

Performance of Green gram varieties under various phosphorus levels in custard apple (*Annona Squamosa*) based agri-horti system



THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

Master of Science (Agriculture)
in
Agroforestry

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**"Neelambhuj Shyamalkomlang Sita Samaropitvambhagam,
Pano Mahasaikacharoochapam Namame Ramam Raghuvanshnatham"**

*Dedicated to
Lord Shri Ram
&
My Beloved Parents*

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I have great pleasure in forwarding the thesis entitled "**Performance of Green gram varieties under various phosphorus levels in custard apple (*Annona squamosa*) based agri-horti system**" submitted by **Mr. Arvind Kumar Upadhyay, I.D. No.AGF-11175**, in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture) in Agroforestry**.

I certify that the work has been carried out under my guidance and the data forming the basis of this thesis, to the best of our knowledge are original and genuine and no part of the work has been submitted for any other degree or dissertation.

Thanking you,

Yours faithfully,

(R. S. Singh)
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under various phosphorus levels in
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Date:

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LIST OF SYMBOL OR ABBREVIATIONS

| | | | |
|-------------------|--------------------------|-------------------------------|------------------------|
| @ | at the rate of | kg /ha | kilogram per hectare |
| % | per cent | m | Metre |
| ⁰ C | Degree Celsius | Max. | Maximum |
| ANOVA | Analysis of variance | m ² | square metre |
| B:C | benefit : cost ratio | Min. | Minimum |
| CD | Critical difference | mg | Milligram |
| Cm | Centimetre | N | Nitrogen |
| CV | coefficient of variance | No. | Number |
| d.f. | Degree of freedom | NS | Non significant |
| DAS | days after sowing | P | Phosphorus |
| dSm ⁻¹ | Decisiemens per metre | P ₂ O ₅ | phosphorus penta oxide |
| EC | electric conductivity | pH | Puissance dehydrogen |
| <i>et al.</i> | (et alii) and else where | Q ha | quintal per hectare |
| <i>Etc</i> | (et cetera) and the rest | R.H. | Relative humidity |
| Fig. | Figure | ₹/ha | rupees per hectare |
| Ha | Hectare | S. No. | Serial number |
| <i>i.e.</i> | (id est.) that is | SEm± | Standard error of mean |
| K | Potassium | <i>viz.</i> | (videlicet) namely |
| kg | kilogram | | |

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INTRODUCTION

Agroforestry is a collective name for land use system and practices where woody perennials are deliberately integrated with crops and/or animals on the same land management unit either in the form of spatial or in temporal sequences and there must be both ecological and economical interaction between the woody and non woody components.

Agri-horti system has emerged as a viable option for achieving cover on one hand and to fulfil the increasing demand of food grain and fodder to human and livestock respectively on other hand. It is an improved indigenous cropping system in India which fully utilizes the growing season and markedly increases the return per unit area per unit time. In this system we can increase the total output from land by growing mainly short duration crops within the alleys of such fruit crops. Tree based cropping system have proved to be very successful in areas receiving less than 1000 mm rainfall with nine months of dry season (Singh, 1987). Such practices are more relevant to the country like India with increasing population and practically no scope further horizontal expansion.

Fruit tree based agro forestry involves intentional and simultaneous association of annual or perennial crops with perennial fruit-producing trees on the same land unit. The relatively short juvenile (pre-production) phase of fruit trees, high market value of products and the contribution of fruits to household dietary needs, fruit-tree-based agro forestry enjoy high popularity among producers worldwide.

In India, due to seasonal variability, there is no limitation in selection of growing various horticultural crops according to their

climatic suitability. In the initial phase of orchard establishment, the major limitation is practically no economic return till trees start bearing fruits. There is ample scope to exploit the interspaces of the fruit trees during the initial 5-6 years for growing of arable crops (Gill and Bisaria, 1995). This is now an established fact, through the investigations carried out in different parts of the country, that food grain crops can be successfully introduced in different orchards during the early years of its establishment for additional production and economic returns. Lands with low nutritional status may be exploited for establishing orchards and making agricultural systems economically viable.

Custard apple (*Annona squamosa* L.) is distributed throughout the tropics and is pre eminently a desert fruit, normally eaten fresh. The vitamin C content is appreciable (35-42 mg/100 g) and slightly higher than the grape fruit. Its nutrient value of thiamine, potassium and dietary fiber are also significant. The tree is a good source of firewood; the light yellow sapwood and brownish heartwood are soft, light in weight and weak. Green fruits, seeds and leaves have effective vermifugal and insecticidal properties. Leaves, shoots, bark and roots have been reported to have medicinal properties. The unripe fruit is astringent, and the root is a drastic purgative. It can be planted as a shade tree and also suitable for growing with short duration arable crops.

Pulses are the most important crops of India and are considered as life blood of agriculture because of their unique position in every known system of farming. Being a leguminous crop they help in maintenance of soil fertility and being rich in protein, which contain 20-25% protein on dry seed basis, which is almost 2.5-3.0 times of the value normally found in cereals. Their deep roots also open up the soil which ensures better aeration. The short duration pulses also fit well in the various cropping system without disturbing the main crop of the system. Pulses are also

important for sustainable agriculture as they improve physical, chemical and biological properties of soil and function as mini-nitrogen factory. India is a major pulse growing country in the world, sharing 25.59 million hectares with a production of 17.289 million tons (Anonymous, 2012).

Mungbean (*Vigna radiata* L.) is a pulse or food legume crop used primarily as dried seed and occasionally as forage of green pods and seeds for vegetables (Lawn, 1955). Almost 90% of Green gram production on a world scale is produced in Asia with India, the world's largest producer, accounting for more than 50% of world production (Vijayalakshmi *et al.*, 2003). Generally, mungbean provide an excellent complement for cereal-based diets, particularly in Asia where it is used in various ways (Lawn and Ahn, 1985). Mungbean is an important pulse crops having high nutritive value. It not only plays an important role in human diet but also in improving the soil fertility by fixing the atmospheric N (Ather Nadeem *et al.*, 2004). Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses (Anjum *et al.*, 2006). Mungbean cultivation is economically because it requires low input and the crop has short maturity. Mungbean is grown by farmer in a variety of cropping system because of its adaptability to marginal condition, early maturity and N fixing ability, this crop fits well in different cropping system. Mungbean, compared with other crops has a better chance of surviving under adverse condition such as poor soil fertility and moisture stress (Poehlman, 1991).

Green gram suffers from want of nutrients; especially immobile element like P. Phosphorus is an essential plant nutrient plays a vital role in the root development, cell division and seed formation. More importantly it is a component of ATP and ADP, which are involved in the

energy transformation driving most of the biochemical reactions including respiration and photosynthesis. Most of the grain legume responds well due to its favourable effects on root proliferation, nodule development, bacterial activity and nitrogen fixation. However the quality of phosphate fertilizer requires for obtaining maximum yield depend on soil type, cultivar, and agro-climatic conditions in relation to the optimum plant population per unit area. Low phosphorous availability in soil affects the pulse production in the country and the production of black gram varieties from year to year with a decreasing trend and consequently, the production is not sufficient to meet the internal demand.

In agri-horti system, competition for solar radiation and nutrient is obvious for the short duration crops like black gram grown in the alleys of fruit crops such as custard apple. Therefore, for the better performance of the system, the black gram genotype must be competitive and adapted to the particular agro climatic condition with these facts in view the present experiment entitled **“Performance of Green gram (*Vigna radiata*) varieties under various phosphorus levels in custard apple (*Annona squamosa*) based agri-horti system”** was undertaken with following objectives:

1. To find out the superior varieties of Green gram under custard apple based agri-horti system.
2. To study the effect of phosphorus levels on growth, yield and nutrient uptake of Green gram under custard apple based agri-horti system.
3. To work out the economics of various treatment.



REVIEW OF LITERATURE

An attempt has been made in this chapter to review the literature available on Green gram and other related crops in the country and abroad with respect to phosphorus, varieties and agri-horti system. Various aspects of phosphorus, varieties and agri-horti system, interaction between trees and crops for light, moisture and nutrients are presented below.

2.1 Effect of Agri-Horti System

Agricultural fields since the time of the practice of growing agricultural crops under scattered trees on farm lands is quite old and does not seem to have changed for centuries. Though the world-wide lists of such trees are long, some of them have received more attention than others. The species diversity in these systems is very much related to ecological conditions. With the increase in rainfall, the species diversity and system complexity increases. Thus there is a proliferation of more diverse multistoried home gardens in the humid areas and less diverse, two tiered canopy of configurations (trees + crop) in drier areas.

On the basis of field experimentation, it has been established that component crops must be complementary to each other. They must be dissimilar in growth habit and maturity period for efficient use of resources (Baker, 1979 and Willey, 1979).

Jama *et al.* (1991) assessed performance of *Acacia albida* and other nitrogen fixing multipurpose trees. Growth performance at 8 densities and

rotationally intercropped with maize and green gram for a 5 year period. Mean height of intercropped *A. albida* were 24% higher than the tree alone (control) by the fifth year. Crop yields were reduced in the intercropping treatments, especially under higher tree densities.

Lal *et al.* (2004) concluded that the lichi plantation –based agri – horticultural system can be raised on degraded gravelly riverbed land in Doon Valley of Utter Pradesh with cowpea, okra, sesame, blackgram and pigeonpea, as intercrops during the *Kharif* season and toria during the Rabi season. The highest net profit of Rs. 4554 ha⁻¹ was obtain from okra-toria cropping system followed by cow pea-toria (Rs1270 ha⁻¹) and blackgram-toria (Rs 779 ha⁻¹) cropping system with benefit: cost ratio of 1.27, 1.08, and 1.05, respectively. The plant growth character of litchi was not influenced by any intercropped.

Ram *et al.* (2007) reported that the introduction of *S. hamata* in natural pasture under annona trees resulted significantly higher total dry forage (3.20,3.89and 3.95tonnes ha⁻¹) and crude protein yield (255.9, 311.7 and 305.1 kg ha⁻¹) than *S. scabra* in first , second and third years , respectively.

Wannawong *et al.* (1991) tested combinations of *Eucalyptus*, *Leucaena* and *Acacia* (*A. auriculiformis*) inter-cropped with Green gram. Results of 3 years trial suggested early supplementary and complementary relationships between some system components that can imply synergistic financial gains. Although these biological interactions turn competitive over time, in this case, the gains should be sufficient to make early adopters to consider the agroforestry systems financially preferable over traditional monocrops.

Pandey *et al.* (1998) evaluated the effect of *rhizobium* inoculation and fertilizer on the yield and yield components of three Green gram cultivars (Pusa 105, Pusa 9531 and Pant Mung 2) alone and under poplar plantation. The treatments included: control; recommended fertilizer rate of 20 kg N, 60 kg P₂O₅, 40 kg and K₂O ha⁻¹, rhizobium treated seeds. The yield and yield components of Green gram were found significantly higher in sole cropping than in agro forestry.

Korwar *et al.* (1999) investigated the performance of green gram (cv. ML-267), black gram (cv. T-9) and cowpea (cv. C-152) monocropped or intercropped with *F. albida* trees at densities 625 or 156 plants ha⁻¹ (4 x 4 and 8 x 8 m spacing), respectively. Grain yields of green gram and black gram were higher under the lower tree density than monocropped or grown under the higher tree density, whereas cowpea yield was lower under the trees at both densities than monocropped. The green gram equivalent yield and net returns were highest with black gram under low tree density, followed by green gram. Soil fertility improved due to intercropping with pulses.

The competition for water and nutrients between trees and food crops is perhaps one of the most important interactions in agro forestry systems. The yields of intercrops were reduced as the age of trees increases (Menzes, 2002).

However, agri-horti system is a part of agro forestry system where the agricultural crops are grown mainly with the fruits crops, in which the agricultural crops should be of short duration with the ability to tolerate shading effect of component tree species. Fruit tree based agro forestry system involves intentional and simultaneous association of annual or

perennial crops with perennial fruit producing trees on the same farm unit. Because of the relatively short juvenile (pre-production) phase of fruit trees, high market value of their products, and the contribution of fruits to household dietary needs, fruit tree based agro forestry enjoys high popularity among resource limited producers worldwide (Bellow, 2004).

Korwar *et al.* (2006) evaluated the influence of three agro forestry tree species, *viz.* aonla, *tamarind* and *senegal* on the growth and yield of green gram and castor under rainfed conditions. They noted that yields of intercrops were significantly influenced by trees and with increase in age of trees, more reduction in arable crop yield was observed. However, grain yield of green gram was similar in sole crop and as intercrop with the three tree species while in castor sole crop was superior to intercropping with tree species. Economic analysis showed the superiority of agro forestry systems over sole crop systems.

Bellow *et al.* (2008) reported that the fruit tree based agro forestry systems have been only modestly studied, although they are common on small holder farms. Such systems based on apple (*Malus* spp.), peach (*Prunus* spp.), and pear (*Pyrus* spp.) are common in northwest Guatemala as low intensity home gardens and are known to increase total farm productivity in communities where farm size is a limiting factor. Two communities with differing demographics, infrastructure, and access to regional markets were selected based on the presence of extensive fruit tree based agro forestry. The influence of family size, land holdings, tree and crop yields on the optimal adoption levels of fruit trees were evaluated through a comparative study of the varying social and physical

infrastructure present in the two communities. Fruit tree based agro forestry was potentially more attractive to relatively prosperous families or those with larger land holdings. Improvements in fruit tree productivity and interspecies competition were of greater importance where family land holdings were smaller. The inability of families to produce sufficient food to meet annual needs, poor fruit quality, and lack of market infrastructure were identified as constraints that limit adoption. The complimentarity of production with the dominant maize crop, home consumption of fruit, and the potential to generate additional cash on limited land holdings were identified as factors promoting adoption of fruit tree based agro forestry.

2.2 Interaction between crops and tree components

2.2.1 Competition for light

Kang *et al.* (1981) attributed low yields from maize rows adjacent to *Leucaena* hedgerow due to shading effect. Willey and Reddy (1981) reported that the shading was found to be more important than below ground competition. Vrinumbe and Okali (1985) reported that the competition for light was a more critical factor than root competition for intercropped maize between teaks trees (*Tectona grandis*). Neumann and Pietrowicz (1989) studied competition in an agro forestry combination of *Grevillea robusta*, maize, and beans in Rawanda, reported that the shade cast by *Grevillea* appeared more important than other effects of the trees. Cannel (1993) concluded that in comparison to the leaf yielding plants, fruits and grain yielding crops tend to be relatively shade intolerant and should therefore be grown in open spaces where possible.

Thakur *et al.* (2008) investigated the impact of changes in incident radiation through crown modification on crop performance. Different shade intensities created through tree crown management significantly affected growth, physiological attributes and yield related parameters in *Vigna mungo* and *Pisum sativum* grown as under storey field crops with *Morus alba* under rainfed conditions. The crown management treatments, namely, no crown removal, 25, 50 and 75% crown removal resulted in 91, 85, 63 and 47% shade, respectively. Plant height, number of flowers and leaf area of crops were reduced significantly with the increase in shade intensities and decrease in distance from the tree trunk. Higher pods per plant, grains per pod, grain yield and harvest index were observed at lower shade intensities. Growth and yield was maximum in open control (without tree); while unmanaged canopy of *Morus* trees caused overall yield reduction of 42% beneath canopy up to 3 m distance from the tree trunk. The crown management regulated physiological attributes in the field crops. The maximum photosynthetic rate was recorded for open plot plants, which declined in plants beneath dense canopy. The amount of water transpired from the crop plants decreased with increase in shade intensity. The conversion efficiency was maximum for plants growing as sole crop which decreased with increasing shade intensities. Based on the results, it can be recommended that out of the four tree canopy management options tried, 75 percent crown removal had the least negative effects on crop growth and yield, thus may be adopted as a compromised crown management practice.

2.2.2 Competition for nutrients

There are innumerable studies indicating how competition for nutrients can reduce crop yields. In most cases, the yield of the

agricultural crop is the criterion by which the merit of an agro forestry system is assessed. Yield depressions of this component therefore receive more attention than those of the associated tree species. Furthermore, since the crop is usually the smaller component (when compared individually), its root system will usually be confined to the soil horizons that are also available to the roots of the trees; but the tree can exploit soil volume beyond reach of the crop. Therefore, the effects of nutrient competition will probably be more severe for the crop components.

Costa *et al.* (2000) observed the inter species differences in root competition exerted by six tree species (*Calliandra calothyrsus*, *Desmodium rensonii*, *Flemingia congesta* {*F. macrophylla*}, *Gliricidia sepium*, *Cassia spectabilis* and *Tithonia diversifolia*) on Green gram grown as hedgerow intercrops in Sri Lanka. All intercrops had significantly lower plant nutrient (N, P, and K) contents than sole Green gram indicating significant competition by hedges for nutrients. All intercrops showed increases of exchangeable soil K and available P (except with *Gliricidia*) during the cropping season. It is concluded that tree roots of hedgerow intercrops exerted significant competition with the annual crop for absorption of nutrients and water. In this study, out of the tree species tested, *Gliricidia* exerted the least competition for nutrients while *Tithonia* exerted the least competition for water.

2.2.3 Competition for water

With the exception of areas with well distributed rainfall, or atonal sites with a continuous supply of below ground water, water competition is likely to occur in most agro forestry systems at some period of time; this period may be as short as dry spell of one or two weeks. The effect

of these events depends upon the severity of the drought and drought tolerance of the plant. It also depends on the degree of competition for other resources, especially nutrients.

Singh *et al.* (1989) reported an alley cropping trial of *Leucaena* with cowpea, castor, and sorghum under semiarid condition in India, competition for water appeared more important than shading effects.

Malik and Sharma (1990) reported that the reduction of yield over 30% for the crops growing at a distance of less than 10 m from the tree line. Thus, despite the use of drought adapted plants, water competition is likely to play a major role in the productivity of agro forestry systems, especially in dry areas.

The competition for moisture in agro forestry systems is commonly occurring phenomenon, which can affect the system adversely (Ong *et al.*, 1991; Rao *et al.*, 1991).

2.3 Effect of phosphorus

2.3.1 Growth and development

Shukla and Dixit (1996) worked on the effect of phosphorus levels (0, 20, 40 and 60 kg ha⁻¹) on summer green gram observed that the plant height, number of primary branch plant⁻¹, and dry matter accumulation were significantly increased by increasing rate of phosphorus up to highest level.

Thakur *et al.* (1999) reported that incremental application of phosphorus (0 and 20, 40 and 60 kg P₂O₅ ha⁻¹) on Green gram (*Vigna*

radiata), resulted in significantly enhanced plant height and branches per plant.

Ram and Dixit (2001) worked on the effect of P application (0, 20, 40 and 60 kg P₂O₅ ha⁻¹) on green gram cv. K 851 found that increasing doses of phosphorus correspondingly enhanced plant height, number of branch per plant, dry matter accumulation and number of leaf per plant.

Tariq *et al.* (2001) reported that the phosphorus and potassium application up to 70 kg ha⁻¹ on Green gram significantly increased the plant height and number of branch per plant by increasing the rate of phosphorus and potassium.

Durai *et al.* (2002) reported that the plant height and number of branch per plant of green gram was significantly influenced by the phosphorus application in combination with PSB and the highest plant height of 42.7 cm was recorded with the application of 40 kg P₂O₅ ha⁻¹.

Seerat *et al.* (2004) conducted a field experiment during the summer season of 2000-01 at the Deemed University, Allahabad, to see the effect of phosphorus status and biofertilizers on the yield of green gram. Different levels of phosphorus (40 and 60 kg ha⁻¹) as per treatment and biofertilizer (*Rhizobium* and phosphate solubilizing bacteria) were applied. The combined application of phosphorus at 60 kg ha⁻¹ and *Rhizobium* resulted in significantly higher plant height (cm) and number of branch per plant.

Yadav (2004) studied effect of incremental levels of phosphorus (0, 20 and 40 kg ha⁻¹) and sulfur (0, 20, 40 and 60 kg ha⁻¹) on the growth

and yield of green gram cv. RMG-62. Increasing levels of P and S resulted in increased plant height, number of branch, number of pod per plant and biological yield with increasing rates of phosphorus and sulfur up to 40 kg ha⁻¹. However, a decline in growth and yield characters as well as yield was noticed be 0 and 40 kg S ha⁻¹.

Chaturvedi *et al.* (2004) evaluated the four phosphorus levels (0, 20, 40 and 60 kg ha⁻¹) in relation to their effect on the growth of green gram cv. K 851 and found that increasing phosphorus levels up to 60 kg P₂O₅ ha⁻¹ had a significant effect on the growth attributes of Green gram *viz.*, plant height, number of branch per plant, number of trifoliolate leaf, leaf area index, dry matter accumulation per plant, crop growth rate, relative growth rate and net assimilation rate.

Karwasra and Yadav (2006) evaluated the effect of various levels of phosphorus (0, 25, 50 and 75 kg P₂O₅ ha⁻¹) on growth attributes of Green gram (*Vigna radiata*), found that application of phosphorus at 50 kg ha⁻¹ enhanced the plant height, branches and other growth parameters significantly.

2.3.2 Yield and yield attributes

Ali *et al.* (1993) worked on Green gram with different phosphorus levels (0, 28, 56 and 84 kg P₂O₅ ha⁻¹.) reported that 56 kg P₂O₅ ha⁻¹ gave significantly higher yield as compared to control but was at par with 84 kg P₂O₅ ha⁻¹. A fertilizer dose of 56 kg P₂O₅ ha⁻¹ was found optimum and economical for harvesting a good yield of Green gram. Similarly, Saxena *et al.* (1996) advocated the use of 60 kg P₂O₅ ha⁻¹ in Green gram.

Mitra *et al.* (1999) worked with phosphorus levels (30, 60 and 90 kg P₂O₅ ha⁻¹) on Green gram showed that the number of pod per plant, grain per pod, test weight and grain yield ha⁻¹ were increased by increasing rate of phosphorus.

Thakur *et al.* (1999) investigated the application of incremental levels of phosphorus (0 and 20, 40 and 60 kg P₂O₅ ha⁻¹) on Green gram noticed significant increase in yield attributes *viz.*, number of pod per plant, grain per pod, test weight and grain yield ha⁻¹ by increasing rates of phosphorus application up to 60 kg P₂O₅ ha⁻¹.

Reddy *et al.* (2000) studied the effect of 3 levels of phosphorus (0, 13.1 and 26.2 kg P ha⁻¹) on Green gram. They observed that with an increase in phosphorus levels from 0 to 26.2 kg P ha⁻¹, yield attributes *viz* pods plant⁻¹, grains pod⁻¹ as well as grain yield and haulm yield ha⁻¹ increased by 53.5, 15.3, 50.6 and 26.3% respectively, over control. But grains pod⁻¹ at 26.2 kg P was comparable with that of 13.1 kg P ha⁻¹. Phosphorus content in haulm and grain increased significantly by the application of 26.2 kg P ha⁻¹.

Singh *et al.* (2001) investigated the response of Green gram cv. MH 96-1 to P application (at 0, 20 and 40 kg ha⁻¹) in relation to farmyard manure (FYM; 0 and 5 t ha⁻¹) and Zn (0 and 15 kg ha⁻¹) levels. They reported that application of 20 and 40 kg P₂O₅ ha⁻¹ produced 9.9 and 18.6% more yield, respectively, over the control. Similarly, Daramwal *et al.* (2001) studied to subsequent levels of phosphorus (0, 30 and 60 kg P₂O₅ ha⁻¹) and found that the highest levels of P₂O₅ application resulted in the average maximum test weight, biological yield, grain yield and harvest index.

Ram and Dixit (2001) investigated the effect of P fertilizer rates (0, 20, 40 and 60 kg P₂O₅ ha⁻¹) on green gram cv. K 851 and found that the increased doses of phosphorus correspondingly increased the grains per pod and grain yield.

Sultan and Mahmood (2002) while worked on the effect of incremental dose of phosphorus (50, 75 and 100 kg P₂O₅ ha⁻¹) on the growth and yield of Green gram showed that number of pod per plant, grain yield, total biomass and P concentration in plants increased with increasing rates of phosphorus application up to 100 kg P₂O₅ ha⁻¹.

Yakadri *et al.* (2002) investigated the effect of incremental doses of phosphorus (40 and 60 kg P₂O₅ ha⁻¹) and N (20, 40 and 60 kg N ha⁻¹) on growth and yield of Green gram (cv. ML-267) reported that the application of nitrogen at 20 kg ha⁻¹ and phosphorus at 60 kg ha⁻¹ caused significant increase in number of pod and grain yield. Similarly, Ali and Mahmood (2003) evaluated the effect of varying levels of phosphorus (0, 50, 75 and 100 kg P₂O₅ ha⁻¹) and nitrogen (0, 25 and 50 kg N ha⁻¹) on the yield of Green gram (*Vigna radiata*) observed that combination of 25 kg N + 75 kg P ha⁻¹ resulted in the maximum grain yield (1112.96 kg ha⁻¹).

Chaudhary *et al.* (2003) investigated the effects of P application at 20, 40 and 60 kg P₂O₅ ha⁻¹ on the yield components of green gram cv. K 851 showed positive effects of P application on pods plant⁻¹, grains pod⁻¹ and test weight. Similar observations were noticed by Singh *et al.* (2003) and Singh *et al.* (2004).

Yadav (2004) worked on the effect of phosphorus (0, 20 and 40 kg ha⁻¹) and sulfur (0, 20, 40 and 60 kg ha⁻¹) application on the growth and

yield of green gram cv. RMG-62 reported increased number of grain per pod, test weight, grain yield and biological yield with increasing rates of phosphorus and sulphur up to 40 kg ha⁻¹ and decreased thereafter.

Chaturvedi *et al.* (2004) evaluated the effect of four phosphorus levels (0, 20, 40 and 60 kg ha⁻¹) in relation to their effect on the growth and yield of green gram cv. K 851 revealed that increasing phosphorus levels up to 60 kg P₂O₅ ha⁻¹ had a significant effect on the yield and yield attributes pods per plant, pod length, grains per pod, 1000 grain weight and grain yield per plant.

Bhat *et al.* (2005) evaluated the four phosphorus rates (0, 30, 60 and 90 kg ha⁻¹) noticed the highest seed yield at 90 kg P ha⁻¹, which was at par with 60 kg P ha⁻¹, and both were significantly superior to 30 kg P ha⁻¹. Likewise, 60 kg P ha⁻¹ significantly improved the yield attributes except test weight compared to the control.

Mandai *et al.* (2005) conducted a field experiment during the summer season of 2000 with 3 levels of phosphorus and 4 levels of irrigation on green gram cv. Pusa Baisakhi found that increasing levels of phosphorus from 0 to 60 kg ha⁻¹ and levels of irrigation from 0 to 30 kg ha⁻¹ correspondingly increased the yield.

Singh *et al.* (2005) studied the effect of incremental levels of phosphorus (0, 20, 40 and 60 kg P₂O₅ ha⁻¹) in Green gram genotypes. They observed significant increase in grain yield with increasing levels of phosphorus application from 0 to 40 kg P₂O₅ ha⁻¹.

Vikrant *et al.* (2005) studied the effect of four phosphorus rates (0, 20, 40 and 60 kg P₂O₅ ha⁻¹) to green gram cv. Asha and found that application of 60 kg P being at par with 40 kg P was significantly superior to 0 and 20 kg P ha⁻¹ in respect of grain and stover yield of green gram.

Karwasra and Yadav (2006) studied the effect of various levels of phosphorus (0, 25, 50 and 75 kg ha⁻¹) on yield and yield attributes of Green gram and found that the application of phosphorus at 50 kg ha⁻¹ enhanced the pods plant⁻¹, grains pod⁻¹ and straw yield significantly.

2.4 Effect of varieties

2.4.1 Growth and development

Sinha (1980) worked on Green gram varieties reported that dry matter accumulation increased with the crop age up to maturity in stem and whole plant, and up to 60 days in leaves. At 60 days after sowing and at maturity, selection 9 produced significantly higher stem and total dry weight as compared to Pusa Baisakhi and Type 1. Similarly, Kanungo (1980) reported that dry matter accumulation in stem, leaves and whole plant at maturity was higher in K 851 as compared to PS 16 and Type 1.

Gupta (1982) observed that Green gram variety ML 4 took significantly higher number of days for flowering and maturity in comparison to remaining varieties. Type 44 took minimum number of days for flowering and maturity. However, there were no significant differences among K 851, PS 16 and UPM 79-1-2 with respect to number

of days taken to flowering and among K 851, ML 26/10/3 and UPM 79-1-2 with respect to days taken to maturity.

Sahu (1986) worked on Green gram genotypes reported that Pusa Baisakhi, K 851 and Type 1 being on par, took significantly lesser time to flower compared to Selection 9. The similar effect was observed with respect to days taken to maturity.

Kalita and Shas (1988) studied 19 Green gram cultivars at Anand (Gujrat) and observed that total reproductive organs (buds, flowers and pods) shedding was lowest in A-57-7 (60.1%) and highest in Gujrat-2 (70.6%).

2.4.2 Yield and yield attributes

Gupta (1982) reported from a study having 6 varieties that ML 26/10/3 gave highest grain yield per plant which was significantly higher over other varieties. Number of pod per plant was significantly higher in ML 26/10/3 and ML 4 compared to other varieties except UPM 79-1-2. Variety K 851 had significantly higher number of grain pod⁻¹ over remaining varieties except ML 4 which was on par with K 851. Type 44 recorded lower number of grain per pod whereas K 851 recorded maximum 1000 grain weight which was significantly higher over remaining varieties. Variety ML 26/10/3 gave significantly higher grain yield over rest of the varieties. ML 4 and UPM 79-1-2 which were on par, yielded significantly higher than that of Type 44, K 851 and PS 16. Variety ML 4 gave significantly higher straw and biological yield over rest of the varieties. Highest harvest index was recorded in ML 26/10/3.

Lal *et al.* (1983) from Kanpur reported that variety PS 16 gave highest grain yield (1240 kg ha⁻¹), followed by K 851 (1200 kg ha⁻¹) during summer.

Takchand *et al.* (1984) while reviewed the varietal demonstrations carried out on farmers fields in Mahendragarh (Hariyana) started that K 851 produced maximum average yield 9784 kg ha⁻¹), followed by Selection 9 (731 kg ha⁻¹) and ML 11 (642 kg ha⁻¹). Sahu (1986) indicated that Selection 9 had significantly higher grain and straw yield.

Sharma *et al.* (1988) from a study conducted at Meghalaya in acidic soil (pH 4.8) found that variety DU-4 gave the highest yield (1.17 t ha⁻¹) followed by B -3 - 8 - 8 (0.89 t ha⁻¹).

Damodaran *et al.* (1989) observed better performance of Vamban - 1 and KB - 51 than T-9 and CO-4. Sood and Saini (1989) reported that under *kharif* season, genotype and environment interaction was significant for yield and yield attribute.

Tomar *et al.* (1993) identified Pant U 19 as the most suitable and economical variety of urdbean among the varieties tested for Northern Madhya Pradesh. Chaudhary *et al.* (1994) reported from Pantnagar that varieties Type 9, UG 218, Pant U 19 and UPU - 9 - 40 - 4 gave mean grain yields of 0.82, 0.83 and 0.75 t ha⁻¹, respectively.

Gaur (1995) reported from Sri Ganganagar that genotype K 851 gave significantly higher yield (1059 kg ha⁻¹) than Pusa Baisakhi (911 kg ha⁻¹) and Type 44 (831 kg ha⁻¹). This variety was also found superior in yield attributing characters.

Prabhakar and Ganapathy (1996) studied the correlation among yield attributes and yield in 6 urdbean varieties and observed that number of pods per plant and harvest index was positively correlated with grain yield. Similarly, Mahto and Mahto (1997) found that grain yield was highly and positively correlated with 1000 grains weight, number of branch per plant and number of grain per pod.

Singh *et al.* (2005) studied the response of different Green gram genotypes (SML 134, SML 357 and SML 688) on growth. The results showed significantly higher plant and higher leaf area in SML 134 than SML 357 which results in more dry matter accumulation in SML 134.

2.5 Nutrient Uptake

Athokpam *et al.* (2009) studied the effect of P application on seed yield and nutrient uptake by blackgram during *kharif* seasons of 2004 and 2005. Three nutrients applied in combination did increase the seed yield significantly over control, however, N and K alone were at par with control. The highest seed yield was recorded with the application of 60 kg P₂O₅ ha⁻¹. The increase in seed yield seems to be due to the effect of P as revealed by the relative higher yields with the treatments having P than those without P or lower P treatments. The total uptake of nutrients by the blackgram was associated with higher biomass production.

Reddy *et al.* (1990) concluded that application of 50 kg P₂O₅ ha⁻¹ significantly increased the protein content in seed of Green gram and urdbean.

Rao and Subramanian (1991) observed that increasing levels of phosphorus significantly increased the phosphorus content and uptake in black gram.

Shukla and Dixit (1996) reported that nitrogen and phosphorus uptake and protein content of Green gram seeds significantly increased due to application of 20, 40 and 60 kg P₂O₅ ha⁻¹ over the control.

Reddy and Ahlawat (1998) observed that application of 18 kg nitrogen + 46kg P₂O₅ha⁻¹ in check pea significantly increased the N and P uptake and protein yield over lower doses and the control.

Soni and Gupta (1999) reported that protein content in Green gram increased significantly with 40 kg p₂o₅ ha⁻¹ than 20 kg p₂o₅ ha⁻¹ and control.

Singh *et al.* (2002) studied the effect of Phosphorus application on seed yield and nutrient uptake by the black gram at Central Agricultural University, Imphal. In the grain yield response of black gram to the various treatments combinations P (0, 30 and 60 kg ha⁻¹) the highest yield was obtained with the application of 15:60 kg P₂O₅ ha⁻¹ which was at par with control and this might be due to higher values of organic carbon, P₂O₅ in the soil. The total uptake of nutrients by black gram was associated with higher biomass production.

Rao and Ali (2006) observed that a study was conducted in Uttar Pradesh, India, during *kharif* 2002 to examine the response and nutrient uptake of urdbean and mung bean genotypes to optimum nutrient supply on nutrient-deficient sandy loam soil. Treatments comprised: control (no

nutrient supply) and optimum nutrient supply (20 kg N, 60 kg P, 20 kg K, 20 kg S and 25 kg Zn ha⁻¹, on a weight basis). In urdbean, P uptake varied from 0.69 to 1.75 mg pot⁻¹ in the control, and 1.60 to 5.29 mg pot⁻¹ in optimum nutrient supply. In mung bean, P uptake ranged from 0.37 to 1.54 mg pot⁻¹ in the control, and 1.52 to 3.76 mg pot⁻¹ in optimum nutrient supply.



MATERIALS AND METHODS

The present investigation entitled “**Performance of Green gram (*Vigna radiata* L.) varieties under various phosphorus levels in custard apple (*Annona Squamosa*) based agri-horti system**” was carried out during *kharif* season of 2012-13. The edaphic and climatic condition under which the experimental crop was raised and materials and techniques employed in conducting the experiment are being described in this chapter.

3.1 Experimental site

The experiment was carried out at the agricultural research farm of Rajiv Gandhi South Campus, Barkachha (BHU) Mirzapur which is situated in vindhyan region of district Mirzapur (25° 10' latitude, 82° 37' longitude and at an altitude of 427 meters above mean sea level) occupying over an area of more than 1000 ha where variety of crops like agricultural, horticultural, medicinal and aromatic plants are grown. Vindhyan soil comes under rainfed and invariably poor fertility status. This region comes under agro-climatic zone III A (semi-arid eastern plain zone).

3.2 Climate and weather

The climate of Barkachha is typically semi-arid, characterized by extremes of temperature both in summer and winter with low rainfall and

moderate humidity. Maximum temperature in summer is as high as 39.65°C and minimum temperature in winter falls below 8.12°C. The annual rainfall of locality was 1059 mm. Of which nearly 90 per cent is contributed by South West monsoon between July to September.

The temperature begins to rise from the month of February and reaches its maximum in May. The mean minimum and maximum relative humidity in this region ranged between 72 and 82 per cent from July to September (Table 3.1).

The rainfall during the experimental period was recorded from the meteorological observatory of the (KVK) horticultural farm. The total rainfall during the crop season was 1207.4 mm, maximum and minimum temperature fluctuated between 37.7°C and 16°C, and relative humidity prevailed between 90 and 33 per cent. The meteorological data of Mirzapur district is given in Table 3.1.

3.3 Soil characteristics of experimental field

Soil samples were taken before actually conducting the experiment from a depth of 0-15 cm, taking all the possible precautions prescribed for soil sampling. The samples were brought to the laboratory, air dried and crushed to pass through 2.0 mm mesh sieve. The processed samples were subjected to appropriate mechanical and chemical analyses. The results thus obtained are presented in Table 3.3.

Table 3.1: Mean week-wise meteorological data during crop season *kharif*, 2012.

| Standard Week (SW) | Month | Date | Rainfall (mm) | Temperature (°C) | | Relative humidity (%) | | Sunshine (hours) | Evaporation (mm) |
|--------------------|-----------|-------|---------------|------------------|------|-----------------------|------|------------------|------------------|
| | | | | Max. | Min. | Max. | Min. | | |
| 28 | July | 09-15 | 125.4 | 34.7 | 28.3 | 79 | 59 | 5.2 | 09-15 |
| 29 | | 16-22 | 163 | 31.5 | 26.4 | 88 | 77 | 2.4 | 16-22 |
| 30 | | 23-29 | 90.4 | 32 | 26.5 | 85 | 69 | 3.7 | 23-29 |
| 31 | | 30-05 | 91.9 | 30.8 | 27.4 | 88 | 81 | 3 | 30-05 |
| 32 | August | 06-12 | 62.6 | 28.9 | 25.8 | 94 | 85 | 2 | 06-12 |
| 33 | | 13-19 | 42.3 | 30.3 | 26 | 88 | 82 | 2.4 | 13-19 |
| 34 | | 20-26 | 70.6 | 33 | 27.4 | 88 | 68 | 3.4 | 20-26 |
| 35 | | 27-02 | 17 | 32.5 | 27.4 | 84 | 69 | 5.4 | 27-02 |
| 36 | September | 03-09 | 37.2 | 32 | 26.2 | 88 | 71 | 3.4 | 03-09 |
| 37 | | 10-16 | 419 | 30.5 | 26.3 | 88 | 77 | 3 | 10-16 |
| 38 | | 17-23 | 80.0 | 30.7 | 29 | 93 | 74 | 2.7 | 17-23 |
| 39 | | 24-30 | 0 | 30 | 24.3 | 88 | 74 | 2.6 | 24-30 |
| 40 | October | 01-07 | 8 | 31.1 | 23.8 | 84 | 55 | 3.6 | 01-07 |
| 41 | | 08-14 | 0 | 33.1 | 23.5 | 83 | 49 | 2.9 | 08-14 |
| 42 | | 15-21 | 0 | 31.7 | 20.4 | 84 | 38 | 2.9 | 15-21 |
| 43 | | 22-28 | 0 | 31.6 | 19.9 | 84 | 53 | 2.6 | 22-28 |
| 44 | | 29-04 | 0 | 30.8 | 16 | 88 | 33 | 2.5 | 29-04 |

Observatory: Krishi Bhawan Mirzapur, is presented in Table 3.1.

Table 3.2. Mean weather data: 10 year mean (2003-2012)

| Month | Rainfall (mm) | Temperature (°C) | | Relative humidity (%) | | Sunshine (hours) | Evaporation (mm) |
|-----------|------------------|---------------------|-------|--------------------------|-------|---------------------|---------------------|
| | | Max. | Min. | Max. | Min. | | |
| January | 1.9 | 19.70 | 7.04 | 86.23 | 44.67 | 6.27 | 1.73 |
| February | 1.6 | 26.95 | 11.15 | 84.58 | 45.20 | 8.35 | 2.42 |
| March | 1.08 | 33.10 | 15.83 | 73.46 | 28.40 | 8.39 | 4.64 |
| April | 0.44 | 35.96 | 20.42 | 57.09 | 23.5 | 9.38 | 5.10 |
| May | 3.27 | 39.85 | 26.65 | 64.86 | 27.50 | 9.18 | 8.64 |
| June | 53.46 | 36.08 | 27.73 | 72.8 | 50.28 | 7.08 | 7.72 |
| July | 57.18 | 32.14 | 27.18 | 84.34 | 71.24 | 4.72 | 3.41 |
| August | 74.23 | 31.18 | 26.73 | 88.5 | 75.10 | 5.35 | 3.27 |
| September | 76.51 | 30.9 | 26.50 | 88.36 | 73.62 | 6.26 | 3.12 |
| October | 0.98 | 31.67 | 20.71 | 85.16 | 45.82 | 8.34 | 3.0 |
| November | 0.23 | 28.41 | 14.67 | 91.31 | 40.65 | 8.20 | 2.5 |
| December | 0.33 | 21.10 | 9.06 | 93.82 | 56.47 | 6.48 | 1.53 |

Source: All India Co-ordinated Research Project on Dry land Agriculture (BHU).

Table 3.3. Mechanical and physico-chemical properties of experimental field

| Particulars | Value | Rating | Method | Reference |
|--|------------|-----------------|--|----------------------------|
| 1. Mechanical analyses | | | | |
| Sand (%) | 56.24 | | Hydrometer | Bouyoucos (1962) |
| Silt (%) | 29.18 | | | |
| Clay (%) | 14.58 | | | |
| Textural class | Sandy loam | | Textural triangle | Black <i>et al.</i> (1965) |
| 2. Physical constants | | | | |
| Bulk density (Mg/m ³) | 1.45 | | Core sample | Black <i>et al.</i> (1965) |
| Particle density (Mg/m ³) | 2.65 | | Pycnometer | |
| 3. Chemical analyses | | | | |
| pH (1:2.5 soil: water suspension) | 5.5 | Slightly acidic | Glass electrode digital pH meter | Sparks (1996) |
| EC (1:2.0 soil: water suspension) dS/m at 25 °C) | 0.30 | Normal | Systronics electrical conductivity meter | Sparks (1996) |
| Organic carbon (%) | 0.27 | Low | Wet digestion method | Walkley and Black's (1934) |
| Available N (kg ha ⁻¹) | 173.44 | Low | Alkaline potassium permanganate | Subbiah & Asija (1956) |
| Available P ₂ O ₅ (kg ha ⁻¹) | 13.82 | Medium | HCL+NH ₄ F | Bray <i>et al.</i> (1954) |
| Available K ₂ O (kg ha ⁻¹) | 141.32 | Medium | 1N Ammonium acetate | Hanway & Heidal (1952) |

3.4 Cropping history of the experimental field

The crop sequences followed in the experimental field during the past five years have been presented in Table 3.4. The cropping history of the experimental site clearly indicates that the field was not cropped continuously and kept fallow during one consecutive *kharif* seasons (2008-09) followed by fallow in *rabi* during 2009-10 to 2010-11. During 2008-09 Green gram-mustard sequence was taken thus, the fertility set up has not been disturbed. Hence, as such the field was ideally suitable for the experiment.

Table 3.4. Cropping history of experimental field

| Year | Season | |
|---------|-------------------|-------------|
| | <i>Kharif</i> | <i>Rabi</i> |
| 2008-09 | Green gram | Mustard |
| 2009-10 | Green gram | Fallow |
| 2010-11 | Pearlmillet | Fallow |
| 2011-12 | Green gram | Fallow - |
| 2012-13 | Experimental crop | - |

3.5 Experimental crops and variety

The experimental crop was Green gram in alleys of custard apple.

3.5.1 Description of Green gram variety

HUM-16

It was developed from the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and notified by Central Varietal Release Committee, ICAR, New Delhi for its cultivation to entire Uttar Pradesh and Uttarakhand. A recommended variety for cultivation in summer and rainy (*kharif*) seasons matures in 65-70 days. Plant height is 45-55 cm. Growth habit is erect. Pod shape is long slender, medium in size. Pod length, seeds/pod and 1000-grain weight is 6.5 cm, 11-12 and 33-36 g, respectively. The grain is green and medium bold. Yield potential is 987 kg ha⁻¹.

SAMRAT

It is a short duration variety developed by CSAUAT, KANPUR, for cultivation during *kharif* season it matures in 60-70 days and attains the Plant height of 45-55 cm. Growth habit is erect. Pod shape is short slender, medium in size. Pod length is 6.2 cm and number of seed pod⁻¹ 8-10. Thousand grains weight is 30-36 g. Plants are Yellow Mosaic Virus resistant, seed medium bold and green. It has yielding ability about 10-12 qt ha⁻¹.

HARAMOTI

It is a short duration variety developed by U.P. Govt. For cultivation during *zaid* as well as in *kharif* season and it matures in 70-75 days. Plant height is 35-45 cm. Growth habit is erect. Pod shape is short

slender, medium in size. Pod length is 8.0 cm and number of seed pod⁻¹ 8-9. 1000 grains weight is 33-36 g. It has green small seeds and a yielding ability of about 08-10 qt ha⁻¹.

3.6 Details of agri-horticulture plantation

3.6.1 The custard apple (variety -Mammoth)

The fruit tree of custard apple (*Annona squamosa* L.) is one of the delicious and nutritious fruits can be grown in areas with rain fall as low as 400 mm. It was probably introduced into Australia from British Guiana. It is erect, with a rounded or spreading crown and trunk 10- 14 inches (25-35 cm) thick. Height of the tree ranges from 15- 35 feet (4.5- 10 m) (Wenkam, 1990). The custard apple was planted in 2005-06 with spacing 5 m × 5 m

3.7 Experimental details

The field experiment was laid out during *kharif* season of 2012 in 7 year old custard apple orchard which was planted in August in 2005-06 at a spacing of 5 x 5 meter. Green gram was sown as an intercrop. The experiment was conducted in Factorial randomized block design having three levels of phosphorus and three varieties of Green gram (*Vigna radiata* L.) with three replication.

The treatments were randomized as per statistical procedure. Experiment consist total 9 treatment combinations replicated thrice (Table 3.6).

Table 3.5. Treatment

| A. | Phosphorus levels | Symbol |
|-----------|--|----------------|
| I. | 0 Kg P ₂ O ₅ ha ⁻¹ | P ₀ |
| II. | 20 Kg P ₂ O ₅ ha ⁻¹ | P ₁ |
| III. | 40 Kg P ₂ O ₅ ha ⁻¹ | P ₂ |
| B. | Variety | |
| I. | HUM-16 | V ₁ |
| II. | Haramoti | V ₂ |
| III. | Samrat | V ₃ |

Table 3.6. The layout plan of experimental field is as follows

| | | |
|-------------------------|---|-----------------------------------|
| Experimental design | : | Factorial Randomized Block design |
| No. of treatment | : | 9 |
| No. of replication | : | 3 |
| Total plots | : | 27 |
| Gross plot size | : | 4m x 3 m = 12m ² |
| Net plot size | : | 3 m x 1.8 m=5.4m ² |
| Plot border | : | 30 cm |
| Row to row distance | : | 30 cm |
| Plant to plant distance | : | 10 cm |

Table 3.7. Treatment details

| S.No. | Treatments | Symbol used |
|--------------|--|-------------------------------|
| 1. | Phosphorus 00 kg ha ⁻¹ + HUM-16 | V ₁ P ₀ |
| 2. | Phosphorus 20 kg ha ⁻¹ + HUM-16 | V ₁ P ₁ |
| 3. | Phosphorus 40 kg ha ⁻¹ + HUM-16 | V ₁ P ₂ |
| 4. | Phosphorus 00 kg ha ⁻¹ + Haramoti | V ₂ P ₀ |
| 5. | Phosphorus 20 kg ha ⁻¹ + Haramoti | V ₂ P ₁ |
| 6. | Phosphorus 40 kg ha ⁻¹ + Haramoti | V ₂ P ₂ |
| 7. | Phosphorus 00 kg ha ⁻¹ + Samrat | V ₃ P ₀ |
| 8. | Phosphorus 20 kg ha ⁻¹ + Samrat | V ₃ P ₁ |
| 9. | Phosphorus 40 kg ha ⁻¹ + Samrat | V ₃ P ₂ |

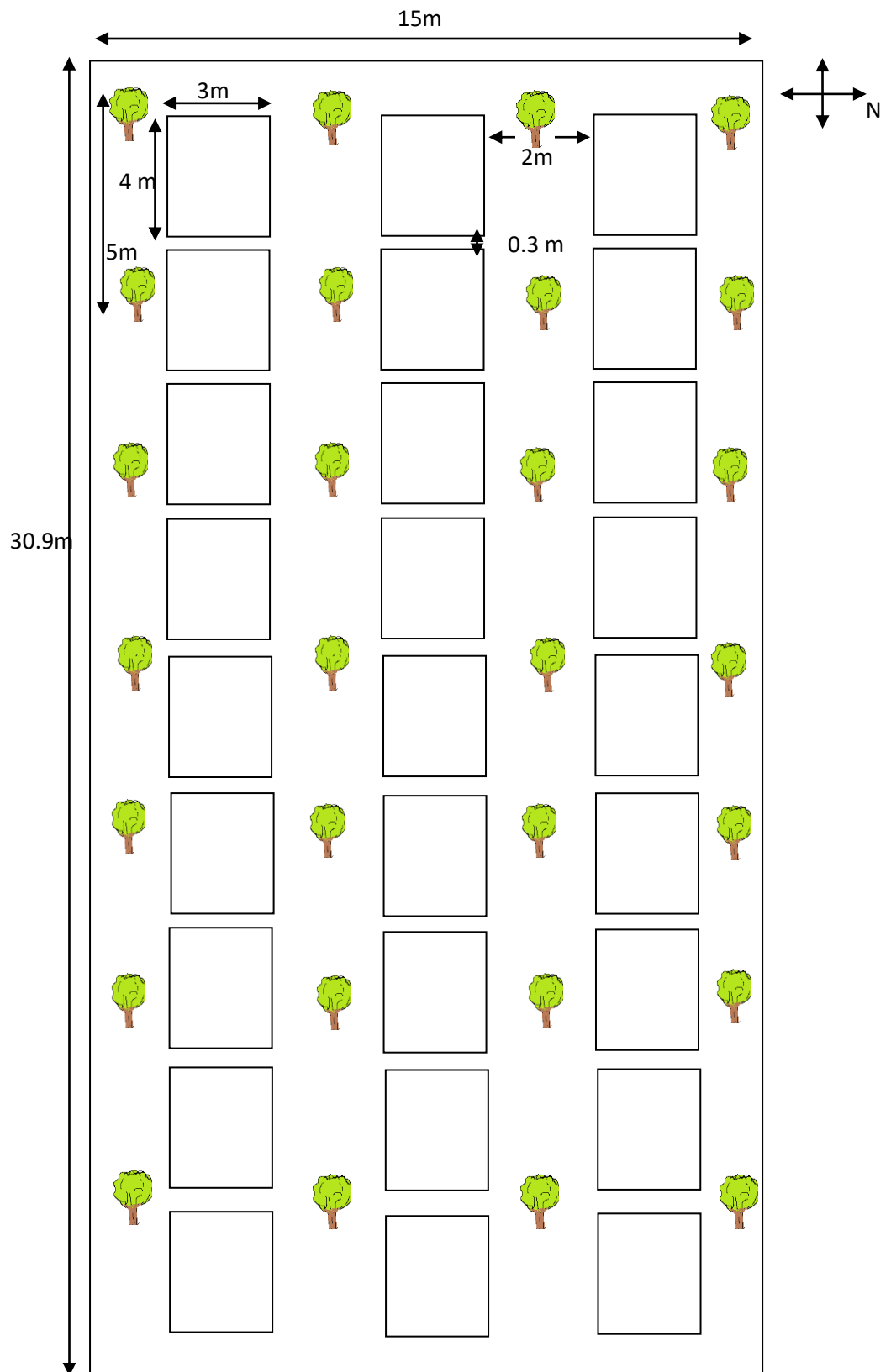


Fig. 3.1. Layout plan of the experiment

3.8 Agronomic practices

The details of cultural operations performed starting from field preparation to harvesting of the crop is given in Table 3.7.

Table 3.8. Schedule of field operations

| S. No. | Operation | Date |
|----------------------------|-----------------------------------|------------|
| (A) Pre-sowing operations | | |
| 1. | Land preparation | |
| | (i) First plough | 13.08.2012 |
| | (ii) Second plough | 15.08.2012 |
| 2. | Layout and experiment | 16.08.2012 |
| (B) Sowing operations | | |
| 1. | Fertilizer application and sowing | 17.08.2012 |
| (C) Post-sowing operations | | |
| 1. | Thinning of crop | 02.09.2012 |
| 2. | Weeding and hoeing | 04.09.2012 |
| 3. | Harvesting | 16.10.2012 |
| 4. | Threshing | 23.10.2012 |
| 5. | Cleaning | 28.10.2012 |

3.8.1 Land preparation

At optimum tilth, field was ploughed with the help of disc plough and harrowing was done followed by planking. Thereafter, the experiment was laid out as per plan and design.

3.8.2 Fertilizer application

The entire quantity of nitrogen and phosphorus and potassium as treatments in the form of urea (46% N), diammonium phosphate (18% N and 46% P₂O₅) and murate of potash (60 % K₂O) were applied below the seeds at the time of sowing of crop. Seed was treated with *Rhizobium*.

3.8.3 Seed rate and sowing

The seed sowing was done manually in the furrow opened by *kudal* at a row distance of 30 cm as per treatment. Relatively higher seed rate (20 kg ha⁻¹) was used for proper maintenance of plant population. A plant spacing of 10 cm within the row was maintained by thinning done about 15 days after sowing.

3.8.4 Thinning and intercultural operation

Extra plants were thinned to maintain the desired plant population at 15 days after sowing. One weeding was done manually by *khurpi* at 17 days after sowing to control weeds.

3.8.5 Harvesting and threshing

Crop was harvested at complete maturity as judged by visual observations. The border rows were harvested first and kept aside. Thereafter, the net plots were harvested by hand picking of the pods when nearly 80 percent pods were matured and harvested crop was left in the field for drying for a period of 3-4 days. Thereafter, small bundles were made and taken to the threshing floor. Bundle weight (grain and straw) was recorded before threshing which was done by beating the plant material with stick.

3.9 Biometric observations

Five plants from each plot were randomly selected and tagged for recording the biometric observations at different stages of growth. The observations on growth attributes were recorded at an interval of 20 days i.e. 20th, 40th DAS and at maturity.

Yield attributes and yield were studied before and after harvesting as per investigation required.

3.9.1 Growth attributes

3.9.1.1 Plant height (cm)

Height of randomly selected and marked plants from each plot was measured from base of the plants up to growing tip of main stem. The average plant height was calculated by taking the mean of observation of five plants and expressed in cm.

3.9.1.2 Dry matter accumulation plant⁻¹ (g)

For recording dry matter accumulation, 5 plants from each plot were cut from the ground level of border rows. Sampled plants were sun dried first then dried in an oven for 24 hours to get constant dry weight. Thereafter, the average dry weight was recorded in g plant.

3.9.1.3 Number of nodules plant⁻¹

Five plants were randomly uprooted along with soil from the penultimate rows from each plot. These plants were kept in water to remove the adhered soil from the roots of the plant. Nodules excised from

the roots with a scalpel were counted, weighed and expressed as number plant⁻¹.

3.9.2 Yield attributing characters

The following observations on yield attributes and yield studies were recorded during the experimentation:

3.9.2.1 Number of pod plant⁻¹

Total number of pod on the tagged plants was counted and average number of pod plant⁻¹ was recorded.

3.9.2.2 Pod length (cm)

Length of five randomly selected pods was measured from five tagged plants and average was worked out to get the pod length.

3.9.2.3 Number of grain pod⁻¹

The ten randomly selected pods from each five tagged plants per plot were taken out and total number of grain was counted. Average number of grain pod⁻¹ was then calculated and recorded.

3.9.2.4 Test weight (g)

Randomly selected 1000 grains from the grain yield samples of crop were counted from each plot and their combined weight was recorded to get the test weight of 1000 grains.

3.9.2.5 Grain yield (kg ha⁻¹)

The seed yield obtained from net plot was thoroughly cleaned; sun

dried and weighed treatment wise. The net plot yield was then converted and expressed as kg ha⁻¹.

3.9.2.6 Straw yield (kg ha⁻¹)

The straw yield of each net plot was sun dried and then weighed treatment wise and expressed in kg ha⁻¹.

3.9.2.7 Biological yield (kg ha⁻¹)

3.9.2.8 Harvest index (%)

The harvest index was calculated by dividing the economic yield by the biological yield and multiplying by 100.

$$\text{Harvest index} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.9.3 Nutrient uptake

Nitrogen content is used and straw was analysed by digestion and distillation methods (Jackson, 1973)

Phosphorus content in grain as well as in straw was determined by Vanado molybdophoric yellow color method followed by spectrophotometric determination by (Koenig and Jonson, 1942).

Nutrient uptake in grain and straw of the crop were calculated by using the formula.

$$\begin{aligned} &\text{Nutrient uptake (kg ha}^{-1}\text{)} \\ &= \frac{\text{Nutrient content (\%)} \times \text{Total dry matter yield (kg ha}^{-1}\text{)}}{100} \end{aligned}$$

3.9.4 Growth parameters of custard apple

The following growth parameters of custard apple, situated at border of the plot, were recorded.

3.9.4.1 Height

The height of custard apple was measured from base of the plants up to growing tip of main stem. The plant height was measured and expressed in feet.

3.9.4.2 Canopy

The canopy area of custard apple was recorded with the help of meter tape and it was recorded from the highest canopy diameter in feet.

3.9.4.3 Stem girth

The stem girth of custard apple was recorded from base of the plants in inches.

3.9.4.4 Shading

The shading area of the custard apple was recorded with the help of meter tape and measured as width and length in feet.

3.10 Economics

The cost of cultivation was worked out by taking into consideration all the expenses incurred. Gross income was worked out by multiplying grain and straw yield of the crop with their prevailing market prices. Calculations were made as per normal rates prevalent at the Research

Farm, R.G.S.C. (B.H.U.), Barkachha, Mirzapur. The cost of fertilizers, manure, plant protection chemicals and seed etc. were taken as per prevailing market prices. Net return (Rs ha⁻¹) and benefit: Cost ratios (BC ratio) were calculated with the help of the following formula:

Net return (Rs ha⁻¹) = Gross return (Rs ha⁻¹) – Cost of cultivation (Rs ha⁻¹)

$$\text{Benefit : cost ratio} = \frac{\text{Net return (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

3.11 Statistical analysis

For determining the significance between the treatment means and to draw valid conclusion, statistical analysis was made. Data obtained from various observations were subjected to statistical analysis by adopting appropriate method of “Analysis of Variance”. The significance of the treatment effect was judged with the help of ‘F’ test (Variance ratio). The difference of the treatments mean was tested using critical difference (C. D.) at 5% level of probability (Gomez and Gomez, 1976).

If the variance ratio (F test) was found significant at 5% level of significance, the standard error of mean (S.Em.±) and critical differences (CD) were calculated for further comparison.

$$\text{S.Em.}\pm = \sqrt{\frac{V_E(a)}{r \times C}}$$

$$\text{C.D. at 5\%} = \text{S.Em.}\pm \times \sqrt{2} \times t \text{ value at value at 5\% of error (a) d.f.}$$



EXPERIMENTAL FINDINGS

The results of the experiment entitled "**Performance of Green gram (*Vigna radiata* L.) varieties under various phosphorus levels in custard apple (*Annona Squamosa*) based agri-horti system**" obtained during the course of investigation are being presented in this chapter under various heads.

4.1 Growth and development studies

4.1.1 Plant height

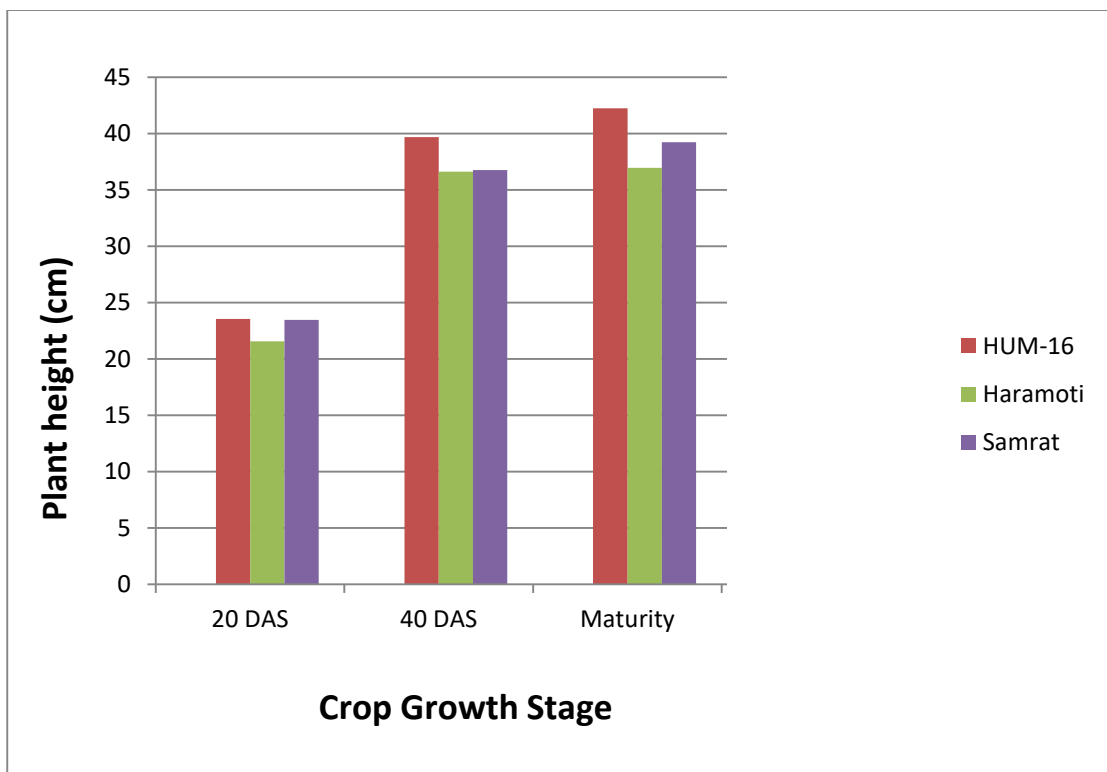
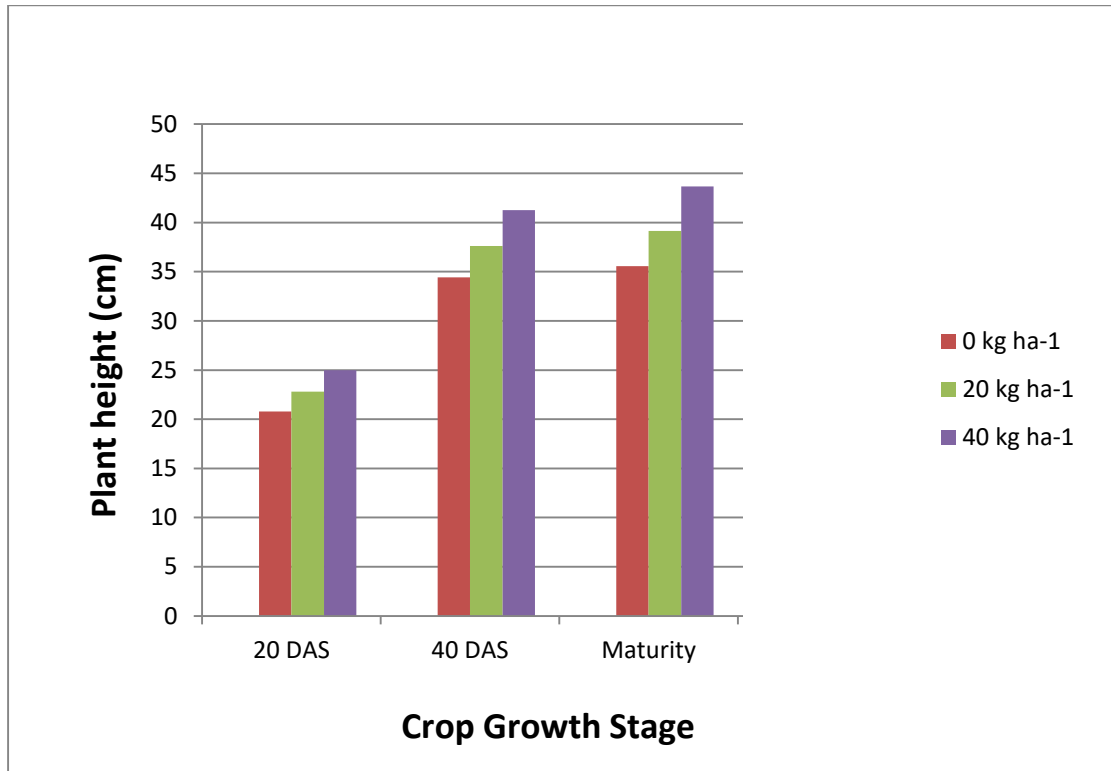
Data pertaining to plant height of green gram as influenced by varieties and phosphorus levels are presented in Table 4.1 and graphically illustrated in Fig 4.1. A close examination of the data revealed that plant height increased with the advancement of crop age and reached to its maximum at maturity. Maximum rate of increase in plant height was obtained between 20 and 40 days after sowing and decreased thereafter.

Plant height increased with increasing levels of phosphorus up to highest level at all the crop growth stages. Phosphorus levels affected the plant height significantly at all the crop growth stages. Significant differences were observed in plant height at all the crop growth stages except at 40 DAS, where 0 and 20 kg and 20 and 40 kg P_2O_5 ha⁻¹ were at par while 40 kg P_2O_5 ha⁻¹ proved significantly superior over the 0 kg P_2O_5 ha⁻¹. Highest and lowest plant heights were obtained at 40 kg and 0 kg P_2O_5 ha⁻¹, respectively at all the crop growth stages.

Table 4.1. Plant height (cm) at various growth stages of in Green gram as influenced by phosphorus level and varieties in custard apple based agri-horti system.

| Treatments | Plant height(cm) | | |
|--|------------------|--------|----------|
| | 20 DAS | 40 DAS | Maturity |
| Phosphorus (kg ha⁻¹) | | | |
| 0 | 20.8 | 34.4 | 35.58 |
| 20 | 22.8 | 37.6 | 39.16 |
| 40 | 25.0 | 41.3 | 43.67 |
| S.Em.± | 0.63 | 1.19 | 1.29 |
| CD at 5% | 1.9 | 3.56 | 3.86 |
| Variety | | | |
| HUM16 | 23.6 | 39.7 | 42.24 |
| Haramoti | 21.6 | 36.6 | 36.96 |
| Samrat | 23.5 | 36.8 | 39.21 |
| S.Em.± | 0.64 | 1.19 | 1.29 |
| CD at 5% | NS | NS | 3.86 |
| P X V Int. | NS | NS | NS |

Fig. 4.1. Plant height (cm) at various growth stages of in Green gram as influenced by phosphorus levels and varieties in custard apple based agri-horti system.



Plant height as affected by varieties was found at par at all the crop growth stages except at maturity. At this stage significantly higher plant height recorded in HUM-16 while it was lower in Haramoti.

The interaction between phosphorus levels and varieties was found not significant at all growth stages.

4.1.2 Shoot dry matter accumulation plant⁻¹ (g)

The data on dry matter accumulation plant⁻¹ of green gram as influenced by phosphorus levels and varieties are presented in Table 4.2 and Fig 4.2.

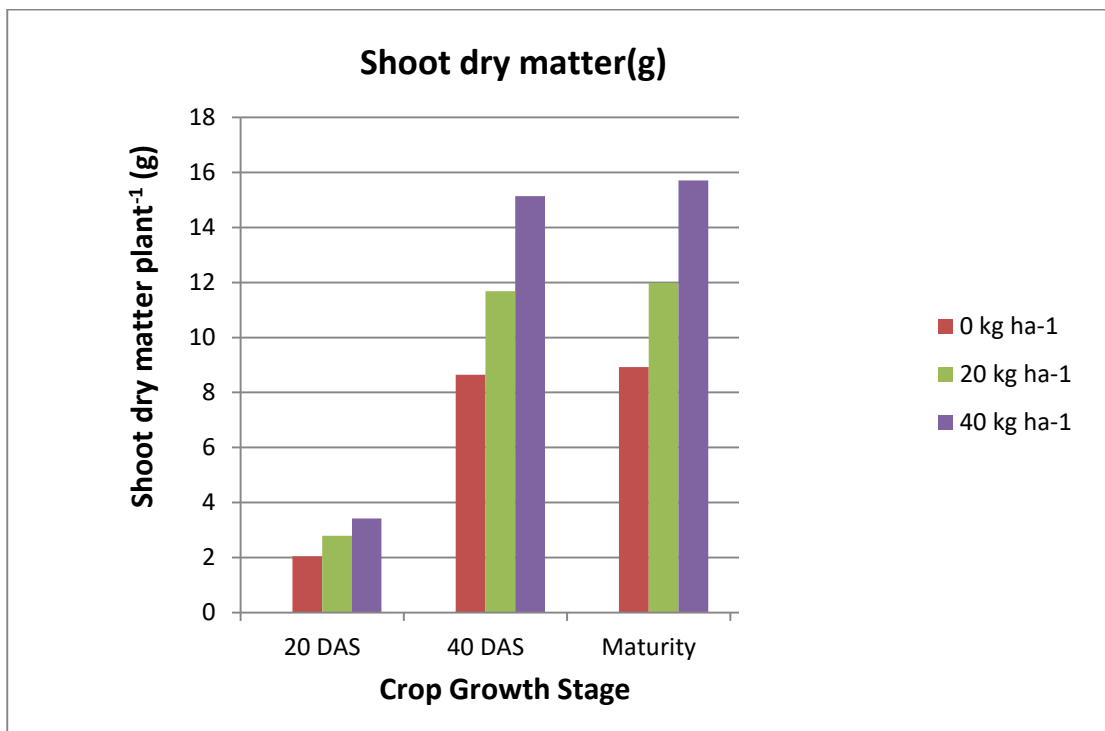
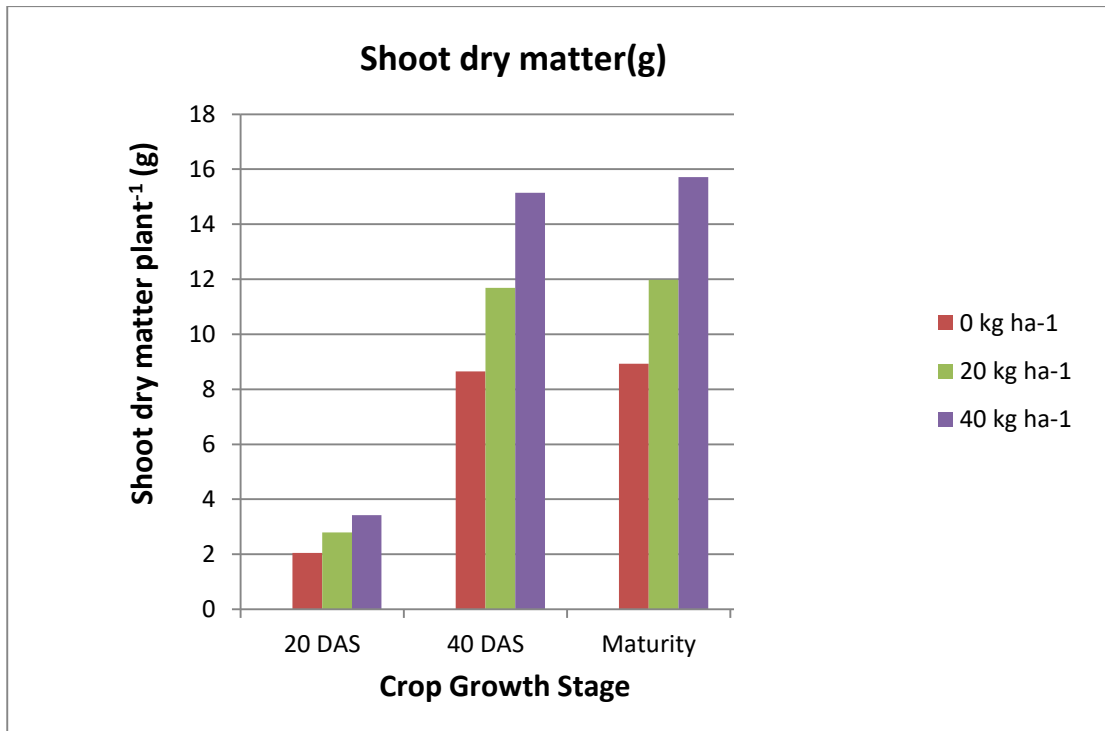
Analysis of the data revealed that with the advancement of crop age, shoot dry matter accumulation increased up to maturity with the advancement of crop growth stages. Variation in phosphorus levels and varieties markedly affected the total dry matter at all the crop growth stages. Increasing levels of phosphorus application from 0 to 40 kg P₂O₅ kg⁻¹ significantly increased the plant dry matter accumulation at all the growth stages.

Differences due to varieties for shoot dry matter accumulation were also found significant at all the crop growth stages. HUM-16 being produced significantly higher dry matter plant⁻¹ than Samrat and Haramoti.

Table 4.2. Shoot dry matter accumulation (g) of green gram at various growth stages of crop growth as influenced by phosphorus level and varieties in custard apple based agri-horti system

| Treatments | Shoot dry weight plant ⁻¹ (g) | | |
|--|--|-------|----------|
| | 20DAS | 40DAS | Maturity |
| Phosphorus (kg ha⁻¹) | | | |
| 0 | 2.05 | 8.65 | 8.93 |
| 20 | 2.80 | 11.69 | 11.98 |
| 40 | 3.43 | 15.14 | 15.71 |
| S.Em± | 0.2 | 0.81 | 0.35 |
| CD at 5% | 0.59 | 2.42 | 1.05 |
| Variety | | | |
| HUM16 | 3.28 | 14.47 | 14.70 |
| Haramoti | 2.42 | 9.96 | 10.68 |
| Samrat | 2.57 | 11.05 | 11.24 |
| S.Em± | 0.2 | 0.81 | 0.35 |
| CD at 5% | 0.59 | 2.42 | 1.05 |
| P X V Int. | NS | NS | NS |

Fig. 4.2. Shoot dry matter accumulation (g) of green gram at various growth stages of crop growth as influenced by phosphorus level and varieties in custard apple based agri-horti system.



4.1.3 Number of nodule plant⁻¹

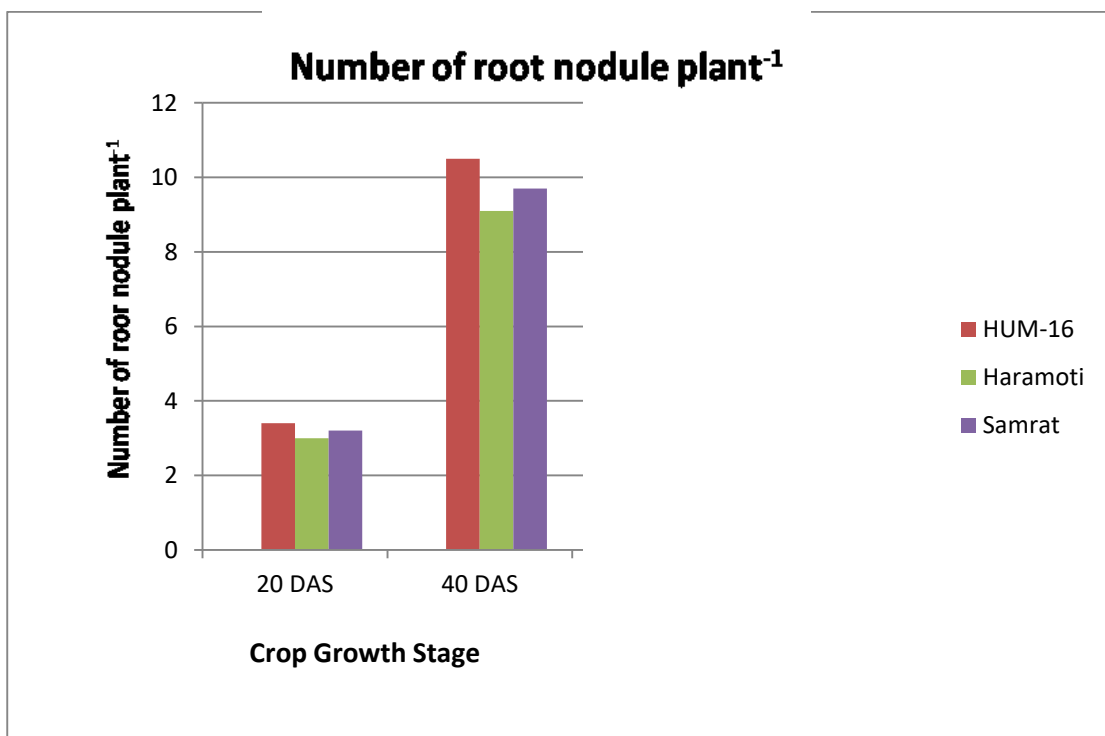
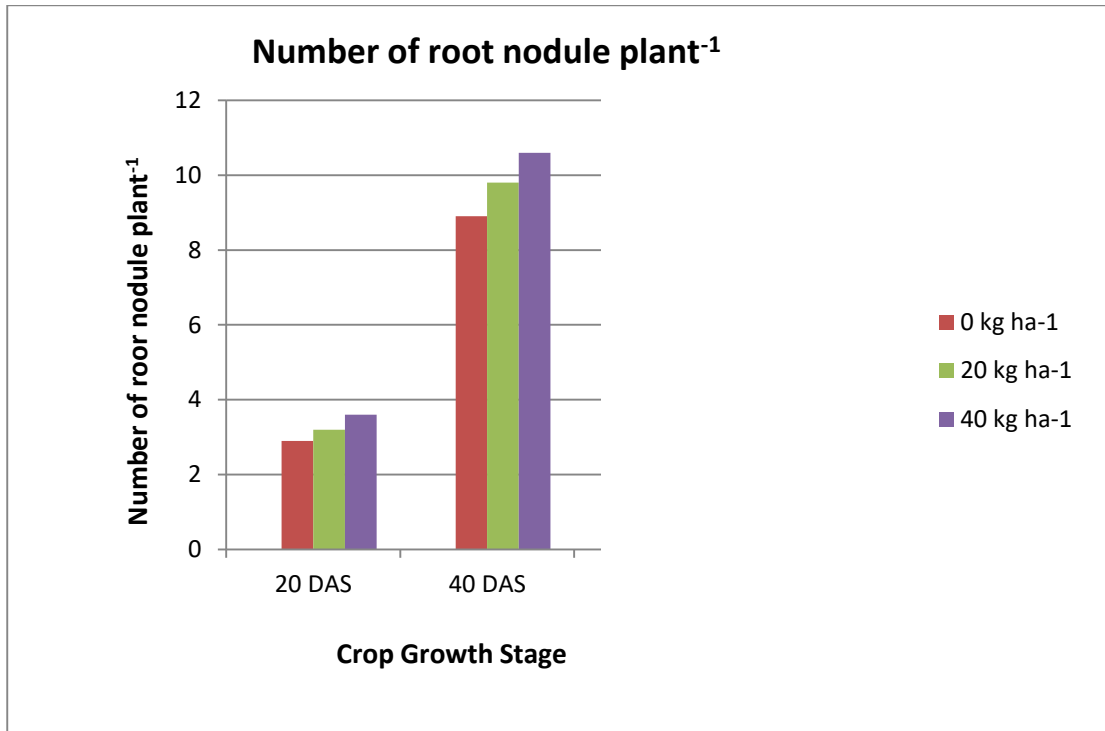
The data on number of root nodule plant⁻¹ recorded at various growth stages are presented in Table 4.3 and graphically depicted in Fig 4.3. A close examination of the data revealed that the number of nodule plant⁻¹ increased up to 40 DAS with the increase in phosphorus doses the number of nodules plant⁻¹ increased correspondingly. Phosphorus levels exerted significant differences among themselves at all the growth stages.

All the varieties showed marked differences in number of nodules plant⁻¹. At 20 and 40 DAS HUM-16 being at par with Samrat recorded significantly higher root nodule than Haramoti.

Table 4.3. Number of root nodules plant⁻¹ at various growth stages of crop as influenced by phosphorus level and varieties in custard apple based agri-horti system.

| Treatments | Root nodules | |
|--|--------------|-------|
| | 20DAS | 40DAS |
| Phosphorus (kg ha⁻¹) | | |
| 0 | 2.9 | 8.9 |
| 20 | 3.2 | 9.8 |
| 40 | 3.6 | 10.6 |
| S.Em± | 0.05 | 0.1 |
| CD at 5% | 0.2 | 0.5 |
| Variety | | |
| HUM16 | 3.4 | 10.5 |
| Haramoti | 3 | 9.1 |
| Samrat | 3.2 | 9.7 |
| S.Em.± | 0.05 | 0.1 |
| CD at 5% | 0.2 | 0.5 |
| P X V Int. | NS | NS |

Fig. 4.3. Number of root nodules plant⁻¹ at various growth stages of crop as influenced by phosphorus level and varieties in custard apple based agri-horti system.



4.2 Yield and yield attributes

4.2.1 Number of pod plant⁻¹

Lucid effect of Phosphorus application was noticed on number of pod plant⁻¹ (Table 4.4 and Fig 4.4). Increasing levels of Phosphorus application correspondingly improved the pods plant⁻¹ up to highest level i.e. 40 kg P₂O₅ ha⁻¹. All the phosphorus levels differed significantly.

Significant differences were noticed among the three varieties with respect to number of pod plant⁻¹ HUM-16 produced maximum number of pod plant⁻¹ followed by Samrat and Haramoti.

4.2.2 Pod length (cm)

Analysis of the data presented in Table 4.4 and Fig 4.4 showed marked effect of phosphorus application on pod length of green gram. Increasing levels of phosphorus application from 0 to 40 kg P₂O₅ ha⁻¹, significantly increased the pod length.

Among the three green gram varieties, HUM-16 though remained comparable to Samrat produced significantly longer pods than Haramoti.

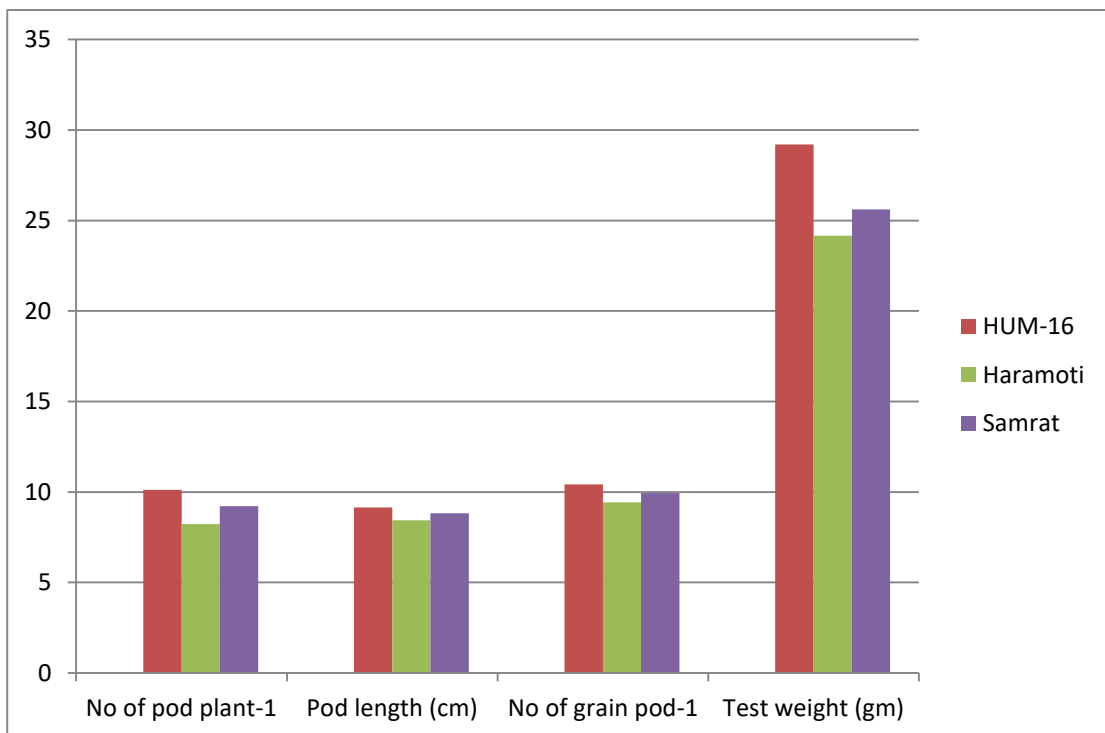
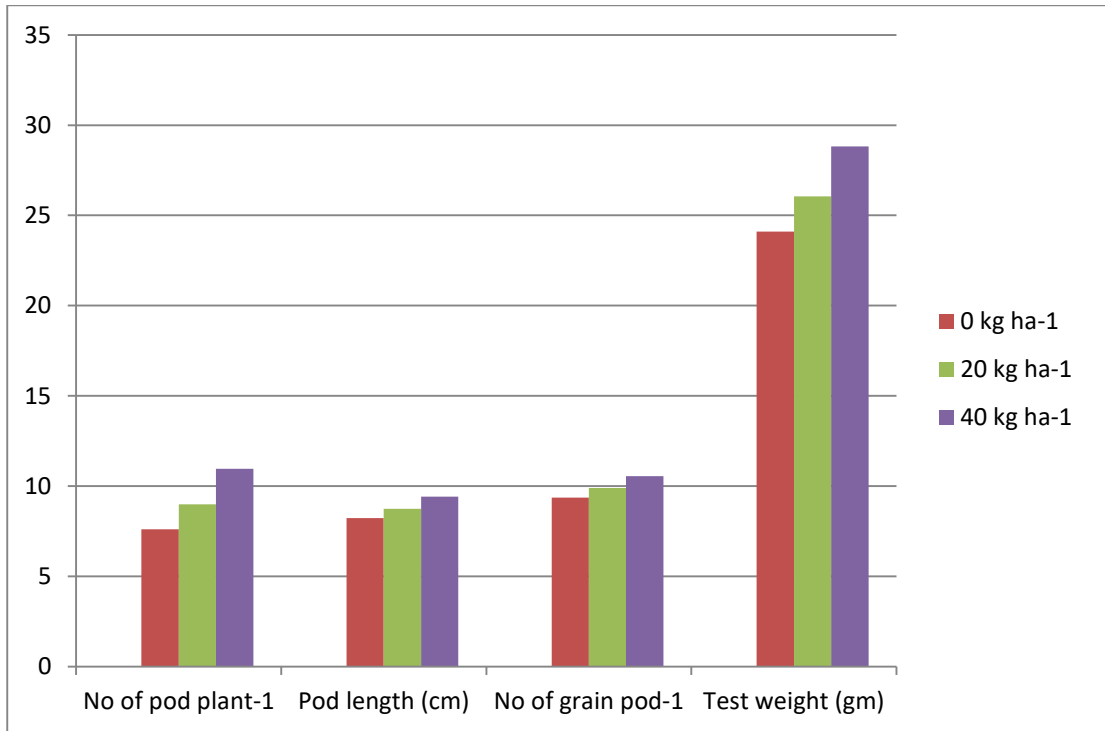
4.2.3 Number of grain pod⁻¹

Analysis of the data presented in Table 4.4 and Fig 4.4 showed marked effect of phosphorus application on number of grain pod⁻¹ of green gram. Increasing levels of phosphorus application from 0 to 40 kg P₂O₅ ha⁻¹ significantly increased the number of grain pod⁻¹.

Table 4.4. Yield attributes of green gram as influenced by phosphorus level and varieties in custard apple based agri-horti system.

| Treatments | Yield attributes | | | |
|--|-------------------------------|-----------------|-------------------------|-----------------|
| | No of pod plant ⁻¹ | Pod length (cm) | Grain pod ⁻¹ | Test weight (g) |
| Phosphorus (kg ha⁻¹) | | | | |
| 0 | 7.60 | 8.2 | 9.36 | 24.10 |
| 20 | 9.00 | 8.7 | 9.89 | 26.06 |
| 40 | 10.97 | 9.4 | 10.54 | 28.82 |
| S.Em. ± | 0.28 | 0.1 | 0.13 | 0.3 |
| CD at 5% | 0.83 | 0.3 | 0.39 | 0.91 |
| Variety | | | | |
| HUM16 | 10.12 | 9.1 | 10.42 | 29.2 |
| Haramoti | 8.22 | 8.4 | 9.43 | 24.16 |
| Samrat | 9.22 | 8.8 | 9.93 | 25.61 |
| S.Em. ± | 0.28 | 0.1 | 0.13 | 0.3 |
| CD at 5% | 0.83 | 0.3 | 0.39 | 0.91 |
| P X V Int. | NS | NS | NS | NS |

Fig.4.4. Yield attributes of green gram as influenced by phosphorus level and varieties in custard apple based agri-horti system.



Among the three green gram varieties, HUM-16 though remained comparable to Samrat produced significantly higher Number of grain pod⁻¹ than Haramoti.

4.2.4 Test weight

Data presented in Table 4.4 and Fig 4.4 revealed that test weight improved with each increment of Phosphorus level from 0 to 40 kg P₂O₅ ha⁻¹. The difference between away two increments of phosphorus levels was significant.

As regards the three green gram varieties, Samrat being at par with Haramoti. HUM-16 though recorded highest test weight than Samrat, and Haramoti.

4.2.5 Grain yield (kg ha⁻¹)

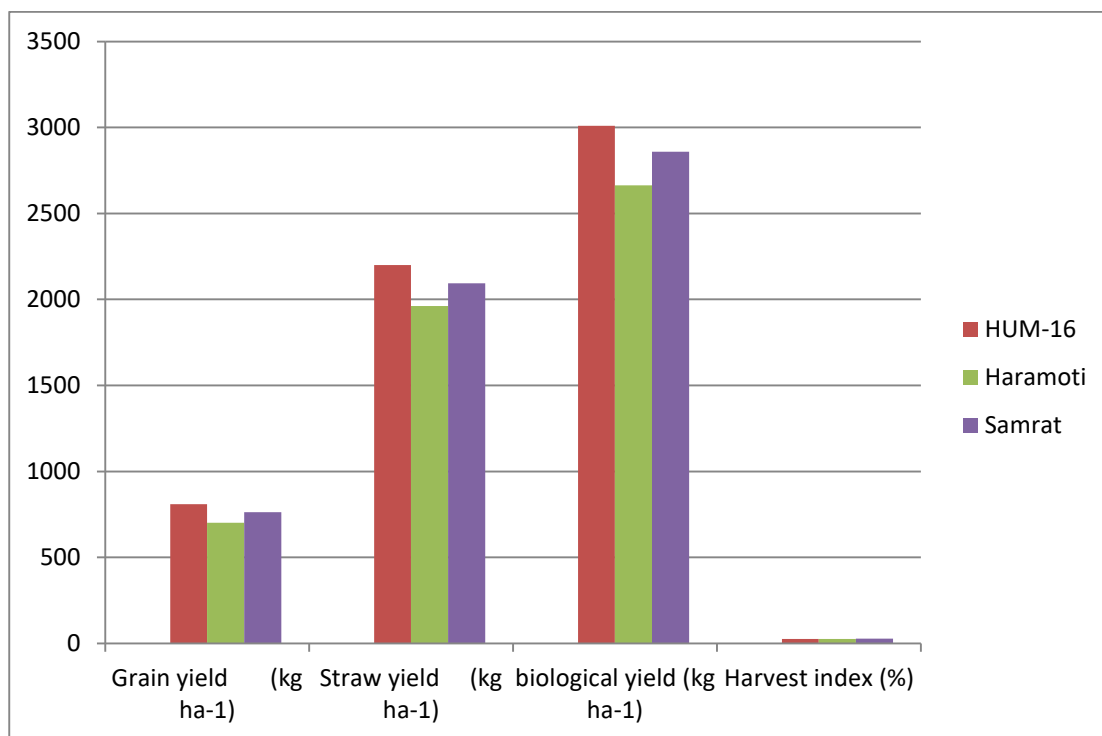
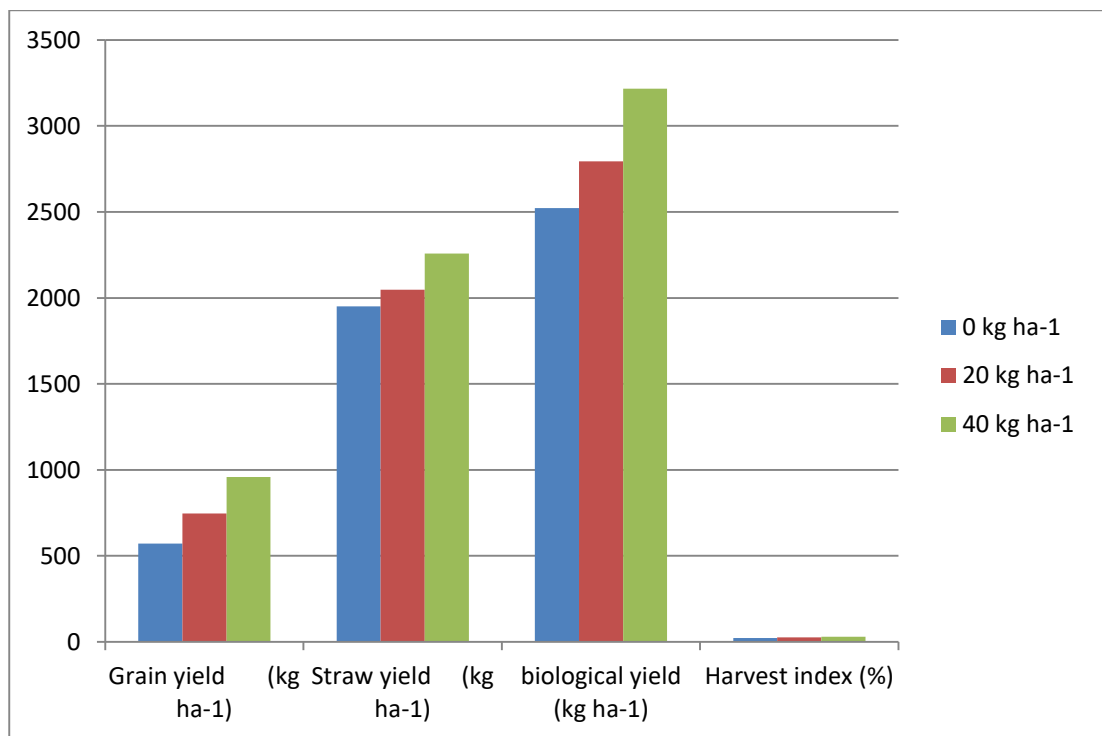
Data pertaining to grain yield of green gram as influenced by phosphorus levels and varieties are presented in Table 4.5. and Fig 4.5. A close examination of the data revealed marked effect of Phosphorus application on grain yield. Increasing levels of phosphorus application from 0 to 40 kg P₂O₅ ha⁻¹ significantly increased the grain yield. Application of 40 kg P₂O₅ ha⁻¹ produced 40 % and 22.0 % higher grain yield than 0 and 20 kg P₂O₅ ha⁻¹, respectively.

Significant differences were noticed among the three varieties with HUM-16 produced maximum grain yield. Followed by Samrat and Haramoti

Table 4.5. Grain yield, straw yield, biological yield and harvest index as influenced by phosphorus level and varieties in custard apple based agri-horti system.

| Treatments | Grain yield (kg ha ⁻¹) | Straw yield (kg ha ⁻¹) | Biological yield (kg ha ⁻¹) | Harvest index (%) |
|-------------------|---------------------------------------|---------------------------------------|---|-------------------------|
| Phosphorus | | | | |
| 0 | 570.74 | 1951.10 | 2521.84 | 22.34 |
| 20 | 745.59 | 2048.00 | 2793.59 | 26.66 |
| 40 | 959.26 | 2257.59 | 3216.85 | 29.52 |
| S.Em. ± | 14.62 | 23.75 | 26.75 | 0.46 |
| CD at 5% | 43.88 | 71.2 | 108.47 | 1.37 |
| Variety | | | | |
| HUM-16 | 810.00 | 2199.82 | 3009.82 | 25.64 |
| Haramoti | 702.22 | 1962.10 | 2664.32 | 25.98 |
| Samrat | 763.37 | 2094.77 | 2858.14 | 26.90 |
| S.Em. ± | 14.62 | 23.75 | 26.75 | 0.46 |
| CD at 5% | 43.88 | 71.2 | 108.47 | 1.37 |
| P X V Int. | NS | NS | NS | NS |

Fig. 4.5. Grain yield, straw yield, biological yield and harvest index as influenced by phosphorus level and varieties in custard apple based agri-horti system.



4.2.6 Straw yield (kg ha⁻¹)

Data on straw yield as influenced by phosphorus levels and varieties are presented in Table 4.5 and Fig 4.5. It was observed that straw yield ha⁻¹ was improved significantly with increasing levels of phosphorus application up to highest level.

Among the three green gram varieties, HUM-16 though remained comparable to Samrat produced significantly higher straw yield than Haramoti.

4.2.7 Biological yield (kg ha⁻¹)

Similar trend was observed in biological yield ha⁻¹ with respect to phosphorus levels and varieties as obtained in straw yield ha⁻¹ (Table 4.5 and Fig 4.5).

4.2.8 Harvest index

Increasing levels of phosphorus application correspondingly improved the harvest index of green gram. Critical examination of the data revealed that harvest index was found significant due to fertility level. Significant higher harvest index obtained in 40 kg ha⁻¹ than other doses. The three varieties did not differ with respect the harvest index

4.3 N, P and K content (%) in grain and straw

Analysis of N, P and K contents in grain and straw of green gram as influenced by varieties and phosphorus levels are presented in Table 4.6.

4.3.1 Nitrogen content (%) in grain

Perusal of data clearly indicated that phosphorus levels had significant effect on N content in grain. N content in grain increased significantly with increasing levels of phosphorus application from 0 to 40 kg P₂O₅ ha⁻¹.

Among the three varieties HUM-16 recorded significantly higher N content in grain than other two varieties. However, Samrat remained at par with Haramoti with respect to grain N content.

4.3.2 Nitrogen content (%) in straw

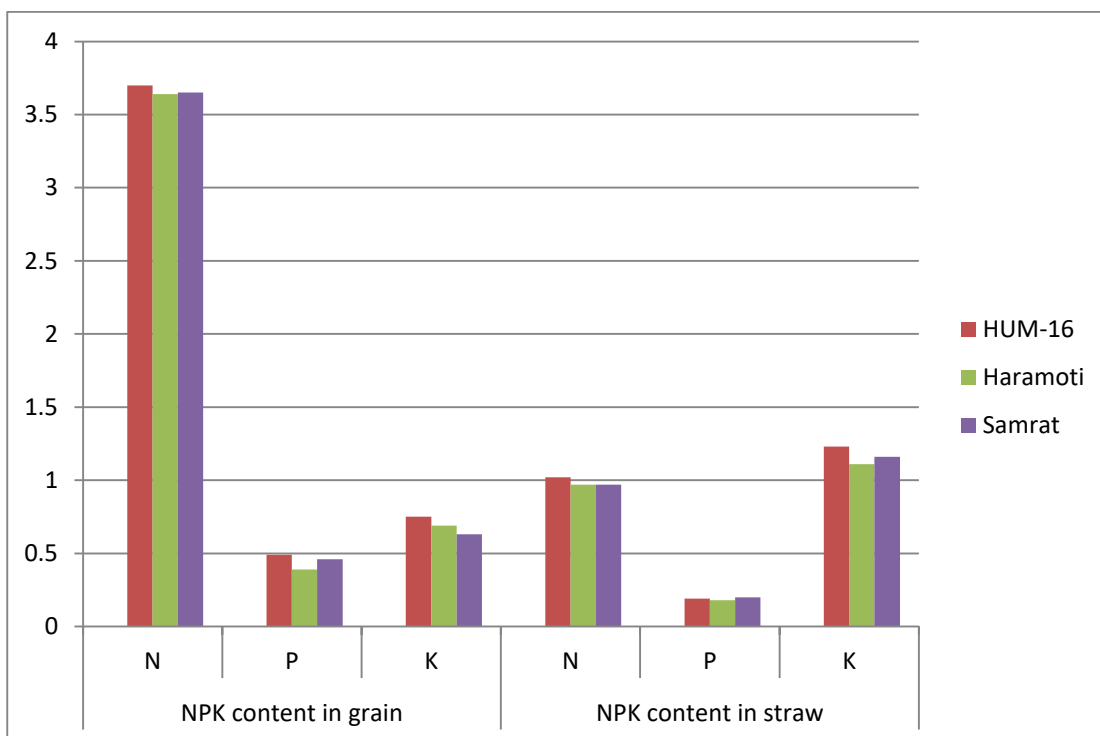
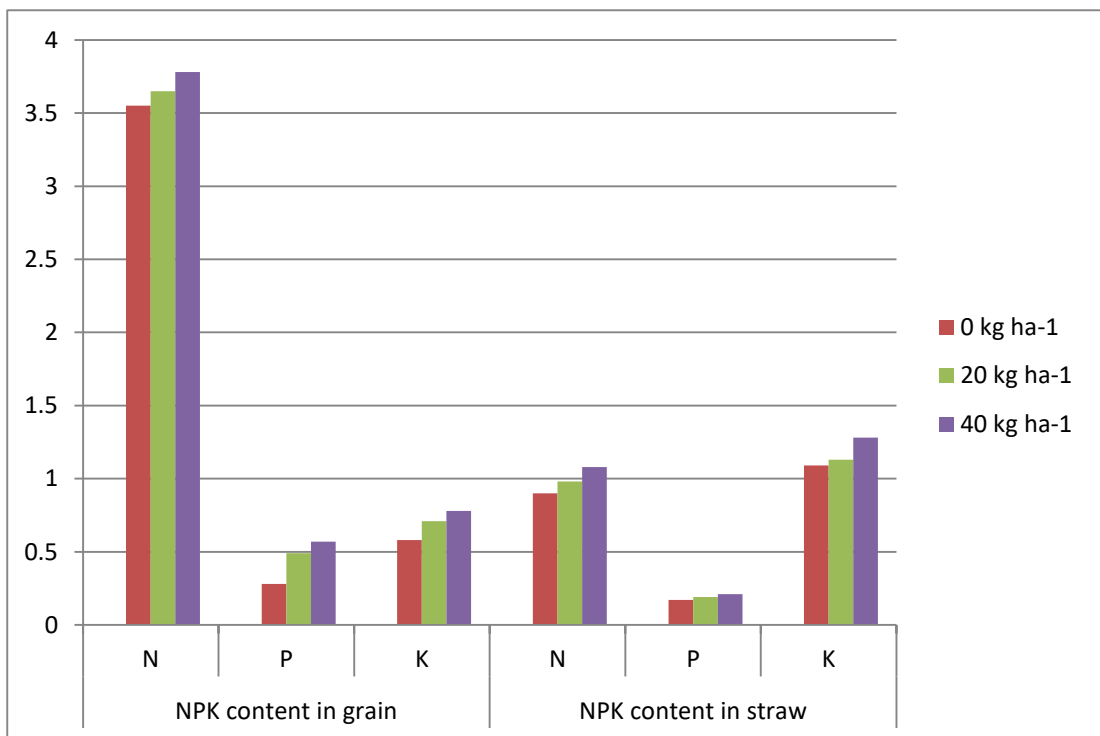
Perusal of data presented in Table 4.6 clearly indicated that increasing phosphorus levels had significant increase in N content in straw. The increasing levels of phosphorus correspondingly increased the N content in straw and all the levels differed significantly.

Among the green gram varieties HUM-16 had significantly higher N content in straw significantly than Samrat and Haramoti.

Table 4.6. Effect of varieties and phosphorus level on N, P₂O₅ and K₂O content (%) in grain and straw of green gram

| Treatments | NPK content in grain | | | NPK content in straw | | |
|---------------------------------------|----------------------|-------|------|----------------------|------|-------|
| | N | P | K | N | P | K |
| Phosphorus(kg ha⁻¹) | | | | | | |
| 0 | 3.55 | 0.28 | 0.58 | 0.90 | 0.17 | 1.09 |
| 20 | 3.65 | 0.49 | 0.71 | 0.98 | 0.19 | 1.13 |
| 40 | 3.78 | 0.57 | 0.78 | 1.08 | 0.21 | 1.28 |
| S.Em. ± | .018 | 0.025 | 0.03 | 0.06 | 0.00 | 0.04 |
| CD at 5% | .05 | 0.07 | 0.08 | 0.072 | 0.02 | 0.12 |
| Variety | | | | | | |
| HUM-16 | 3.70 | 0.49 | 0.75 | 1.02 | 0.19 | 1.23 |
| Haramoti | 3.64 | 0.39 | 0.69 | 0.97 | 0.18 | 1.11 |
| Samrat | 3.65 | 0.46 | 0.63 | 0.97 | 0.20 | 1.16 |
| S.Em. ± | 0.014 | 0.018 | 0.03 | 0.015 | 0.00 | 0.028 |
| CD at 5% | .04 | 0.05 | 0.08 | 0.041 | 0.01 | 0.08 |
| PXV Int. | NS | NS | NS | NS | NS | NS |

Fig. 4.6. Effect of varieties and phosphorus level on N, P₂O₅ and K₂O content (%) in grain and straw of green gram.



4.3.3 Phosphorus content (%) in grain

Perusal of data presented in Table 4.6 clearly indicated that phosphorus levels had significant differences in P content in grain. The increasing levels of phosphorus application from 0 to 40 kg P₂O₅ ha⁻¹ significantly increased the P content in grain.

Among the green gram varieties HUM-16 produced highest P content in grain and being at par with Samrat both recorded significantly higher grain P content than Haramoti.

4.3.4 Phosphorus content (%) in straw

The P content in straw increased correspondingly with increasing levels of Phosphorus up to 40 kg P₂O₅ ha⁻¹. However, significant difference was observed only between 0 and 40 kg phosphorus levels.

As regards the green gram varieties, Samrat though remained comparable to HUM-16 produced significantly higher P content in straw than Haramoti.

4.3.5 Potassium content (%) in grain

The K content in grain increased markedly with increasing P levels up to 40 kg P₂O₅ ha⁻¹. However 40 kg P₂O₅ ha⁻¹ there was also found at par with 20 kg P₂O₅ ha⁻¹.

As regards the green gram varieties, HUM-16 produced maximum K content in grain and being at par with Samrat recorded significantly higher K content in grain than Haramoti.

4.3.6 Potassium content (%) in straw

Perusal of data presented in Table 4.6 clearly indicated that increasing phosphorus levels up to 40 kg P₂O₅ ha⁻¹ produced significant differences in K content in straw. Among the green gram varieties HUM-16 recorded highest K content in straw and being at par with Haramoti proved distinctly superior over Samrat.

4.4 Nutrient (N, P and K) uptake (kg ha⁻¹)

The data pertaining to N, P and K uptake by grain and straw as influenced by phosphorus levels and varieties are presented in Table 4.7.

4.4.1 Nitrogen uptake (kg ha⁻¹) by grain

Data revealed that nitrogen uptake (kg ha⁻¹) by grain increased significantly with increasing of phosphorus levels up to 40 kg P₂O₅ ha⁻¹. As regards the varieties HUM-16 recorded significantly higher N uptake by grain than other two varieties. Samrat also proved its distinct superiority over Haramoti with respect to N uptake by grain.

4.4.2 Nitrogen uptake (kg ha⁻¹) by straw

Nitrogen uptake by straw, Increased significantly with the increasing phosphorus levels up to 40 kg P₂O₅ ha⁻¹.

As regards the varieties, HUM-16 recorded significantly higher N uptake by straw than the other two varieties Samrat also showed its distinct superiority over Haramoti.

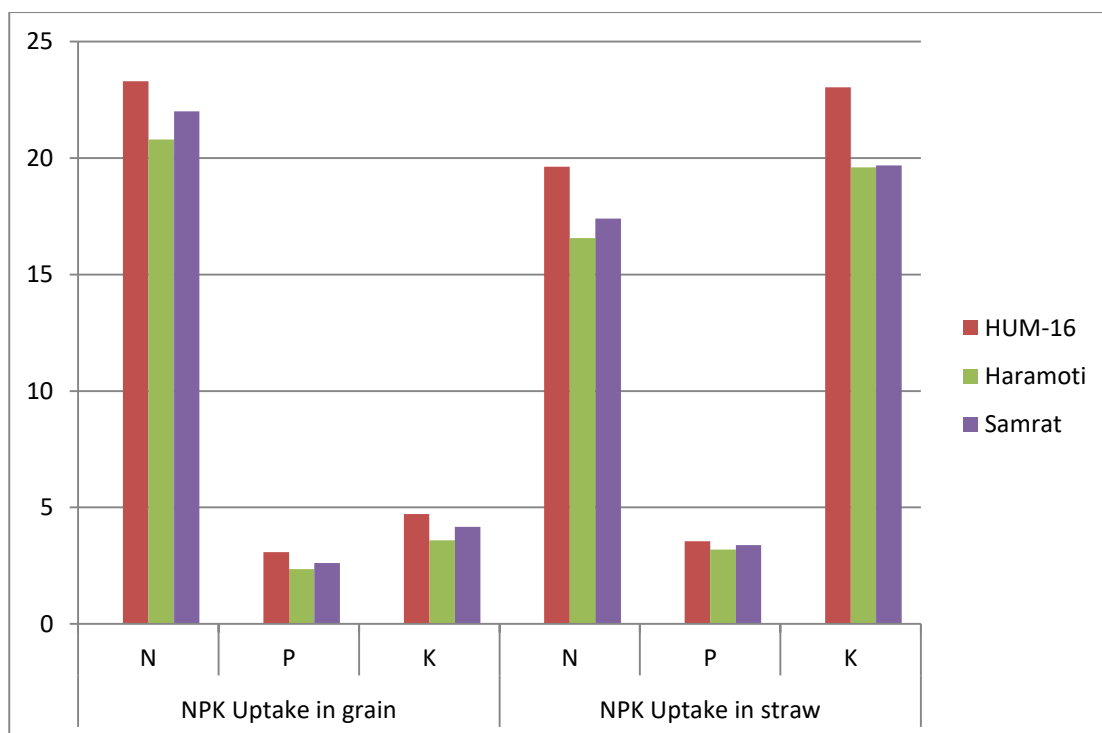
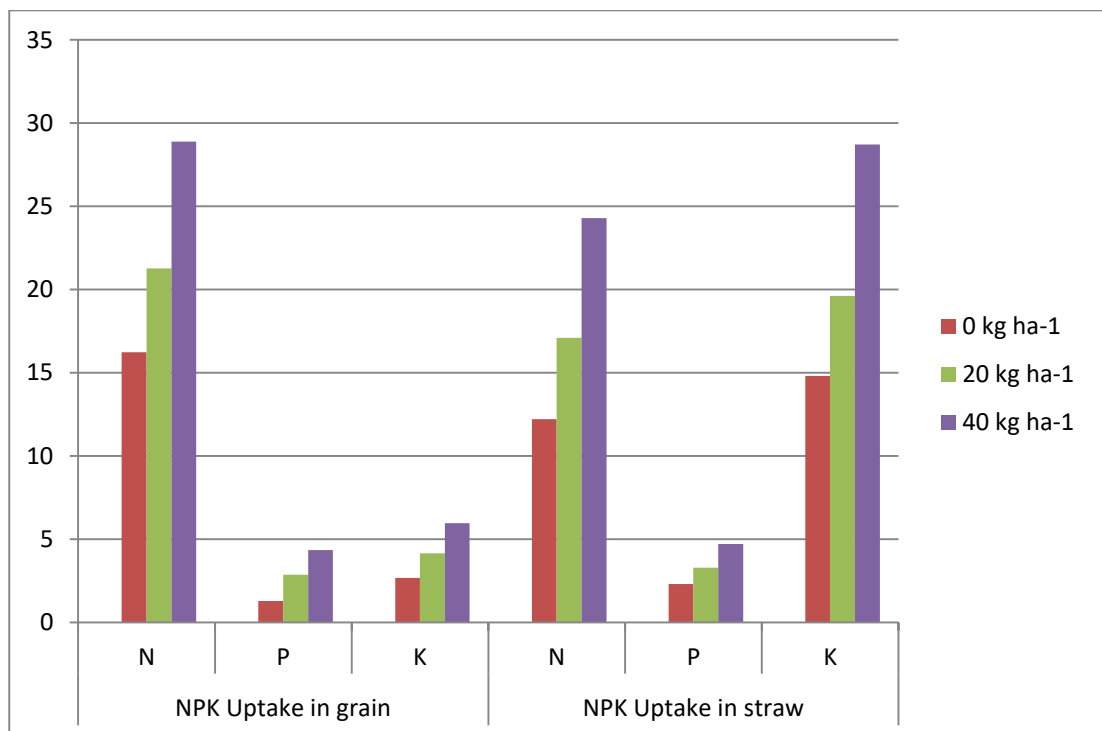
4.4.3 Phosphorus uptake (kg ha⁻¹) by grain

Data presented in Table 4.7 revealed that phosphorus uptake (kg ha⁻¹) by grain increased significantly with increasing of phosphorus levels up to 40 kg P₂O₅ ha⁻¹.

Table 4.7. Effect of varieties and phosphorus level on N, P₂O₅ and K₂O uptake (%) in grain and straw of green gram

| Treatments | NPK Uptake in grain | | | NPK Uptake in straw | | |
|--|---------------------|-------|------|---------------------|-------|-------|
| | N | P | K | N | P | K |
| Phosphorus (Kg ha⁻¹) | | | | | | |
| 0 | 16.23 | 1.28 | 2.66 | 12.21 | 2.30 | 14.80 |
| 20 | 21.28 | 2.85 | 4.14 | 17.09 | 3.29 | 19.61 |
| 40 | 28.9 | 4.35 | 5.96 | 24.30 | 4.71 | 28.71 |
| S. Em.± | 0.50 | 0.03 | 0.19 | 0.45 | 0.03 | 0.53 |
| CD at 5% | 1.39 | 0.09 | 0.53 | 1.20 | 0.11 | 1.46 |
| Variety | | | | | | |
| HUM-16 | 23.3 | 3.08 | 4.72 | 19.63 | 3.55 | 23.04 |
| Haramoti | 20.8 | 2.62 | 4.17 | 16.57 | 3.19 | 19.60 |
| Samrat | 22.0 | 2.35 | 3.59 | 17.40 | 3.38 | 19.69 |
| S.Em. ± | 0.40 | 0.039 | 0.13 | 0.43 | 0.036 | 0.68 |
| CD at 5% | 1.13 | 0.11 | 0.38 | 1.20 | 0.10 | 1.88 |
| PXV Int. | NS | NS | NS | NS | NS | NS |

Fig. 4.7. Effect of varieties and phosphorus level on N, P₂O₅ and K₂O uptake (%) in grain and straw of green gram



Among the three black gram varieties maximum phosphorus uptake (kg ha^{-1}) by grain was recorded in HUM-16 followed by Samrat and Haramoti. All the varieties differed significantly among themselves.

4.4.4 Phosphorus uptake (kg ha^{-1}) by straw

Phosphorus uptake by straw, increased significantly with the increasing phosphorus levels from 0 to $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$.

As regards the varieties, HUM-16 recorded significantly higher P uptake by straw than the other two varieties. Samrat also showed its distinct superiority over Haramoti.

4.4.5 Potassium uptake (kg ha^{-1}) by grain

Potassium uptake by grain, increased significantly with the increasing phosphorus levels up to $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$.

Among the varieties, HUM-16 recorded significantly higher K uptake by grain than the other two varieties. Samrat also proved significantly superior over Haramoti.

4.4.6 Potassium uptake (kg ha^{-1}) by straw

Potassium uptake by straw, increased significantly with the increasing phosphorus levels up to $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. Among the varieties, maximum potassium uptake (kg ha^{-1}) by straw was recorded in HUM-16 followed by Samrat and Haramoti. All the varieties differed significantly among themselves.

4.5 Growth parameter of custard apple

Data on the growth parameters of custard apple as influence by various treatments applied on green gram in custard apple + agri- horti system are given in Table 4.8.

Perusal of data presented in table 4.8. Revealed that the three phosphorus levels as well as green gram varieties failed to influence the growth parameter of viz. plant height, canopy diameter, stem girth as well as shading of custard apple.

4.6 Economics

Data presented in table 4.9 revealed that cost of cultivation of green gram increased correspondingly with increasing rates of phosphorus application up to maximum level. Gross return and net returns also followed the similar trend. Application of 40 kg P₂O₅ ha⁻¹ recorded 134.9 and 52.6% higher net return than 0 and 20 kg P₂O₅ ha⁻¹, respectively. B: C ratio was also improved markedly with increasing levels of phosphorus application.

Among the three green gram varieties, HUM-16 resulted in markedly higher gross return, net return and B: C ratio than other two varieties. Samrat also proved its distinct superiority over Haramoti with respect to net return and net B: C ratio.

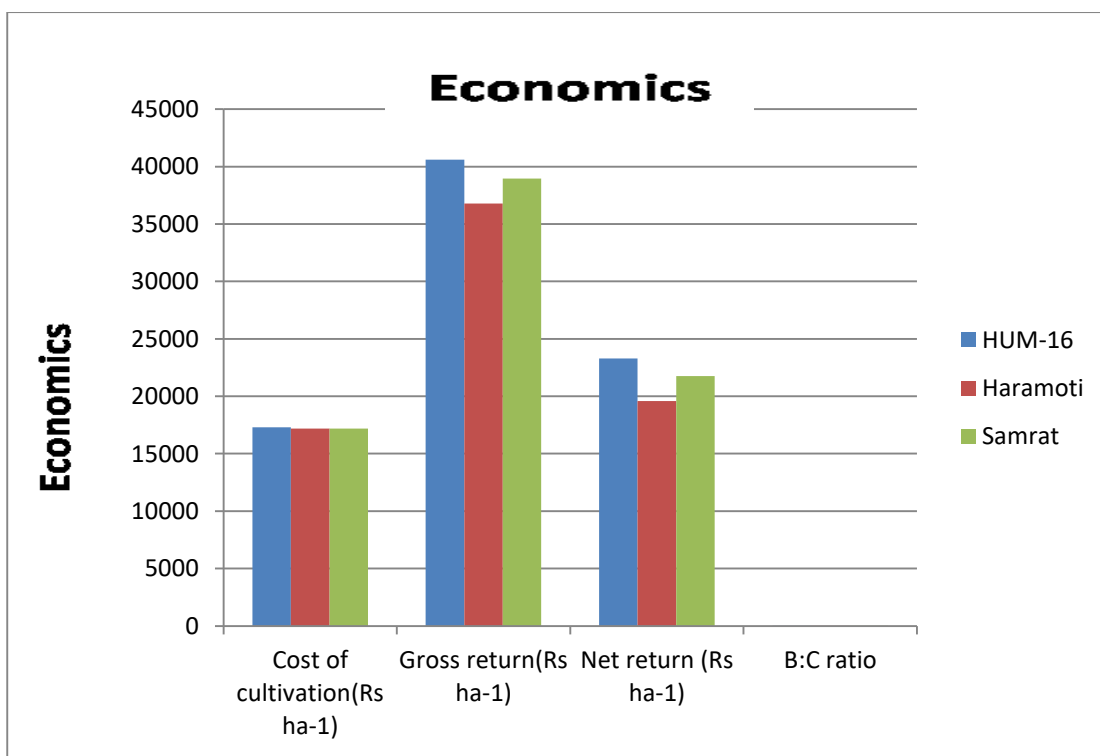
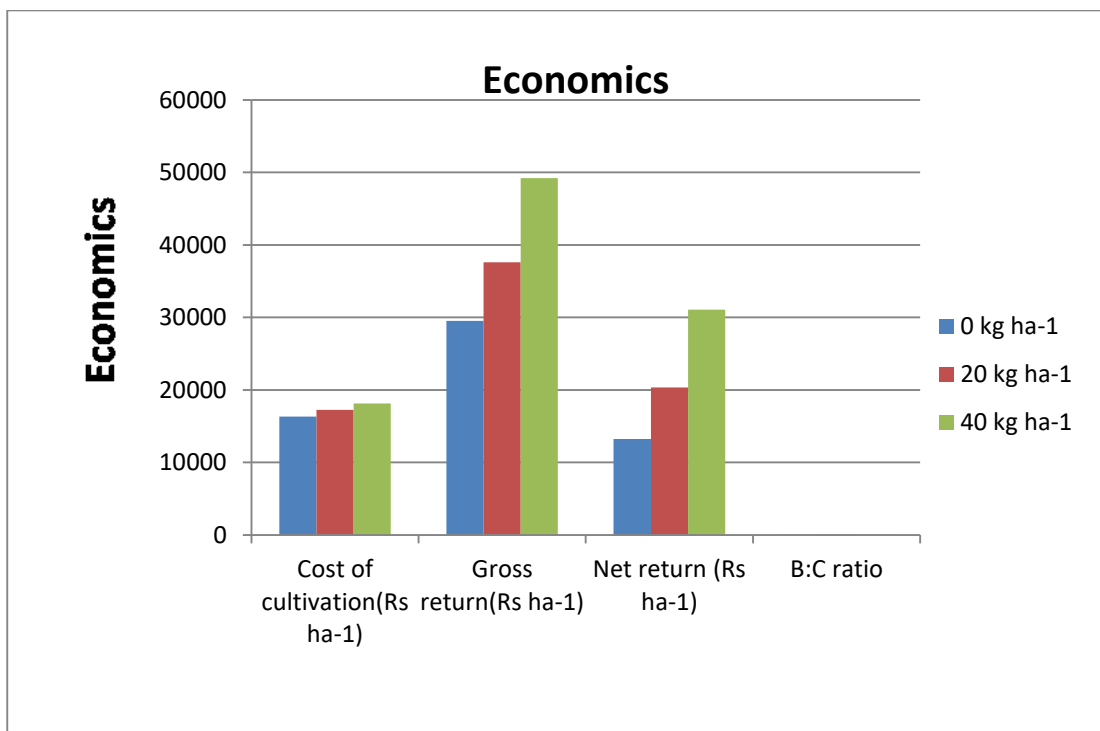
Table 4.8. Effect of phosphorus levels applied to Green gram varieties on growth and shading effect of custard apple in custard apple + Green gram agri-horti system.

| Treatments | Growth parameters of custard apple at harvest | | | | |
|--|---|------------|-----------------|------------|-----------|
| | Plant height (m) | Canopy (m) | Stem girth (cm) | Shading | |
| | | | | Length (m) | Width (m) |
| Phosphorus (Kg ha⁻¹) | | | | | |
| 0 | 3.15 | 2.83 | 8.88 | 2.86 | 2.43 |
| 20 | 3.17 | 2.81 | 8.87 | 2.85 | 2.44 |
| 40 | 3.14 | 2.82 | 8.85 | 2.87 | 2.39 |
| CD at 5% | Not Analyzed | | | | |
| Variety | | | | | |
| HUM-16 | 3.17 | 2.79 | 8.85 | 2.88 | 2.42 |
| Haramoti | 3.20 | 2.76 | 8.86 | 2.84 | 2.41 |
| Samrat | 3.13 | 2.80 | 8.84 | 2.86 | 2.40 |
| CD at 5% | Not Analyzed | | | | |

Table 4.9. Economics of green gram as influenced by phosphorus level and varieties

| Treatments | Cost of cultivation (₹ ha^{-1}) | Gross return (₹ ha^{-1}) | Net return (₹ ha^{-1}) | B:C ratio |
|--|--|---|---|------------------|
| Phosphorus (kg ha^{-1}) | | | | |
| 0 | 16307 | 29529 | 13222 | 1.81 |
| 20 | 17242 | 37598 | 20356 | 2.18 |
| 40 | 18137 | 49205 | 31068 | 2.71 |
| Variety | | | | |
| HUM-16 | 17300 | 40605 | 23305 | 2.34 |
| Haramoti | 17194 | 36768 | 19575 | 2.13 |
| Samrat | 17194 | 38959 | 21766 | 2.26 |

Fig. 4.8. Economics of green gram as influenced by phosphorus level and varieties.



4.7 Economics (Custard apple based agri-horti system)

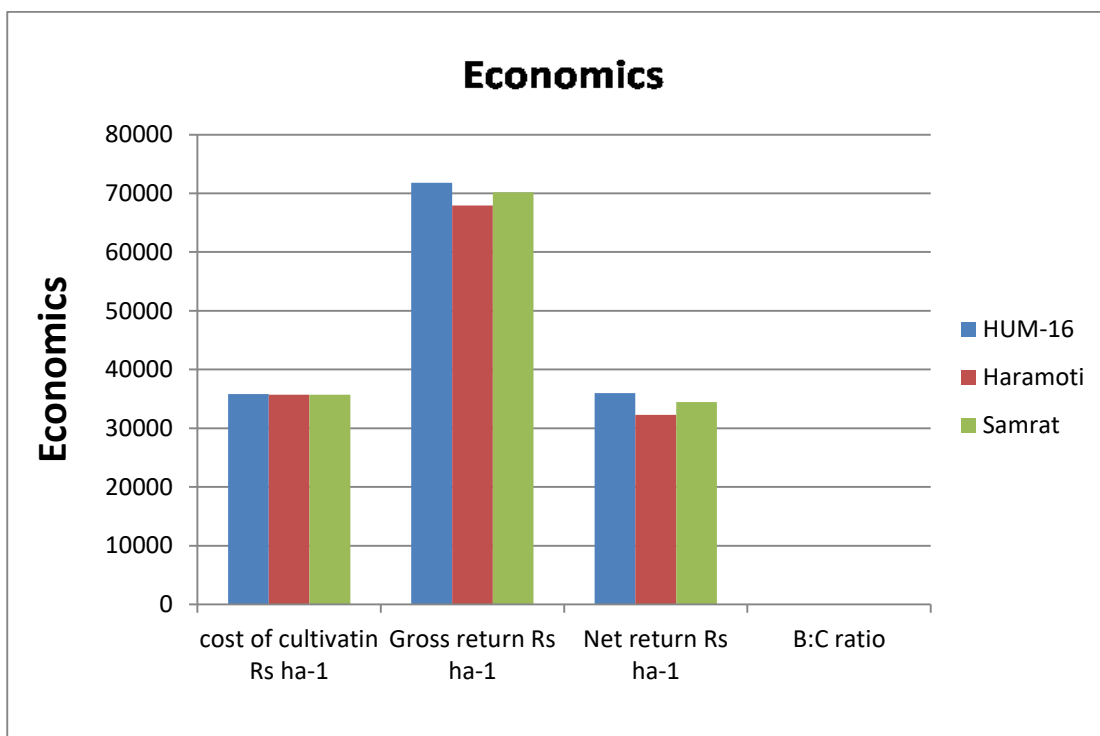
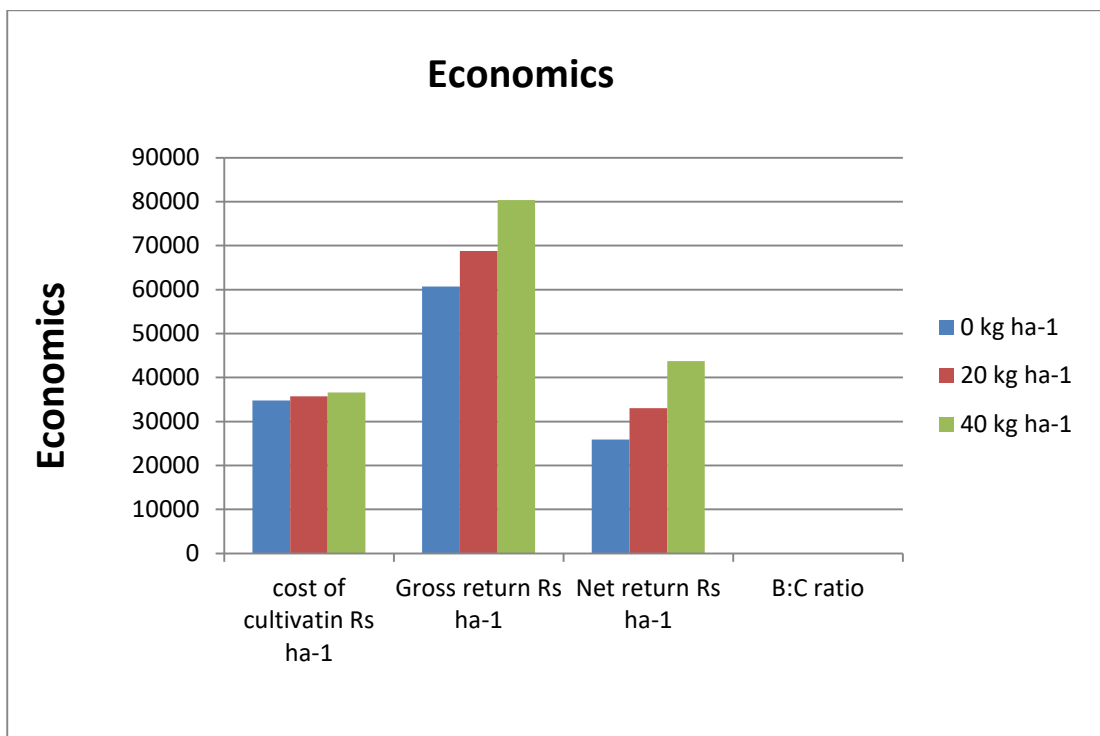
Economics of different treatments pertaining to custard apple based agri-horti system have been presented in Table 4.10. It is evident from the data that cost of cultivation enhanced with increasing rates of phosphorus application and maximum was recorded at 40 kg P₂O₅ ha⁻¹. Gross return, net return and B: C ratio also improved correspondingly with increasing levels of phosphorus application up to 40 kg P₂O₅ ha⁻¹.

As regards the green gram varieties, HUM-16 recorded maximum gross return, net return and B: C ratio than other two varieties. Samrat also registered its distinct superiority over Haramoti with respect to net return and net B: C ratio of custard apple + Green gram agri-horti system.

Table 4.10. Economics of Custard apple+ Green gram agri-horti system as influenced by phosphorus levels applied to Green gram varieties.

| Treatments | Cost of cultivation (₹ ha ⁻¹) | Gross return (₹ ha ⁻¹) | Net return (₹ ha ⁻¹) | B:C ratio |
|--|---|------------------------------------|----------------------------------|-----------|
| Phosphorus (kg ha⁻¹) | | | | |
| 0 | 34805 | 60714 | 25909 | 1.74 |
| 20 | 35740 | 68783 | 33043 | 1.92 |
| 40 | 36635 | 80390 | 43755 | 2.19 |
| Variety | | | | |
| HUM-16 | 35798 | 71790 | 35992 | 2.00 |
| Haramoti | 35692 | 67953 | 32262 | 1.90 |
| Samrat | 35692 | 70144 | 34453 | 1.96 |

Fig. 4.9. Economics of Custard apple+ Green gram agri-horti system as influenced by phosphorus levels applied to Green gram varieties.



DISCUSSION

Result of the study entitled “**Performance of Green gram varieties under various phosphorus levels in custard apple (*Annona squamosa*) based agri-horti system**” has been presented in the preceding chapter in detail. In this chapter an attempt has been made to evaluate the important observations recorded during the course of investigation in terms of cause and effect relationship. Economic yield, which is produced by a crop, is the cumulative function of growth and development parameters, size of the photosynthetic system and its efficiency, duration and translocation of photosynthates to economic sink. Yield per unit area is the cumulative function of yield per plant. Yield per plant is the function of number of pod plant⁻¹, number of grain pod⁻¹ and test weight. There are some growth parameters, which contribute indirectly to yield. These characters are affected by physiological and metabolic processes, which are modified by environmental conditions, fertilizer application and other cultural practices. The variation in yield has been analyzed in terms of differences in yield components. The results are discussed under following heads as follows.

5.1 Effect of weather

Results of field investigations are affected by weather conditions. Any discussion of the results would, therefore, be not appropriate without taking into consideration the weather relationship with crop to arrive at correct interpretation and conclusion.

The weather factors *viz.*, rainfall, temperature (minimum and

maximum), relative humidity, evaporation and sunshine hours recorded during crop duration of the present experimentation are given in Table 3.1 and depicted in Fig. 3.1. The variation in weather parameters has pronounced effect on growth and development of the crop. For achieving the yield potential every crop has its own cardinal point of air temperature, relative humidity, vapour pressure and sunshine duration. If the fluctuation becomes too wide from optimum, the plants suffer leading to poor growth, development and yield. This effect is more pronounced in crops which are grown in diverse climatic and edaphic conditions.

Every crop requires a set of definite environmental condition for its proper growth and development. Green gram requires fairly hot conditions during growth to produce maximum yield and generally grown as rainy season crop in northern India. Heavy rainfall particularly during the flowering stage is harmful and adversely affects the production. This crop requires hot and humid climate during growth and development phase. Temperature is known to have strong effect on vegetative and reproductive phases. The unusual temperature severely affects germination and plant stand. The meteorological data (Table 3.1) recorded during the crop season showed that the average temperature was within the optimum range for growth of green gram. The rainfall received during the study was low but well distributed and during the maturity phase occurrence of dry weather supported the yield parameters and so the yield of crop.

5.2 Effect of phosphorus.

Phosphorus is a structural component of cell constituents and metabolically active compounds that play an important role in plant

metabolism. Being constituent of sugar phosphates ADP and ATP, it involves in energy transportation. Phosphorus is also involves in basic reaction of photosynthesis. Moreover, as a constituent of chromosomes, it stimulates cell division and is necessary for meristematic growth. This suggests the role of phosphorus in rapid growth and development of plants.

In the present study grain yield ha^{-1} significantly increased with application of increasing doses of phosphorus up to $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. These findings are in close conformity of the results reported by Daramwal *et al.* (2001), Sharma *et al.* (2003), Singh *et al.* (2004), and Karwasra *et al.* (2006).

Growth characters *viz.*, plant height dry, matter accumulation and root nodule improved markedly with phosphorus application particularly at later stages of observation.

Increasing levels of phosphorus application up to $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ markedly improved functional leaves plant^{-1} particularly at later stages. Watson (1952) reported that higher leaf count might be due to production of leaves from maximum growing points. Leaf expansion is related to the extension of epidermal cells and this process might be impaired in phosphorus deficient plants for various reasons *viz.* low phosphorus content of epidermal cells (Treeby *et al.*, 1987) and decrease in root hydraulic conductivity (Radin, 1990). According to Lauer *et al.* (1989), photosynthetic efficiency per unit chlorophyll is much higher in phosphorus sufficient plants. This might have helped the greater production of photosynthates at higher rates of phosphorus application and consequently the better growth and dry matter accumulations.

The better growth parameters at higher rates of P application helped in realizing improved yield parameters.

Relatively higher grain yield obtained with application of 40 kg P₂O₅ ha⁻¹ was due to higher grain yield per plant and its attributes *viz.*, number of pod plant⁻¹ and number of grain pod⁻¹ (Table 4.4). Better plant growth measured in terms of higher plant height and dry matter accumulation (Table 4.1 to 4.2) might have led the plants to produce better yield attributes and there by the higher yield particularly at 40 kg P₂O₅ ha⁻¹. These results showed similarity with the findings of Athokpam *et al.* (2009), Yadav *et al.* (2007), Singh *et al.* (2005) and Bhat *et al.* (2005).

The higher grain yield and biological yield with the application of 40 kg P₂O₅ ha⁻¹ compared to 20 and 0 kg P₂O₅ ha⁻¹ indicated that the vegetative growth had positive association with grain yield. Similar results were also reported by Daramwal *et al.* (2001), Chaturvedi *et al.* (2004), Yakadri *et al.* (2004) and Bhat *et al.* (2005).

5.3 Effect of varieties

The yield of a crop is result of the successful completion of the growth and development activities in individual plant, which in turn, would depend upon genetic potential of the variety and the environmental condition. Real potential of the variety could be exploited to its maximum with several agronomic manipulations which alter the micro-environment of a crop. Therefore, to realize the maximum potential under a set of agro climatic conditions, it is essential that various factors of plant environment should be maintained at optimum level.

In the present study the results showed that HUM-16 though remained, produced significantly higher grain yield than Samrat and Haramoti. HUM-16 was the highest yielder (810 kg P₂O₅ ha⁻¹), and produced 5% and 13% higher grain yield than Samrat and Haramoti respectively. Higher yield in HUM-16 might be due to its inherited genetic makeup as evident by comparatively higher number of pod per plant and grain per pod. Differential response of different varieties was also observed by Mahto and Mahto (1997) and Prabhakar and Ganapathy (1996).

The total dry matter production in a variety indicates the potential for yield, but its mobilization towards the grain yield is an important factor for economic yield. It is the function of crop growth rate in total growth period and is related with grain yield. The capacity of a plant to produce dry matter depends upon the size and duration of the photosynthetic apparatus, i.e. leaf but it also depends upon the genetic potential of the varieties that have more capability to translocate the assimilates towards economic yield due to differential response of different varieties.

Varieties under the study showed significant differences in their harvest index. The three Green gram varieties did not differ with respect the harvest index. It may be due to the genetic potential of the varieties. Similar findings were also reported by Gupta (1982) and Malik (1980).

5.3 Economics

40 kg P₂O₅ gave maximum gross return (₹ 80390) net return (₹ 25909) and B: C ratio (4.19). Among the variety, HUM-16 was found most superior than other variety.

The data of economics of Green gram cultivation under phosphorus levels are given in table of economics of Green gram cultivation under various level of phosphorus doses are given in table 4.9.

5.4 Effect of agri-horti system

Agroforestry has become an important land use system in India and the competition for water and nutrients between trees and food crops is perhaps one of the important interactions in Agroforestry systems. The farmers grow fruit tree plantations because of good market demand, easy availability of quality planting material and compatibility with agricultural crops. Fruit plantations intercropped with agricultural crops have better growth than those without intercrops and the growth of trees are also variable under different intercrops.

The growth characters of fruit trees, *viz.*, tree height, canopy diameter, stem girth and shading area recorded during various growth stages of crop. The findings of the present study indicated that growth attributes of crop such as plant height, number of branch, number of leaf and dry matter accumulation showed marked variation under agri-horticultural system. This may be attributed due to their competitive interaction because of increased shading effect of custard apple trees. In this system, the tree and crop components interacted in a more competitive way which lead to the decreased yield of crop under custard apple based system. These results are in concurrence with those reported by Neumann and Pietrowicz (1989). The intensity of competition is greatest when site requirements are similar, and the growth and development proceed synchronously for both the components. Therefore, the opportunity for complementarities of resource use between the

components is restricted by the fact that all plants are competing for the same, usually finite resources (light, water, nutrients). These results are in conformity with those of Singh *et al.* (1989), Malik and Sharma (1990) and Costa *et al.* (2000). The number of leaf due to agri-horticultural system was higher with sole crop system. This may be due to the fact that under sole crop system lack of competition provided better opportunity due to absence of tree component.

The value of yield attributes showed marked variations were recorded under custard apple based agri-horticultural system. This might be due to shading effect of fruit tree on crop at the time of photosynthesis resulting poor production of photosynthates and poor production of yield attributes and competition for light, moisture and nutrients at the time of pod development and grain filling stage.

Yield is the cumulative result of growth characters *viz.*, plant height, number of branch per plant, number of leaf and dry matter accumulation per unit area and yield attributes *viz.*, number of pod plant⁻¹, pod length, number of grains pod⁻¹, and 1000 grain weight.

The grain and straw yield showed variation were recorded in custard apple based agri-horticultural system. It may be due to the competition between crop and fruit tree component for both above and below the ground for space, sunlight, nutrients, and moisture, respectively.



SUMMARY AND CONCLUSION

In this chapter an attempt has been made to summarize the results presented in the chapter experimental findings, and also to draw valid conclusions based on the significant findings of the present investigation entitled “**Performance of Green Gram Varieties under Various Phosphorus Level in Custard Apple (*Annona Squamosa*) Based Agri-Horti System**”. The investigation was conducted during rainy (*kharif*) season of 2012 at the Agricultural Research Farm of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur.

The soil of the experimental field was sandy loam in texture and medium acidic soil reaction (pH 5.5). It was moderately fertile, being low in organic carbon (0.27%), low in available nitrogen (173.44 kg ha⁻¹), and medium in available phosphorus (13.82 kg ha⁻¹) and medium in available potassium (141.32 kg ha⁻¹). The experiment was conducted in six years old custard apple orchard planted at 5 x 5 meter spacing. The experiment was laid out in Factorial Randomized Block Design with agri-horti system (fruit based agro forestry system) *i.e.* custard apple based agri-horti system. Treatments were replicated thrice. The experiment comprises 9 treatment combination. The requisite quantity of seed at the rate of 20 kg for green gram was sown with help of *kudal* directly in rows 30 x 10 cm apart.

Crop response to the treatments were measured in term of various quantitative indices, *viz.*, plant height, number of nodules plant⁻¹, number of trifoliolate leaves plant⁻¹, number of branches plant⁻¹, dry matter accumulation plant⁻¹, yield components *viz.*, number of pods plant⁻¹,

grains pod⁻¹, 1000-grain weight, grain and straw yields, and uptake of the nutrient (N, P and K). The data collected during the course of experimentation were subjected to statistical analysis to draw valid conclusion. Finally the different treatments were analyzed for their gross return, net return and benefit: cost ratio. The important findings and broad conclusions emerging from the investigation are summarized as under.

1. Plant height increased with the advancement of crop age and reached to its maximum at maturity. Variations in plant height were observed with phosphorus levels at all the crop growth stages. The taller plant height was obtained with the 40 kg P₂O₅ ha⁻¹, and the smallest with 0 kg P₂O₅ ha⁻¹. Green gram variety HUM-16 recorded taller than other two varieties Samrat and Haramoti.
2. Shoot dry matter accumulation plant⁻¹ increased up to 40 days after sowing. The maximum and the minimum dry matter accumulation plant⁻¹ were observed with 40 kg P₂O₅ ha⁻¹ and 0 kg P₂O₅ ha⁻¹, respectively throughout the crop growth period. The HUM-16 observed higher shoot matter accumulation plant⁻¹ than other two varieties Haramoti and Samrat.
3. The maximum root nodule was recorded at 40 kg P₂O₅ ha⁻¹ at 40 days after sowing. The green gram varieties HUM-16 recorded significantly higher root nodule than other two varieties.
4. The yield attributes viz., number of pods plant⁻¹, pod length, number of grain pod⁻¹, test weight (g) were recorded higher in 40 kg P₂O₅ ha⁻¹. Among the green gram varieties HUM-16 produce maximum number of pods plant⁻¹, pod length, number of grain pod⁻¹, than other two varieties.
5. The maximum grain and straw yields was observed in 40 kg P₂O₅ ha⁻¹. As regards the green gram varieties, HUM-16 produced

higher grain and straw yields than other two varieties Samrat and Haramoti.

6. The nutrient content (N, P and k) in grain and straw were increased with increasing levels of P application up to 40 kg ha⁻¹. Among the green gram varieties, HUM-16 recorded maximum N, P and k content in grain and straw than other two varieties except P content in straw.
7. The maximum gross return, net return and benefit: Cost ratios were also obtained in 40 kg P₂O₅ ha⁻¹. The maximum and the minimum gross return, net return and benefit: cost ratio were HUM-16 than other two varieties Samrat and Haramoti.

Conclusion

On the basis of experimental findings, the following conclusions may be drawn:

1. Application of Phosphorus at 40 kg P₂O₅ ha⁻¹, to Green gram was found suitable to realize the high yield and profit in custard apple + Green gram agri-horti system.
2. The Green gram variety HUM-16 was found highly productive and remunerative as compared to Samrat and Haramoti under agro climatic conditions of Vindhyan region of India.

The present study was conducted for one year; therefore, more trials need to be conducted to ascertain these findings.



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APPENDICES

Appendix I. Common cost of cultivation in green gram (₹ ha⁻¹)

| S. No. | Operations | Input | Rate (₹/unit) | Cost (₹) |
|--------------|---|---------------------------------|----------------------|--------------|
| 1. | Land preparation | | | |
| | (i) One deep ploughing by soil turning plough | One tractor (35 HP) for 2.5 hrs | 310 ha ⁻¹ | 775 |
| | (ii) Harrowing and planking | One tractor (35 HP) for 4 hrs | 310 ha ⁻¹ | 1240 |
| 2. | Layout | 5 Man day | 125/man day | 625 |
| 3. | Seed sowing | 20 Man day | 125/man day | 2500 |
| 4. | Weeding & Hoeing | 20 Man day | 125/man day | 2500 |
| 5. | Harvesting | 20 Man day | 125/man day | 2500 |
| 6. | Threshing | 20 Man day | 125/man day | 2500 |
| Total | | | | 12640 |

Appendix II. Cost of Fertilizer and seed.

| S.No. | Treatments | Input | Rate (₹) | Cost (₹) | Total cost |
|-------|---|---|--|--------------------|------------|
| 1. | Phosphorus (kg ha⁻¹) 0 | Fertilizers (kg ha⁻¹) Urea - 43.47 DAP - Application of fertilizer (2 Man days) | 7.0 kg ⁻¹ 125/Man day | 304 250 | 554 |
| 2. | 20 | Urea - 26.65 DAP - 43.47 Application of fertilizer (2 Man days) | 7.0 kg ⁻¹ 23kg ⁻¹ 125/Man day | 186 1000 250 | 1436 |
| 3. | 40 | Urea – 4.5 DAP – 86.95 Application of fertilizer (2 Man days) | 7.0 kg ⁻¹ 23 kg ⁻¹ 125/Man day | 31 2000 250 | 2281 |
| 4. | Varieties HUM-16 | Seed rate (kg ha⁻¹) 20 | 105 kg ⁻¹ | 2100 | 2100 |
| 5. | Haramoti | 20 | 110 kg ⁻¹ | 2200 | 2200 |
| 6. | Samrat | 20 | 105 kg ⁻¹ | 2100 | 2100 |

Appendix III.

| Treatment | General cost of cultivation (ha⁻¹) | Cost of Seed & fertilizer | Working Capital | Interest on working capital @12%/annum | Land Revenue | Total |
|------------------|---|--------------------------------------|------------------------|---|---------------------|--------------|
| P 0 + HUM-16 | 12640 | 2754 | 15394 | 923.64 | 60 | 16372 |
| P 20 + HUM-16 | 12640 | 3636 | 16276 | 976.56 | 60 | 17313 |
| P 40 + HUM-16 | 12640 | 4481 | 17121 | 1027.26 | 60 | 18202 |
| P 0 + Haramoti | 12640 | 2654 | 15294 | 917.64 | 60 | 16272 |
| P 20 + Haramoti | 12640 | 3536 | 16176 | 970.56 | 60 | 17207 |
| P 40 + Haramoti | 12640 | 4381 | 17021 | 1021.26 | 60 | 18102 |
| P 0 + Samrat | 12640 | 2654 | 15294 | 917.64 | 60 | 16272 |
| P 20 + Samrat | 12640 | 3536 | 16176 | 970.56 | 60 | 17207 |
| P 40 + Samrat | 12640 | 4381 | 17021 | 1021.26 | 60 | 18102 |

Appendix IV

| S. No. | Operations | Input | Rate (₹/unit) | Cost (₹) |
|---|---|---|--------------------------|-----------------|
| 1. | Manure and Fertilizer 200 :100 :50 g NPK/plant | Urea - 140 kg/ha | 7.0 kg ⁻¹ | 980 |
| | | DAP - 86.8 kg/ha | 23kg ⁻¹ | 1966 |
| | | MOP - 33.5 kg/ha | 17kg ⁻¹ | 570 |
| | | FYM - 6 tones/ha | 1500/tones | 9000 |
| | | Application of manure & fertilizer (10 Man day) | 125/Man days | 1250 |
| 2. | Weeding | 10 Man day | 125/Man days | 1250 |
| 3. | Harvesting fruit | 12 Man day | 125/Man days | 1500 |
| Working capital | | | | 16516 |
| Interest on working capital @12%/annum | | | | 1982 |
| Total | | | | 18498 |

Appendix V: Yield attributes, yield and economic of custard apple tree.

| Fruit tree | No. of average fruits tree⁻¹ | Average weight of fruit (g.) | Number of fruit tree ha⁻¹ | Fruit yield (kg ha⁻¹) | Rate of fruit (₹/kg) | Gross income from fruit tree |
|----------------------|--|-------------------------------------|---|---|-----------------------------|-------------------------------------|
| Custard apple | 38.5 | 81 | 400 | 1247 | 25 | 31185 |

