.1 | 19.5 | 6.5 |
| 11-20 | 0 | 10.7 | 33.3 | 16.6 | 18.1 | 7.5 |
| 21-30 | 0 | 11.4 | 35.6 | 13.6 | 14.9 | 7.3 |
| **Jan. '97** | | | | | | |
| 1-10 | 0 | 13.4 | 33.7 | 17.7 | 12.1 | 7.2 |
| 11-20 | 0 | 14.1 | 35.5 | 19.0 | 15.7 | 6.4 |
| 21-30 | 0 | 12.6 | 30.1 | 16.8 | 12.8 | 7.0 |
| **Feb. 97** | | | | | | |
| 1-10 | 0 | 12.8 | 28.0 | 15.7 | 13.4 | 8.1 |
| 10-20 | 0 | 12.9 | 29.5 | 12.8 | 10.6 | 8.5 |
| 21-30 | 0 | 14.7 | 30.8 | 14.3 | 12.5 | 8.4 |
| **March '97** | | | | | | |
| 1-10 | 0 | 12.8 | 28.0 | 15.7 | 18.4 | 8.1 |
| 11-20 | 0 | 14.9 | 36.8 | 12.4 | 15.3 | 8.0 |
| 21-30 | 0 | 22.0 | 37.0 | 15.8 | 15.8 | 6.9 |

**Source**: Meteorological Unit of IAR ABU

**Appendix IV**

Meteorological data showing sunshine hours, min. and max. relative humidity and maximum and minimum temperature

| **Month** | **Relative humidity** | | **Mean** | **Temperature** | | **Mean** | **Sunshine** |
|---|---|---|---|---|---|---|---|
| | Min | Max | | Min | Max | | Hours |
| October | 65.9 | 76.5% | 71.3% | 20.0 | 31-2°C | 25-3°c | 7.6 hrs |
| November | 30.1 | 43.6 | 35.4 | NA | 32.1°c | 32.9°c | 8.8 hrs |
| December | 17.4 | 18.5 | 17.8 | NA | 32.4°c | 31.4°c | 8.4 hrs |
| January | NA | NA | NA | NA | NA | NA | NA |
| February | 11.1 | 12.1 | 11.6 | NA | NA | NA | NA |
| March | 11.4 | 11.9 | 11.6 | NA | 34.0°c | 33.4°c | 6.5 hrs |
| April | 27.6 | 45.0 | 36.3 | NA | 36.9 | 36.9 | 6.9 hrs |

Source: Meteorological Unit of IAR ABU Zaria

NA = Figures not available.

## *BIOGRAPHY*

| | |
|---|---|
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| | | |
|---|---|---|
| Turaki Primary School Sokoto | 1970-77 | School Leaving Certificate |
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***Working Experience***

| | |
|---|---|
| Assistant Farm Manager, NYSC Farm, Yola, Adamawa State | 1988-89 |
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| Area Leaf Manager, International Tobacco Plc Zaria | 1991-92 |
| District Leaf Manager, International Tobacco Plc Zaria | 1992-94 |
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