NUTRITIONAL REQUIREMENT OF VEGETABLE COWPEA (*Vigna unguiculata* L.) IN NORTHERN DRYZONE OF KARNATAKA

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CERTIFICATE

This is to certify that the thesis entitled "**Nutritional requirement of vegetable cowpea (*Vigna unguiculata* L.) in northern dry zone of Karnataka**" submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE** to the University of Horticultural Sciences, Bagalkot, is a record of research work carried out by **KAVIRAJA. H.** ID No. **UHS15PGM633** under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associateship, fellowship or other similar titles.

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Affectionately Dedicated to

My Beloved Parents

Hanumanthappa. k and Pusphalatha
and

my adorable Chairperson

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1. INTRODUCTION

Cowpea (*Vigna unguiculata* L.) is an important legume vegetable belongs to family Fabaceae (Ng and Marechal, 1985). The genus *Vigna* consists of 169 species out of which 120 are endemic to Africa, 28 to Asia, 14 to America and 7 to Australia respectively. Cowpea has a chromosome number 2n=22. It has many synonyms like black eye pea, southern pea, field pea, china bean and crowder pea (Ng and Marechal, 1985). According to Ng and Marechal (1985) the primary centre of origin is Southern Africa and its cultivation spreads to East and West Africa and Asia.

It is one of the most important legume vegetable crop grown extensively for its long tender pods as well as seeds throughout India. There are four cultivated sub species are recognized *viz.*, *Vigna unguiculata* sub sp. *Cylindrical* (Catjang), *Vigna unguiculata* sub sp. *dekindtiana*, *Vigna unguiculata* sub sp. *sesquipedalis* (Yardlong bean) and *Vigna unguiculata* sub sp. *unguiculata* (Black-eyed pea) (Ng and Marechal, 1985).

Cowpea is one of the most important food legume crops in the semi-arid tropics covering Asia, Africa, Southern Europe and Central America and it is native of Central Africa (Singh, 2003). It is a warm weather crop well adapted to many areas of the humid tropics and Sub tropical climate with a drought tolerant nature. But it is intolerant to frost and water logged condition (Singh, 2003). It fixes 30-60 kg N per ha (Danielnyoki and Patrick, 2014). In addition, it is a compatible intercrop in maize, millets, papaya, banana and sorghum (IITA, 2003).

Cowpea plays an important role in nutritional aspects also, an edible green pods of 100 g contains 84.6 g moisture, 4.3 g protein, 0.2 g fat, 0.9 g minerals, 2.0 g fiber, 8.0 g carbohydrates. (Sebetha *et al.*, 2010) and its seed is a nutritious component in the human diet, as well as a nutritious feed for livestock (Fatokun, 2002). In India, it is grown highest in the states like Rajasthan with an area of 12.31 lakh per ha, production of 5.73 lakh per ha and productivity of 976 kg per ha and in Gujrat with an area of 2.15 lakh per ha, production of 2.10 lakh per ha and productivity of 465 kg per ha (FAO, 2015).

Among the pulses, cowpea stands fourth in Karnataka in terms of area and production. In Karnataka cowpea is grown in an area of 0.88 lakh per ha with a production of 0.42 lakh per ha. The productivity as low as 505 kg per ha (FAO, 2015). In Karnataka Arka Garima, Arka Suman and Arka Mangala vegetable cowpea varieties are extensively grown in the districts of Dharwad, Gadag and Mysore with an optimal yield of 15-20 quintal per ha. However its spread is not much in Bagalkot district as compared to other pulse crop.

The production and productivity of vegetable cowpea is low, due to lack of proper nutrient management practices, among which integrated nutrient management is one of the major factor which helps in mitigating the scarcity of nutrients and improves the yield (Anuja and Vijayalakshmi, 2014). This accounts for considerable variation in fruit quality and yield parameters. Protein deficiency is prevalent in India because of the fact that people are predominantly vegetarians (FAO, 2015).

To overcome the protein malnutrition of Indian population, there is a need for versatile crop with high protein content which is suitable for Indian climate and different cropping systems (Cisse *et al.*, 1997). Even though vegetable cowpea is similar to its grain counterpart, its nutrient requirement may differ because of its highly nutritious in nature as well because of its early harvesting (Lincoln and Edvardo, 2006).

The proper nutrient management is one of the major factor for increasing the percentage of nutrients availability in the soil which influences better growth and development of the crop (Meera *et al.*, 2010). Variation in nutrient availability to the crop results in higher or lower yield, improved or reduced crop development and also fluctuates physiology of the crop. Decrease in Nitrogen content causes decrease in quality and seed yield. By using inorganic fertilizers along with organic manures increases the availability of N, P, K Ca and Mg content in the soil (Sailajakumari and Ushakumari, 2002).

Application of phosphorus to improve yield of cowpea by enhancing number of pods per plant, number of seeds per pod and mean seed weight (Ayodele and Oso, 2014). Application of potassium to legumes enhancing growth, yield, nodulation and nitrogen fixation (Giller, 2000).

With this background, the present investigation on "Nutritional studies on vegetable cowpea (*Vigna unguiculata* L.) in northern dry zone of Karnataka" was undertaken with the following objectives.

1. To find out the optimum dose of N, P, K in vegetable cowpea in northern dry zone of Karnataka.

2. To assess the nutrition quality (protein and nutrient content) varieties of vegetable cowpea as influenced by the varieties and nutrition management practices.

3. To study the organoleptic test of vegetable cowpea varieties.

4. To identify suitable vegetable cowpea variety in northern dry zone of Karnataka.

2. REVIEW OF LITERATURE

The literature on response of different varieties and effect of different levels of nutrition management practices on vegetable cowpea (*Vigna unguiculata* L.) yield and quality have been reviewed in this chapter.

2.1 Morphology and biology of vegetable cowpea

2.1.1 Growth habit

Cowpea is a warm-season crop well adapted to many areas of the humid tropics and Sub tropical climate with a drought tolerant in nature. But it is intolerant to frost and water logged condition (Singh, 2003). It is an annual herb reaching heights of up to 80 cm with a strong taproot with many spreading lateral roots in the surface soil and many globular nodules (Summerfield and Robertz, 1985). Growth forms vary and many are erect, trailing, climbing and bushy. The stems are striate, smooth or slightly hairy and sometimes tinged with purple (Summerfield and Robertz, 1985).

The seed are variable in shape like kidney, ovoid, crowder, globose and rhomboid. Seeds relatively large (0.2-1.2 cm long) and weigh 5-30 g per 100 seeds (Chevalier, 1944).

The flowers are conspicuous, self-pollinating, borne on short pedicels and the corollas may be white, dirty yellow, pink, pale blue or purple in colour and arranged in racemose or intermediate inflorescence at the distal ends of 5-60 cm long peduncles (Kay, 1979).

The pod is green at early stage and when maturing it becomes usually yellow, light brown, pink or purple. The pod length may vary from less than 11 cm to more than 100 cm (Rachie and Rawal, 1976).

Leaves are alternate and trifoliate. First pair of leaves is simple and opposite. Leaves exhibit considerable variation in size (6-16 x 4-11 cm) and shape (linear, lanceolate to ovate) and they are usually dark green and strong taproot with many spreading lateral roots in the surface soil and many globular nodules (Singh *et al.*, 1997).

The root nodules are smooth and spherical, about 5 mm in diameter (Singh *et al.*, 1997).

Ahenkora *et al.* (1998) reported that seeds are the largest contributor to the overall protein intake of several rural and urban families. According to Diouf, 2011 the crude protein content of the seeds and leaves of cowpea ranges between 23 and 32 % respectively.

2.1.2 Organoleptic evaluation of different cowpea varieties

Odedeji and Okyeleke (2011) revealed that dehulled cowpea showed higher crude protein (23.12 %), carbohydrates (62.86 %), fat (1.6 %), ash (1.03 %), crude fibre (0.48 %) and moister (10.89 %) as compared to whole cowpea flour (22.85 and 61.67 %) respectively.

Sanizakariya and Yusufmurtala (2014) reported that cowpea grains treated with Permethrin (0.60 %) recorded higher score on taste (3.40 ± 0.23), odour (3.60±0.12) and appearance (3.73 ± 0.17) of the cooked grain as compare to seeds treated with Neem-Afri bio-pesticidfe (3.11 ± 0.17).

Ogundele *et al.* (2015) reported that nutritional composition of soyabean showed higher moisture content of (48.36 to 54.9 %), protein content (4.44 to 11.60 %), ash (1.17 to 1.88 %), crude fat (1.91 to 5.28 %), crude fiber (0.92 to 1.19 %) and carbohydrate (31.69 to 36.63 %) as compare to cowpea fresh seeds.

2.2 Influence of N, P, K fertilizers on growth and yield of cowpea

Malagi *et al.* (2005) revealed that harvest index differed significantly due to different levels of fertilizers with the lowest harvest index (1.25 %) noticed with highest dose of fertilizer (NPK at 60 kg per ha).

Kishanswaroop (2006) revealed that maximum yield of green pods (124.35 kg, 128.3 kg and 138.39 kg) per ha was obtained with the application of 80 kg, P, 60 kg K, 20 kg N/ha + *Rhizobium* inoculation. The length of root (16.71 cm, 16.63 cm and 17.61 cm) and uptake of phosphorus (5.38 kg), uptake of N (23.57 kg) and potash (14.40 kg) per ha in soil was recorded maximum with the application of 120 kg P, 120 kg K and 20 kg N + Rhizobium inoculation.

Kabir *et al.* (2007) opined that application of 0 + 60 + 40 kg NPK per ha showed maximum number of nodules (9.23 plant^{-1}), number of effective nodules (6.67 plant^{-1}), fresh weight of nodules (5.43 g/plant), dry weight of nodules (1.78 g/plant), and moisture content of nodules (35.2 g) respectively.

Abayomi *et al.* (2008) opined that application of 150 kg NPK per ha significantly increase the plant height (20.21 cm), number of leaves per plant (24.20), total number of flowers (25.40) and total dry matter (24.79 g) respectively.

Magani and Kuchinda (2009) reported that grain yields with 35.5 kg P ha^{-1} did not differ significantly from that of 75 kg P ha^{-1} giving a yield of 1.85 tons ha^{-1} and 1.91 ton ha $^{-1}$ respectively.

Hasan *et al.* (2010) revealed that application of N at the rate of 25 kg ha^{-1} gave maxmium biomass yield of 547 kg ha^{-1} and increasing the application to 30 kg ha^{-1} did not differ significantly with a yield of 549 kg ha^{-1}.

Ayodele and Oso (2014) (a) found that application of P at 20 kg ha^{-1} in the presence of basal 20 kg N and 30 kg K_2 O ha^{-1} is optimum P rate for cowpea production with a grain yield of (1.26 q/ha) compared to control (0.78 q/ha).

Meera *et al.* (2010) opined that application poultry manure in two split doses along with inorganic fertilizers at 20:30:10 kg N, P and K per hectare shows significant increase in plant height (106.8 cm), dry matter production (9.678 kg/ha), number of branches per plant (16.50) and seed yield (418.9 kg/ha) as compare to different organic and inorganic treatments.

Azarpour *et al.* (2011) opined that 45 kg P ha^{--1} gave the highest grain yield of (1.57 tons ha^{-1}) as compare to control (0.88 tons ha^{-1}).

Boampong *et al.* (2016) concluded that cowpea cultivers like Asontem had showed significantly higher plant population at harvest (97.5 %) than Asetenapa (90.5 %) and flowering was earlier in Asetenapa (42.3 days) compare to Asontem (46.3 days) with different levels of N, P and K fertilizers.

Joshi *et al.* (2016) revealed that Recommended Dose of Fertilizer 20-40-0 NPK kg ha-^{1} recorded significantly higher chlorophyll content of leaves (2.16 mg) at

60 DAS, crude protein content (23.03 %) in green seeds higher over rest of the other inorganic treatments.

2.3 Effect of nitrogen (N) fertilization on growth, yield and quality of cowpea

Nitrogen is an integral component of many compounds, including chlorophyll and enzymes, essential for plant growth processes. It is an essential component of amino acids and related proteins. Nitrogen is essential for carbohydrate use within plants and stimulates root growth and development as well as the uptake of other nutrients. This element encourages above ground vegetative growth and gives a deep green colour to the leaves (Brady, 1990).

It has been observed that application of nitrogen fertilizer significantly and positively influenced the plant height, number of primary and secondary branches per plant of many legumes (Subhan, 1991). Nitrogen is also important for plant growth due to its influence on leaf area index and consequently light interception (Grindlay, 1997).

Nitrogen availability to the legumes can be increased either with manual inoculation or with application of commercial nitrogen fertilizer. The nitrogen not only improves the yield and yield components of legumes (Baboo and Mishra, 2004).

Application of Nitrogen at 40 kg to cowpea plants significantly increased in plant growth (115.6 cm), dry matter content (12 g), yield (15 q/ha) and its quality as well as the nutritional value of seeds (Amujoyegbe and Alofe, 2003).

According to Varela and Seif, (2004) applying nitrates to soil will increase leaf area which invariably increases sunlight interception for a higher rate of photosynthesis. Increasing the leaf area index will lead to increased light interception and subsequently increase dry matter production. Therefore, selection of optimum nitrogen rates is essential for better performance of the cowpea.

Nitrogen deficiency generally results in stunted growth and chlorotic leaves caused by poor assimilate formation that leads to premature flowering and shortening of the growth cycle. The presence of N in excess promotes development of the above ground organs with abundant dark green (high chlorophyll) tissues of soft consistency and relatively poor root growth. This increases the risk of lodging and reduces the plants resistance to harsh climatic conditions and to foliar diseases (Lincoln and Edvardo, 2006).

Anilkumarsingh *et al.* (2007) revealed that application of 30 kg N and 60 kg P_2O_5 per ha and Rhizobium inoculation significantly increased the plant height (52.34 cm and 52.58 cm), number of nodules per plant (7.92 and 3.99), weight of nodules per plant (0.55 g and 0.62 g), number of pods per plant (59.39 and 57.55), weight of the pod (1.87 g and 1.89 g), length of the pod (30.44 cm and 32.80 cm) and seed yield (21.15 kg, 21.05 kg and 21.52 kg) at 30, 60 and 90 days as compare to application of 60 kg N and 90 kg P_2O_5 per ha and Rhizobium inoculation.

Patel and Singh (2009) revealed that application of 20 kg N + 40 kg P_2O_5 per ha along with *Rhizobium* seed inoculation gave significantly higher plant height (48.18 cm and 47.30 cm), maximum nodulation per plant (9.60 and 9.07), number of cluster per plant (34.83 and 33.33), number of pods per plant (34.83 and 33.33) and 50 per cent flowering (51.11 and 48.58 %) as compare to other treatments.

The greatest seed yield (238 kg), 100 seed weight (20.3 g), number of pods per plant (24) and number of leaves per plant (170) was showed highest by the use of 30 kg N per ha (Gohari *et al.*, 2010).

Nadiagad *et al.* (2013) opined that cobalt along with 100 and 75 per cent nitrogen fertilizer application to the plant showed that significantly increased nitrogenous activity (26.9 and 25.2 %), increased nodules numbers (88.5 and 83), and weights of nodules (1.98 g and 1.8 g), highest plant height (46.9 cm and 42.3 cm), leaf area (1828 cm^2 and 1699 cm^2) and root length (19.3 cm and 17.7 cm). The addition of cobalt to the soil saves 25% nitrogen fertilizer consumption.

Nkaa *et al.* (2014) reported that 50 kg phosphorus application showed significant increase on Plant height (19.5 cm), leaf area (119.7 cm), number of leaves per plant (45) and number of branches (15.3) in all the weeks of measurement and also had a significant effect on seed yield (77 kg/ha), pod yield (203 kg/ha), number of nodules (6.8) and total above ground dry matter (143 kg/ha) in all varieties used.

Hasan *et al.* (2010) revealed that application of 30 kg N per ha shows significant effect on plant height (91.15 cm), increased the green forage (42.88 Mt per ha), dry and organic matter (60.9 and 5.49 Mt per ha) and crude protein (1.23 %) as compare to different levels of fertilizer treatments.

Shivarn and Yadava (2015) reported that application of nitrogen and phosphorus at 40 and 80 kg per ha resulted in significantly higher plant height (21.30 cm), dry matter accumulation (43.63g/ha), number of branches per plant (43), chlorophyll content (1.9 mg), total effective fresh and dry weight of nodules per plant (1.95 g and 1.6 g), seed yield (1482 kg/ha) and stover yield (1220 kg/ha) as compare to nitrogen and phosphorus @ 30 and 50 kg per ha.

Verma *et al.* (2015) reported that application of nitrogen at 40 kg per ha and phosphorus 80 kg per ha showed significantly increase in higher N (63.6 kg/ha), P (11.57 kg/ha) and K (82.1 kg/ha) uptake.

Daramy *et al.* (2017) revealed that application of nitrogen 40 kg N per ha and phosphorus 45 kg P_2O_5 per ha fertilizers showed a significant effect on growth (21.35 cm), number of leaves (36.93) and pod yield (1930 kg/ha) of cowpea cultivar Asontem.

2.3.1 Effect of Nitrogen (N) fertilization on nodulation and N fixation in cowpea

Good establishment and vigorous growth of legumes ensure good development of nodules and thus results in high N fixation. However, high soil N, particularly mineral N, during initial growth retards nodule formation (Tewari, 1965).

Nitrogen shortage early in the life of the plant will adversely affect nodule weight and total nitrogenase activity (Huxley and Summerfield, 1973). Nitrogen application at either vegetative, flowering or pod filing stage can potentially increase the proportion of plant N derived from N fixation (Yinbo *et al.*, 1997).

Although leguminous crops like cowpea, can fix atmospheric nitrogen with rhizobia, they require mineral nitrogen as starter dose when grown on deficient soils such as those of tropical Africa in other to establish the plants during early growth period when nodules have not stated functioning (Osborne and Riedell, 2006).

Modhej *et al.* (2008) reported that mineral N in the soil inhibited symbiotic nitrogen fixation but it was relative to start of nodulation and N_2 fixation at early vegetative growth at low concentration.

Amba and Garbal (2013) reported that application of nitrogen at 20 kg N per ha significantly reduced number of nodules (15.04) at 2 week after sowing and application of phosphorus at 26.4 kg P per ha significantly produced higher number of nodules (25.93) as compare to different levels of fertilizers.

2.4 Effect of phosphorus (P) fertilization on the growth and yield of cowpea

It plays a vital role in cell division, flowering, fruiting and nodulation and application of phosphorus is recommended for cowpea production in phosphorus deficient soils (Rajput, 1994).

Phosphorus application decreases zinc concentration in the cowpea grain which can affect the nutritional quality (Buerkert *et al.*, 1998). Egle *et al.* (1999) reported that increasing phosphorus as a fertilizer promotes reproductive yields and inflorescence production.

Bennettlarety and Ofori (2000) indicated that application of phosphorus fertilizers can increase triple cowpea stover production.

Phosphorus is a major mineral nutrient required by plants, but is one of the most immobile, inaccessible and unavailable nutrients present in soils (Narang *et al.*, 2000).

Ma *et al.* (2001) reported that relative growth rate and crop growth rate were significantly different among phosphorus rates of 0, 35 and 70 kg per ha.

Deficiency in phosphorus results in stunted shoot and root growth due to reduced cell division and reduced cell enlargement. Phosphorus deficiency stimulated uptake of excess cations over anions by plants and hence enhanced proton release that could increase acidification which may facilitate P acquisition (Tang *et al.*, 2001). Phosphorus plays key roles in many plant processes such as energy metabolism, nitrogen fixation, synthesis of nucleic acids and membranes, photosynthesis, respiration and enzyme regulation (Vance, 2001).

Legumes are phosphorus loving plants. It is required for the physiological processes of protein synthesis and energy transfer in plants (Oti *et al.*, 2004).

Singh *et al.* (2004) revealed that phosphorus is an element that is not required in large quantities, but it is critical to cowpea yield because of its multiple effects on nutrition as all growing plants require P for proper growth and development.

Anuja *et al.* (2006) opined that application of 70 kg phosphorus and 70 kg potassium per ha significantly increased the pod yield per plot (4.80 kg and 3.58 kg), average pod length (18.29 cm and 14.48 cm), pod width (1.03 cm and 0.96 cm), crude protein content (25.44 % and 25.13 %) and total dry matter content (21.65 g/plant and 19.41 g/plant).

The dry matter production is increased by phosphorus application and its distribution is also affected for instance, phosphorus deficient plants usually have more dry matter partitioned to roots than shoots, probably as a result of higher export rates of photosynthates to roots (Fageria *et al.*, 2006).

Das *et al.* (2008) reported that phosphorus is an important essential nutrient for seed production and for formation of healthy and sound root system.

Magani and Kuchinda (2009) opined that increasing levels of phosphorus up to 60 kg per ha^{-1} significantly improved in plant height (32.33 cm). Phosphorus 30 kg per ha application increase the branching in cowpea in the range of 2.2 - 15.1 branches per plant, number of leaves per plant in the range of 22.9 to 297.8 as compare to control. They also reported that application of 37.5 kg P was the most economical level for maximum grain yield (2141.7 kg/ha) and crude protein content (24.96 %) and plant height was increased by 63 per cent and 35.9 per cent at 8 weeks after sowing as compared to control (75 kg).

Mawo *et al.* (2016) reported that Phosphorus application 0, 20 and 40 P kg^{-1} significantly enhanced shoot (1.16 g, 1.59 g and 1.39 g) and root dry weight (0.33 g, 0.68 g and 0.80 g), total biomass (148 kg, 227 kg and 219 kg), number of nodules (15, 13 and 14), nodules dry weight (0.01 g, 0.08 g and 0.027 g), N (3.99, 5.16 and 4.29 kg per ha) and P (0.13, 0.27 and 0.25 kg per ha) uptake in the genotype (IT92KD-405.2) compare to other genotypes.

Jadhav *et al.* (2011) reported that plant height (50.77 cm), seed yield (16.10 kg), maximum nodulation (6.52), protein content (19.18 percent) and number of branches per plant (4.51) were found significantly increase with 20 kg N + 40 kg P_2O_5 per ha along with *Rhizobium* seed inoculation. Earliness in flowering was observed with *Rhizobium* inoculation with 10 kg per ha N and higher level of phosphorus 40 kg per ha.

Muralikrishna and Solanki (2011) reported that plant height (45.20 cm), number of leaves per plant (20.76), vegetable pod yield (1585 kg per ha) and B:C ratio (1: 1.9) were found maximum with application of 30 kg N ha^{-1} + azetobactor followed by 20 kg N ha^{-1} + azetobactor.

Singh *et al.* (2011) revealed that application of 60 kg P ha^{-1} showed significant response to pods per plant (54 and 49), grain (1472 kg and 1235 kg) and stover yield (2072 kg and 2158 kg) and 100 seed weight (20.30 g and 20.98 g) was highest in both the varieties (KVX303096G and TN5-78) with the application of 60 kg P ha^{-1}.

Hussein *et al.* (2014) reported that addition of K incorporation with P increased in plant height (60.16 cm), no of leaves (60.16), no of pods per plant (22.24), fresh weight of stem (192 g) and leaves (196) showed positive effects of P and K fertilizers were more under normal irrigation than stress treatments.

Ndor *et al.* (2012) opined that application of 40 kg P per ha showed significantly higher number of nodulation count per plant (34.95 and 32.24), number of pod per plant (20.64 and 20.24), seed weight per plant (39.56 g and 37.64 g), pods weight per plant (51.45 g and 45.31 g) and seed weight per ha (1.56 and 1.52 q/ha) as compared to other P levels.

Maneeshkumar *et al.* (2013) opined that the application of phosphorus 60 kg and molybdenum 10 mg had a significant influence on plant height (42 and 43.15 cm), number of leaves per plant (18.56 and 25.0), green forage (12.95 g and 18.65 g) and chemical nutrient uptake N (3.12 kg), P (1.67 kg) and K (3.14 kg) respectively.

Prasad *et al.* (2013) revealed that application of Rhizobium and PSB along with phosphorus at 80 kg per ha showed increase in plant height (14.34 cm, 32.49 cm and 87.40 cm), number of leaves (7.13, 31.80 and 136.73), number of branches (3.60 and 31.80) and number of nodules per plant (19.87) at 15, 30 and 45 days interval respectively.

Ayodele and Oso, (a) (2014) revealed that periodical application of 20 and 40 kg P_2 O_5 per ha significantly increased plant height (20.1 cm and 22.3 cm), leaf area (1705 cm and 1845 cm), number of pods per plant (33 and 36), number of nodules (44 and 47) and grain yield (1.22 kg and 1.26 kg).

Ayodele and Oso, (b) (2014), reported that application of 45 kg P_2 O_5 per ha either in single superphosphate or triple superphosphate significantly improved the cowpea growth and yield (0.798 Mt per ha).

Danielnyoki and Patrick, (2014) revealed that *Rhizobium* inoculation and supplementation of phosphorus independently or in combination had positive effects on seed yield (953 kg and 1054 kg/ha) and stover yield (2579 kg and 2577 kg/ha) as compare to control (2075 and 5556 kg/ha).

George *et al.* (2014) revealed that rhizobial inoculants supplemented with phosphorus 30 kg and potassium 50 kg in enhancing growth (25.3 cm), yield (2.3 kg), photosynthesis (23 %), nodulation (42 %) and nitrogen fixation (11 kg) of legumes as compare to other treatments.

Karikari *et al.* (2015) opined that application of Phosphorus at 60 kg ha^{-1} shows highest seed yield of (1682 kg/ha) and (1476 kg/ha) per ha for major and minor seasons respectively.

2.4.1 Effect of phosphorus (P) fertilization on nodulation and N fixation of cowpea

Application of phosphorus fertilizer to legumes is geared towards enhancing not only their growth and yield, but also nodulation and nitrogen fixation (Robson and Hara, 1981).

Robson and Hara (1981) concluded that P nutrition increased symbiotic nitrogen fixation in most legumes by stimulating host plant growth rather than by exerting specific effects on rhizobial growth or on nodule formation and function.

Armstrong *et al.* (1999) reported that phosphorus plays a key role in the symbiotic N fixation process by increasing top and root growth, decreasing the time needed for developing nodules to become active. And increasing the number and size of nodules and the amount of N assimilated per unit weight of nodules in the soil surrounding roots.

Kudikeri *et al.* (1973) revealed that application of phosphorus increased nodule mass and nitrogen fixation at all the three stages (*i.e.* flowering, pod-filling, and physiological maturity) but the effects of phosphorus were more pronounced at the flowering and pod filling stages.

Gentili and Danell (2002) observed that P fertilizer significantly enhanced nodule dry weights of the cowpea but higher concentration phosphorus leads to lower nodule number.

Fageria *et al.* (2006) reported that phosphorus is effectively translocated into grain at high rates, since phosphorus is necessary for the production of protein, phospholipids and phytin in bean. In particular, phosphorus appears essential for both nodulation and nitrogen fixation.

Siddiqui *et al.* (2007) reported that before developing nodules, cowpea depends on phosphorus, which not only helps seedling growth but also aids early nodulation, leading to optimum growth and biomass production.

Rahman *et al.* (2008) revealed that beneficial effect of phosphorus supply is caused by a strong stimulating effect on nodulation and nitrogen fixation capacity of leguminous plant.

Rotaru and Sinclair (2009) opined that symbiotic nitrogen fixation has a higher P requirement for maximum activity than growth supported by nitrate assimilation because of the high energy requirement for the reduction of atmospheric nitrogen by nitrogenase system.

2.5 Effect of potash (K) fertilization on growth and yield of cowpea

Geetha *et al.* (2011) concluded that crop with 20 mm water through micro-sprinkler resulted in significantly increase in higher green pod yield (1009 kg per ha), number of pods (60.4) per plant and 50 per cent flowering (39.2) days as compared to nitrogen and potassium level of 20 kg per ha.

Potassium has no direct role in nodulation, but its addition can increase nodulation on deficient soils (Giller, 2000). Sangakkara *et al.* (2001) reported that K fertilizer can be considered a significant factor in overcoming soil moisture stress in Cowpea and Mungbean.

Potassium was found to be important for cowpea in dry conditions by promoting vegetative growth and optimizing physiological parameters which influence subsequent pod yields (Oliveira *et al.*, 2009).

Francisco *et al.* (2013) opined that application of 67.73 kg of P_2O_5 and 35 kg of K_2O per ha showed highest grain yield (21 ton per ha) as compare to other chemical fertilizer treatments.

Priyadharshini and Seran (2015) reported that application of K at 60 kg per ha gave high yield (1.44 tons per ha) followed by other treatments T_1 (1.42 tons per ha) and T_4 (1.35 tons per ha).

Rahelehjenabi *et al.* (2015) revealed that application of 30 kg of nitrogen and potassium fertilizers per hectare showed highest amount of seed yield (1555 kg per ha) and higher pod yield (3557 kg per ha) as compare to application 40 kg nitrogen and potassium fertilizers per ha.

2.6 Effect of Organic manures on growth, yield of cowpea

The success of sustainable agriculture is very much dependent upon the availability of cheap and good quality organic manures. Among the sources of available organic manures, vermicompost is a potential source due to the presence of readily available plant nutrients, growth enhancing substances, and a number of beneficial microorganisms like nitrogen fixing, P solubilising and cellulose decomposing organisms (Sailajakumari and Ushakumari, 2002).

Sailajakumari and Ushakumari (2002) concluded that among the different treatments, enriched vermicompost showed its superiority over other treatments for yield (1072.5 kg) and uptake of major nutrients like N (77.8 kg), P (11.94 kg), K (33.72), Ca (26.31 kg) and Mg (8.68 kg) per ha.

Obadoni *et al.* (2009) revealed that application vermicompost at 50 kg per ha cause an increase in plant height at 3, 6 and 9 weeks after planting, number of pods (198.8), (123.5), (203.3) and (75.8), and in case of 50% flowering (53.5), (31.3), (44) and (49.5) shows significant between four varieties (IT87D-941-1, IT93K-452-1 IT84S-2246-4 and IT90K-277-2).

Organic manures like FYM, vermicompost, poultry manure and oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, sodicity and pH (Alabadan *et al.*, 2009).

Subbarayappa *et al.* (2009) opined that application of 100 per cent RDF + FYM (40:60: 80 kg + 10 t FYM/ha) significantly increased the pod length (15.85 cm), seed yield (1586 kg per ha), stover yield (5124 kg per ha) and harvest index (0.23). However, significantly higher net returns and higher B:C ratio was recorded in 100 per cent RDF + FYM 40:60: 80 kg + 10 t FYM/ha) followed by 75 per cent RDF + FYM (20:45:60 kg + 5 t FYM/ha) respectively.

Joseanyandrade *et al.* (2011) revealed that sandy and clayey soils were amended with TSC at rates of 0, 7.5, 15, 30, and 60 t ha^{-1} shows increased shoot dry weight (1.70 g, 3.60 g, 3.93 g and 4.71 g) of cowpea plants after 45 days after emergence as compare to un amended soil and application of TSC increased N accumulation (28.2 and 32 ton per ha) in the cowpea plants.

Bapidas and Waga (2011) opined that growth parameters like plant height (25.6 cm), number of leaves (28.6), branches per plant (20.2) and yield parameters like no of pods per plant (14.64), diameter (4.71 cm) and length of pods (23.09 cm) was increased with the treatment of 75 per cent RDF + Vermicompost + *Rhizobium* + PSB was found significant over control and RDF alone. Maximum nitrogen and phosphorus uptake by plant was found significant in treatment 75 per cent RDF + Vermicompost + *Rhizobium* + PSB.

Dhaka *et al.* (2013) opined that seed yield of cowpea increased to the extent of (13.5 kg, 27.3 kg, 24.9 kg and 32.3 kg) and stover yield to the extent of (8.6, 13.2, 12.4 and 19.9 kg per ha) with the application of 5 and 10 t FYM per ha and 2.5 and 5 ton vermicompost per ha respectively.

Annu and Sharma (2014) revealed that the application of vermicompost at 5 ton per ha and combined application of S + Mo + Fe found significantly increasing the green pod yield (18.57 ton per ha and 19.58 ton per ha) of cowpea over control (15.53 ton per ha).

Vijayalakshmi and Anuja (2014) reported that FYM @ 25 ton per ha + neem cake @ 5 ton per ha + panchagavya 3 per cent increases in plant height (30.25 cm). Whereas, number of branches per plant (15.4), was favourably enhanced by the treatment of FYM @ 25 ton per ha + vermicompost @ 5 ton per ha + panchagavya 3 per cent. The highest yield per ha showed at FYM @ 25 ton per ha + vermicompost @ 5 ton per ha + panchagavya 3 per cent recorded yield of (6.75 ton per ha) in season I and (6.22 ton per ha) in season II as compared to (3.64 ton per ha and 3.59 ton per ha) in the control during season I and season II respectively.

Ashwanikumar and Pandita (2016) reported that INM treatments differed significantly in seed yield (4.71 kg/ha^{-1}), number of pods per plant (13.3), pod length (23.9 cm), number of seeds per pod (12.5), 1000-seed weight (102.7g) as compare to control condition (no organic fertilizer).

Itelima *et al.* (2015) opined that application of Bio-fertilizer produced from cow dung saw dust mixture combined with Bio-fertilizer produced from poultry droppings saw dust mixture in the ratio of 1:4 led to remarkable difference in average number of pod per plant (23.00), average length of one pod (0.16 cm), average number of seed per pod (16.00), average number of seed per pot (1104), total weight of bean seed (165 g) and yield (49.5 kg/ha) as compare to control condition.

Application of recommended dose of fertilizer 20-40-0 NPK kg per ha and vermicompost at 2 ton ha recorded highest plant height (27.67 cm and 26.25 cm), higher green pod (79.60 and 77.09), stover yield (6860 kg and 6748 kg), pod length (13.45 cm and 13.82 cm) and yield contributing characters (Joshi *et al.,* 2016).

Msaakpa (2016) reported that application of different rates of vermicompost (50 kg per ha) and poultry manure (20 kg per ha) causes increase in plant height (22.3 cm), number of leaves (45), pod length (21.6 cm), number of pods per plant (134), number of seeds per pod (12.5), total dry matter (23.6 g), 1000 seed weight (105.3 g) and total seed yield (95.2 kg/ha) respectively.

Msaakpa (2016) opined that varieties and rates of poultry manure exerted significant effects on the growth and yield of cowpea. Variety UAM 091046 -6 -2 produced the longest pod length (13.50 cm), number of seeds per plant (119.82), 100 seed yield (16.51 kg/ha), number of pods per plant (13.42), total dry matter yield (21.10 g) and highest seed yield (837. 40 kg per ha) as compare to IT98KD – 573-2-1 variety.

3. MATERIAL AND METHODS

A field experiment "Nutritional studies on vegetable cowpea in northern dry zone of Karnataka" was carried out during *kharif* season of 2016-17 under rainfed conditions at Haveli farm, UHS, Bagalkot. The details of the material used and techniques adopted during the investigation are presented below.

3.1 Location of the experimental site

The experiment was conducted at research block of vegetable section in Haveli farm, Bagalkot. Bagalkot is situated in northern dry zone of Karnataka State at 16^{o} 46' North latitude, 74^{o} 59' East longitude and at an altitude of 533.0 meters above the mean sea level.

3.2 Soil characteristics

The soil of the experimental field was reddish loamy with 37% clay, 38% silt and 25% sand with pH of 6.33. The physical and chemical properties of soils of experimental site analysed from composite soil sample collected from 0-15 cm depth are presented in Appendix I.

3.3 Climate Conditions

The climatic conditions prevailed during crop period from August 2016 to October 2016 are presented here. The total rainfall received during crop growth period was 331.00 mm in 9 rainy days. The maximum and minimum temperature during crop growth period varied 30.90 ^{0}C to 17 ^{0}C respectively. The relative humidity ranged between 86 to 70 % during crop period. The meteorological data recorded at MHREC, Bagalkot during 2016 is presented in Appendix II.

3.4 Experimental details

3.4.1 Design and layout

The experiment was conducted at Haveli farm, UHS, Bagalkot during *Kharif* season 2016 - 2017.

Number of treatments : 10

Experimental design : Factorial RBD

Number of replications : 3

The plan of layout of the experiment is given in Fig. 3.3

3.4.2 Plot size

Gross Plot size : 4.05 m × 2.6 m

Net Plot size : 3.15 m × 2.2 m

3.4.3 Treatment details

Factor I

A) Two Varieties: I. Arka Suman (V_1)

II. Arka Garima (V_2)

Factor II (Levels of N, P and K Supply)

a) F_1: 125 % Recommend dose of Fertilizer

b) F_2: 100 % Recommend dose of Fertilizer

c) F_3: 75 % Recommend dose of Fertilizer

d) F_4: 50 % Recommend dose of Fertilizer

e) F_5: 100% Recommend dose of N supply through Vermicompost + PSB

Cowpea Recommended dose of fertilizer is 25:75:60 kg N: P_2O_5: K_2O per hectare and *Rhizobium* 3.75 kg/ha + PSB (10g/kg of seed) (As per POP of UHS Bagalkot).

3.4.4 Crop and variety

The experimental material comprised of two varieties received from Indian Institute of Horticulture Research, Hessaraghatta, Bangalore. The list of varieties with their characters described in Table 3.4.4

Plate 1: General view of experimental plot at Haveli farm, UHS Baglkot

N

R1		R2		R3
V_1F_1		V_2F_5		V_1F_4
V_1F_5		V_2F_1		V_1F_1
V_1F_3	**1.25 mt**	V_2F_4	**1.25 mt**	V_1F_3
V_1F_2		V_2F_3		V_1F_2
V_1F_4		V_2F_2		V_1F_5

V_2F_2		V_1F_3		V_2F_5
V_2F_5		V_1F_4		V_2F_3
V_2F_3		V_1F_2		V_2F_4
V_2F_1		V_1F_5		V_2F_1
V_2F_4		V_1F_1		V_1F_2

2.6 m

4.05 m

Fig. 3.3: Plan and Layout of the Experiment

Name of the crop	Variety	Variety Description
Vegetable cowpea	Arka Suman	It is a cross between T.U.V.762 x V. uniquiculata sub sp. sesquipedalis. Plants tall, vigorous, bushy, with small vines and photo insensitive. Leaf colour dark green. Flower colour purple. Pods dark green, long, thick, round, fleshy and string less. Tolerant to heat, drought and low moisture stress. Duration 65 days. pod yield 18 t/ha.
	Arka Garima	It is a cross between V. uniquiculata x T.U.V.762 sub sp.sesquipedalis. Plants tall, vigorous, bushy, with small vines and photo insensitive. Leaf colour light green. Flower colour purple. Pods light green, long, thick, round, fleshy and string less. Tolerant to heat, drought and low moisture stress. Duration 60 days. Pod Yield 15 t/ha.

3.5 Cultural operations

The cultural operations carried out in the experimental plot are explained below.

3.5.1 Preparation of experimental site

The land was brought to a fine tilth by repeated ploughing and harrowing. The plot of requisite dimension was prepared as per the plan. A gap of 1.25 m between two replications was provided for laying out the irrigation channels and working space.

3.5.2 Sowing and Gap filling

Seeds collected from sources were treated with 10 g *rhizobium* before sowing. The ridges and furrows were opened at 45 cm and two to three seeds per hill were sown by dibbling on one side of the ridge at 20 cm distance. The sowing was done on August 29th 2016 in *kharif* season and irrigation was given after the sowing. Thinning of excess seedlings and gap filling was done one week after sowing.

3.5.3 Fertilizer application

Recommended dose 25:75:60 kg/ha of nitrogen, phosphorus and potassium and FYM-10 t/ha were applied in the form of urea, diammonium phosphate and muriate of potash respectively at the time sowing, half the dose of N and full dose of P and K were applied as basal dose and remaining half dose of N was applied as a top dress at 30 days after sowing.

3.5.4 Weeding and irrigation

The plots were kept weed free by hand weeding. Irrigation was given at an interval of 6-7 days during experimentation, depending on the soil moisture status and climatic conditions.

3.5.5 Harvesting

Cowpea pods were harvested at tender stage. The pickings were done and pod yield per plot of each treatment was recorded and calculated per hectare.

3.6 Biometric observations

For recording various observations, five plants in each experimental plot were randomly selected by avoiding border plants. The selected plants were tagged for taking observations on various growth and yield parameters.

Parameters		**Procedure followed**
1.	Plant height (cm)	Plant height from the ground level to the growing tip of the plant was recorded at 30 and 60 days and mean plant height was worked out and expressed in centimetre
2.	Number of leaves per plant	The number of leaves was counted from in the tip of the plant at 30 days and 60 days after sowing

3.	Leaf area index	Leaf area index (LAI) was worked out by using the formula as suggested by Watson (1952) at 30 and 60 DAS $$LAI = \frac{\text{Leaf area } (cm^2)}{\text{Land area } (cm^2)}$$
4.	Dry matter production (g $plant^{-1}$)	Oven dry weight (drying at 65 ^{o} C at constant weight) of stem, root, leaves and pod at different crop growth stages was weighed and expressed in grams

3.6.2 Yield and yield parameters of Vegetable Cowpea

Parameters		**Procedure followed**
1.	Vegetable pod yield per plant	The number of marketable green pods harvested in tagged plants pooled and weighed and expressed as (kg) per plant.
2.	Pod Length	Pod length (cm) was measured randomly on tagged ten pods at the time of harvest and expressed in centimetres.
3.	Number of pods per clusters	Number of pods produced on pod bearing cluster of tagged plants in each experimental plot was counted and average was worked out.
4.	Number of clusters per plant	The number of clusters produced by the tagged plants in each experimental plot was counted and average was worked out.
5.	Fresh weight of ten pods/at harvest (g)	Ten green vegetable pods harvested from the tagged plants were selected randomly and average weight was recorded in grams.

6.	Fresh seed weight/plant at harvest (g)	Ten green vegetable pods are randomly selected from the tagged plants and peeled and seeds selected randomly and average weight was recorded in grams.
7.	Vegetable pod, seed, stover yield and total biomass yield per hectare	$\text{Yield/ha (kg)} = \dfrac{\text{Yield/plot (kg)} \times 10{,}000}{\text{Plot area} \times 1{,}000}$

3.6.3 Quality parameters

Parameters		Procedure followed
1.	Protein per cent in pods	Protein content of fresh pods from each variety was estimated as per the Lowry's method and expressed in g/100 g of pods.
2.	Organoleptic sensory evaluation	Evaluated for seed colour, Texture and over all acceptability in vegetable cowpea varieties through sensory evaluation
3.	Nutrient content of Stover (%)	The tagged plants were selected randomly from the different treatment in the replication and measured for Nitrogen, Potassium and Phosphorus content present in different parts of plant.

3.7 Statistical analysis

The data collected from the experiment was subjected to various statistical analysis to draw the suitable inference. The details of the statistical procedure followed are given below.

3.7.1 Analysis of variance (ANOVA)

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1967). Using the mean values of randomly selected plants in each replication from all treatments to find out the significance of treatment effects. The details of analysis of variance are as follows

Source of variation	**Degrees of freedom (d. f)**	**S.S.**	**M.S.S.**	**F ratio (Cal. F)**
Replication	(r-1)	RSS	Mr (M_1)	Mr/Me
Treatment	(t-1)	TSS	Mt (M_2)	Mt/Me
Error	(r-1) (t-1)	ESS	Me (M_3)	-
Total	(n-1)	-	-	-

Where,

r = Number of replication Mr= Mean sum of square of replication

t = Number of treatments Mg = Mean sum of square of genotypes

Me = Mean sum of square of error

Statistical significance of variation due to varieties was tested by comparing calculated values to table F values at one per cent and five per cent level of probability.

4. EXPERIMENTAL RESULTS

The results of the field experiment "Nutritional studies on vegetable cowpea (*Vigna unguiculata* L.) in Northern dry zone of Karnataka" conducted during *kharif* season in 2016-2017 at Haveli farm, UHS Bagalkot to study the are presented in this chapter.

4.1 Growth parameters

4.1.1 Plant height (cm)

The data furnished in the Table 1 revealed that plant height differed significantly due to varieties at all the growth stages (30 DAS and 60 DAS). At 30 DAS, variety Arka Suman recorded significantly higher plant height (13.51 cm) as compared to Arka Garima (12.41 cm). Similarly, at 60 DAS, significantly higher plant height was recorded with variety Arka Suman (25.21 cm) over Arka Garima (23.42 cm).

The variation in plant height due to nutrient management practices was significant at all the growth stages. At 30 DAS, application of 125 per cent of RDF (F_1) recorded significantly higher plant height (15.35 cm) over all other levels of nutrients tested. At 60 DAS, application of 125 per cent of RDF (F_1) recorded significantly higher plant height (27.32 cm) over all other nutrients management practices expect F_2- 100 per cent of RDF which was on par with F_1.

Among varieties and nutrient management practices V_1 F_1 recorded significantly highest plant height (15.58 cm) at 30 DAS. But there is no significant difference between varieties and nutrient management practices at 60 DAS respectively.

4.1.2 Number of leaves per plant

The number of leaves of cowpea varieties at 30 DAS and 60 DAS was significantly influenced by varieties and different nutrient management practices.

Table 1: Influence of different levels of nutrients on plant height at 30 and 60 days after sowing of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Plant height (cm) at 30 DAS						Plant height (cm) at 60 DAS					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	15.58	13.61	12.84	12.48	13.08	**13.51**	28.04	27.07	25.33	20.11	25.70	**25.21**
V_2	15.12	12.34	11.61	10.92	12.10	**12.41**	26.60	25.00	22.09	19.13	23.33	**23.39**
Mean	**15.35**	**12.97**	**12.23**	**11.70**	**12.59**	**13.08**	**27.32**	**26.04**	**23.71**	**20.02**	**24.52**	**24.32**
For comparing means of	**S.Em.±**			**CD at 5%**			**S.Em.±**			**CD at 5%**		
Varieties	0.25			0.74			0.55			1.63		
Nutrients	0.39			1.17			0.87			2.58		
V × F	0.56			1.65			1.23			NS		

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g / kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 2: Influence of different levels of nutrients on number of leaves at 30 and 60 days after sowing of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Number of leaves at 30 DAS						Number of leaves at 60 DAS					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	23.33	20.00	19.33	18.33	19.00	**20.00**	80.67	80.00	79.67	78.33	79.33	**79.60**
V_2	20.33	19.00	18.67	15.67	18.33	**18.40**	80.33	79.67	74.67	73.33	77.67	**77.13**
Mean	**21.83**	**19.50**	**19.00**	**17.00**	**18.67**	**19.20**	**80.50**	**79.84**	**77.17**	**75.83**	**78.50**	**78.37**

For comparing means of	S.Em.± (30 DAS)	CD at 5% (30 DAS)	S.Em.± (60 DAS)	CD at 5% (60 DAS)
Varieties	0.44	1.31	0.61	1.80
Nutrients	0.70	2.07	0.96	2.85
V × F	0.98	2.92	1.35	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

The data recorded in the Table 2 revealed that variety Arka Suman recorded significantly higher number of leaves (20) as compare to Arka Garima (18.40) at 30 DAS. Similarly, at 60 DAS, significantly higher number of leaves was recorded with variety Arka Suman (79.60) over Arka Garima (77.13).

The variation in number of leaves due to nutrient management practices was significant at all the growth stages. At 30 DAS, application of 125 per cent of RDF (F_1) recorded significantly higher number of leaves (21.83) over other nutrient management practices. Similarly, at 60 DAS, application of 125 per cent of RDF (F_1) recorded significantly higher number of leaves (80.50) over all other levels of nutrients tested.

Among varieties and nutrient management practices V_1 F_1 recorded significantly highest number of leaves (23.33) at 30 DAS. But there is no significant difference between varieties and nutrient management practices at 60 DAS respectively.

4.1.3 Leaf area index

The data presented in Table 3 clearly indicates that, leaf area index differed significantly due to varieties at all the growth stages (30 DAS and 60 DAS). At 30 DAS, variety Arka Suman recorded significantly higher leaf area index (0.64) as compared to Arka Garima (0.56). Similarly, at 60 DAS, significantly higher leaf area index was recorded with variety Arka Suman (0.72) over Arka Garima (0.67).

The variation in leaf area index due to nutrient management practices was significant at all the growth stages. At 30 DAS, application of 125 per cent of RDF (F_1) recorded significantly higher leaf area index (0.65) over all other levels of nutrients tested. At 60 DAS, application of 125 per cent of RDF (F_1) recorded significantly higher leaf area index (0.74) over all other nutrients management practices.

Interaction effect of varieties and nutrient management practices on leaf area index did not differ significantly at all the growth stages.

Table 3: Influence of different levels of nutrients on leaf area index at 30 and 60 days after sowing of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Leaf area index at 30 DAS						Leaf area index at 60 DAS					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	0.68	0.65	0.62	0.61	0.64	**0.64**	0.76	0.72	0.74	0.67	0.72	**0.72**
V_2	0.62	0.58	0.54	0.50	0.57	**0.56**	0.71	0.69	0.63	0.65	0.68	**0.67**
Mean	**0.65**	**0.62**	**0.58**	**0.56**	**0.60**	**0.60**	**0.74**	**0.71**	**0.69**	**0.66**	**0.70**	**0.70**

For comparing means of	S.Em.±	CD at 5%	S.Em.±	CD at 5%
Varieties	0.09	0.29	0.12	0.37
Nutrients	0.14	0.46	0.17	0.52
V × F	0.20	NS	0.24	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

4.1.4 Total dry matter

4.1.4.1 Stem weight

The stem weight differed significantly on adoption of varieties and different nutrient management practices at harvest. Significantly higher dry weight of stem (12.39 g/plant) were recorded in variety Arka Suman as compare to Arka Garima (12.10 g/plant) at harvest.

The variation in stem dry weight due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) recorded significantly higher stem dry weight (12.25 g/plant) over all other nutrients management practices expect F_2- 100 per cent of RDF and F_5- 100 per cent N supply through vermicompost which was on par with F_1.

Interaction effect of varieties and nutrient management practices on stem dry weight did not differ significantly at all the growth stages.

4.1.4.2 Leaf weight

The data furnished in the Table 4 revealed that leaf dry weight differed significantly due to varieties at all the growth stages. Variety Arka Suman recorded significantly higher leaf dry weight (12.29 g/plant) as compared to Arka Garima (11.63 g/plant) at harvest respectively.

The variation in leaf dry weight due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) recorded significantly higher leaf dry weight (12.43 g/plant) over all other nutrients management practices expect F_2- 100 per cent of RDF which was on par with F_1.

Interaction effect of varieties and nutrient management practices on leaf dry weight did not differ significantly irrespective of growth stages.

4.1.4.3 Root weight

The dry weight of root was significantly influenced by varieties and nutrient management practices (Table 5). Significantly higher dry weight of root (2.03 g/plant) were recorded in variety Arka Suman as compared to Arka Garima (1.96 g/plant) at harvest respectively.

Table 4: Influence of different levels of nutrients on stem and leaves dry weight at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Stem dry weight (g /plant) at harvest						Leaves dry weight (g /plant) at harvest					
	F_1	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**
V_1	12.64	12.40	12.25	12.20	12.49	**12.39**	13.65	12.61	11.37	11.03	12.92	**12.29**
V_2	12.47	12.25	11.97	11.73	12.10	**12.10**	11.21	12.20	11.99	10.93	11.73	**11.63**
Mean	**12.55**	**12.33**	**12.11**	**11.97**	**12.30**	**12.25**	**12.43**	**12.40**	**11.68**	**10.98**	**12.33**	**11.96**
For comparing means of	**S.Em.±**			**CD at 5%**			**S.Em.±**			**CD at 5%**		
Varieties	0.06			0.18			0.22			0.66		
Nutrients	0.09			0.29			0.35			1.05		
V × F	0.13			NS			0.50			NS		

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 5: Influence of different levels of nutrients on root and pod dry weight at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Root dry weight (g /plant) at harvest						Pod dry weight (g /plant) at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	2.70	1.92	1.90	1.41	2.09	**2.03**	9.87	8.23	7.77	7.45	8.2305	**8.27**
V_2	1.94	1.91	1.84	1.83	2.28	**1.96**	8.23	7.93	7.44	6.77	7.73	**7.62**
Mean	**2.32**	**1.92**	**1.87**	**1.62**	**2.18**	**1.98**	**9.05**	**8.08**	**7.61**	**7.11**	**7.89**	**7.95**

For comparing means of	Root dry weight S.Em.±	Root dry weight CD at 5%	Pod dry weight S.Em.±	Pod dry weight CD at 5%
Varieties	0.10	0.29	0.10	0.39
Nutrients	0.16	0.46	0.15	0.62
V × F	0.22	0.65	0.21	0.82

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

The variation in root dry weight due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) recorded significantly highest dry weight of root (2.32 g/plant) over all other nutrients management practices.

Among varieties and nutrient management practices V_1 F_1 recorded significantly highest dry weight of root (2.70 g/plant) as compare to all other nutrients management practices at harvest.

4.1.4.4 Pod weight

The data presented in table 5 clearly indicates that, dry weight of pod differed significantly by adoption of varieties and different nutrient management practices. Significantly higher dry weight of pod (8.27 g/plant) were recorded in variety Arka Suman as compared to Arka Garima (7.62 g/plant) at harvest.

The variation in pod dry weight due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) reported significantly highest dry weight of pod (9.05 g/plant) over all other nutrients tested.

Among varieties and nutrient management practices V_1 F_1 recorded significantly highest dry weight of pod (9.87 g/plant) as compare to all other nutrients management practices at harvest.

4.2 Yield parameters

4.2.1 Number of pods per cluster

The data presented in table 6 obviously indicates that, the number of pods per cluster was not significantly differed due to varieties, nutrient management practices and their interaction effects.

4.2.2 Number of cluster per plant

The data mentioned in Table 6 indicates that, number of cluster per plant differed significantly due to varieties at all the growth stages. Variety Arka Suman recorded significantly higher number of cluster per plant (4.73) as compared to Arka Garima (3.86) at harvest respectively.

Table 6: Influence of different levels of nutrients on number of pods per cluster and number of cluster per plant at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Number of pods per cluster at harvest						Number of cluster per plant at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	2.00	2.00	2.00	2.00	2.00	**2.00**	5.67	5.33	4.33	3.67	4.67	**4.73**
V_2	2.00	2.00	2.00	2.00	2.00	**2.00**	4.00	4.00	3.67	3.33	4.00	**3.86**
Mean	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**5.3**	**4.50**	**4.15**	**4.03**	**4.33**	**4.63**

For comparing means of	S.Em.$\pm$	CD at 5%	S.Em.$\pm$	CD at 5%
Varieties	0.09	NS	0.18	0.72
Nutrients	0.14	NS	0.26	1.14
V × F	0.20	NS	0.39	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

The variation in number of cluster per plant due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) recorded significantly higher number of cluster per plant (5.3) as compared to F_3 and F_4 at harvest respectively.

Interaction effect of varieties and nutrient management practice on number of cluster per plant did not differ significantly at all growth stages.

4.2.3 Number of pods

The number of pods per plant at harvest was significantly influenced by varieties and nutrient management practices (Table 7). Significantly higher number of pods (9.50) were recorded in variety Arka Suman as compared to Arka Garima (8.37) at harvest.

The variation in number of number of pods per plant due to nutrient management practices was significant at all the growth stages. Application of 125 per cent RDF (F_1) observed significantly higher number of pods (11.36) over all other nutrient management practices.

Interaction effect of varieties and nutrient management practices on number of pods per plant did not differ significantly at all growth stages.

4.2.4 Pod length

The data mentioned in Table 8 indicates that, the pod length of cowpea was significantly influenced by varieties and different management practices.

Significantly higher pod length (18.34 cm) was recorded in variety Arka Garima as compared to Arka Suman (13.96 cm) at harvest respectively.

The variation in pod length due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed highest pod length (14.76 cm) over all other nutrient management practices expect F_2- 100 per cent of RDF and F_5- 100 per cent N supply through vermicompost which was on par with F_1.

Table 7: Influence of different levels of nutrients on number of pods and pod yield at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Number of pods at harvest						Pod yield (g /plant) at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	12.53	10.23	8.56	6.37	9.84	**9.50**	10.42	10.15	8.95	7.85	9.91	**9.45**
V_2	10.19	9.65	7.54	5.71	8.79	**8.37**	9.29	8.81	7.82	6.71	8.75	**8.27**
Mean	**11.36**	**9.94**	**8.05**	**6.04**	**9.32**	**8.94**	**9.86**	**9.48**	**8.39**	**7.28**	**9.33**	**8.87**

For comparing means of	S.Em.$\pm$	CD at 5%	S.Em.$\pm$	CD at 5%
Varieties	0.41	1.22	0.41	1.22
Nutrients	0.65	1.93	0.65	1.96
V × F	0.92	NS	0.92	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 8: Influence of different levels of Nutrients on pod length at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)					
	Pod length (cm) at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean
V_1	14.76	14.24	13.88	13.47	13.50	**13.96**
V_2	19.56	18.09	17.53	17	19.57	**18.34**
Mean	**17.16**	**16.17**	**15.70**	**15.25**	**16.52**	**16.16**
For comparing means of	**S.Em.±**			**CD at 5%**		
Varieties	0.24			0.70		
Nutrients	0.37			1.11		
V × F	0.53			NS		

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Interaction effect of varieties and nutrient management practice on pod length did not differ significantly at all growth stages.

4.2.5 Fresh weight of pods

The fresh weight of pod was significantly influenced by varieties and nutrient management practices (Table 9). Significantly higher fresh weight of pod (24.28 g/plant) were recorded in variety Arka Suman as compared to Arka Garima (16.88 g/plant) at harvest respectively.

The variation in fresh weight of pod due to nutrient management practices was significant at all the growth stages. Application of 125 per cent RDF (F_1) recorded significantly higher fresh weight of pod (21.30 g/plant) as compared to F_3 and F_2 at harvest.

Interaction effect of varieties and nutrient management practice on fresh weight of pod did not differ significantly at all growth stages.

4.2.6 Seeds fresh weight

The data mentioned in Table 9 indicates that, the fresh weight of seeds was significantly influenced by varieties and different management practices at harvest respectively.

Significantly higher fresh weight of seed (10.51 g/plant) was recorded in variety Arka Suman as compared to Arka Garima (9.74 g/plant) at harvest.

The variation in fresh weight of seed due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed highest fresh weight of seed (10.68 g/plant) as compared to F_2, F_5 and F_3 at harvest respectively.

Interaction effect of varieties and nutrient management practice on fresh weight of seed did not differ significantly at all growth stages.

Table 9: Influence of different levels of nutrients on fresh weight of pods and seeds at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices											
	Fresh weight (g /plant) of pods at harvest						Fresh seeds weight (g /plant) at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	25.25	24.69	25.04	21.67	25.75	**24.28**	10.72	10.61	10.42	10.30	10.52	**10.51**
V_2	17.35	16.49	16.97	16.45	16.72	**16.88**	10.64	9.87	9.66	8.90	9.65	**9.74**
Mean	**21.30**	**20.82**	**21.01**	**19.06**	**20.74**	**20.59**	**10.68**	**10.24**	**10.04**	**9.60**	**10.09**	**10.13**

For comparing means of	S.Em.±	CD at 5%	S.Em.±	CD at 5%
Varieties	0.10	0.39	0.12	0.35
Nutrients	0.15	0.62	0.19	0.56
V × F	0.21	NS	0.27	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

4.2.7 Total bio mass yield

The data mentioned in Table 10 indicates that, total bio mass yield per plant was significantly influenced by varieties and different nutrient management practices.

Significantly higher bio mass yield per plant (3072.0 kg/ha) was recorded in variety Arka Suman as compared to Arka Garima (2922.0 kg/ha) at harvest.

The variation in total bio mass yield per plant due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed highest bio mass yield per plant (3534.6 kg/ha) over other nutrient management practices at harvest.

Interaction effect of varieties and nutrient management practices on total bio mass yield per plant did not differ significantly at all growth stages.

4.2.8 Pod yield

The pod yield per hectare was significantly influenced by varieties and different nutrient management practices (Table 11). Significantly higher pod yield per hectare (1456.1 kg/ha) in variety Arka Suman as compare to Arka Garima (1425.1 kg/ha) at harvest respectively.

The variation in pod yield per plant due to nutrient management practices was significant at all the growth stages. Application of 125 per cent RDF (F_1) at harvest resulted in significantly higher pod yield (1693.9 kg/ha) over other nutrient management tested.

Among varieties and nutrient management practices V_1 F_1 recorded highest pod yield (1742.4 kg/ha) over other nutrient management practices expect V_2 F_1 which was on par with V_1 F_1 at harvest respectively.

4.2.9 Seed yield

The data mentioned in Table 11 indicates that, seed yield per hectare was significantly influenced by varieties and different nutrient management practices.

Table 10: Influence of different levels of nutrients on total bio mass yield at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)					
	Total bio mass (kg/ ha) at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean
V_1	3654.7	3280.5	2667.7	2538.5	3218.6	**3072.0**
V_2	3414.6	3030.0	2752.8	2454.9	2957.9	**2922.0**
Mean	**3534.6**	**3155.2**	**2710.2**	**2496.7**	**3088.2**	**2997.0**
For comparing means of	**S.Em.±**			**CD at 5%**		
Varieties	38			156		
Nutrients	61			247		
V × F	86			NS		

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 11: Influence of different levels of nutrients on pod and seed yield at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Pod yield (kg /ha) at harvest						Seed yield (kg /ha)at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	1742.4	1545.4	1242.4	1210.1	1540.4	**1456.1**	1697.6	1498.2	1320.3	1187.6	1342.6	**1409.2**
V_2	1645.4	1493.9	1342.4	1187.5	1456.6	**1425.1**	1610.6	1421.2	1300.7	1165.4	1268.3	**1353.2**
Mean	**1693.9**	**1519.6**	**1292.4**	**1198.8**	**1498.5**	**1440.6**	**1654.1**	**1459.7**	**1310.5**	**1176.5**	**1305.4**	**1381.2**

For comparing means of	Pod yield S.Em.±	Pod yield CD at 5%	Seed yield S.Em.±	Seed yield CD at 5%
Varieties	36	112	31	97
Nutrients	55	158	51	154
V × F	77	172	73	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 3.75 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Significantly higher seed yield (1409.2 kg/ha) was recorded in variety Arka Suman as compared to Arka Garima (1353.2 kg/ha) at harvest.

The variation in pod yield per plant due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed highest seed yield (1654.1 kg/ha) over other nutrient management practices expect F_2 -100 per cent RDF which was on par with F_1 treatment at harvest.

Interaction effect of varieties and nutrient management practice on seed yield per hectare did not differ significantly at all growth stages.

4.2.10 Stover yield

The stover yield was significantly influenced by varieties and different nutrient management practices (Table 12). Significantly higher stover yield per hectare (1615.8 kg/ha) was recorded in variety Arka Suman as compared to Arka Garima (1496.8 kg/ha) at harvest respectively.

The variation in stover yield per plant due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed highest stover yield per hectare (1840.7 kg/ha) over other nutrient management practices.

Interaction effect of varieties and nutrient management practice on stover yield per hectare did not differ significantly at all growth stages.

4.2.11 Harvest index

The harvest index was significantly influenced by varieties and different nutrient management practices (Table 13). Significantly higher harvest index (0.28) in variety Arka Suman as compare to Arka Garima (0.26) at harvest respectively.

The variation in harvest index due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed highest harvest index (0.33) over all other nutrient tested at harvest.

Interaction effect of varieties and nutrient management practices on harvest index did not differ significantly at all growth stages.

Table 12: Influence of different levels of Nutrients on stover yield at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)					
	Stover yield (kg/ ha) at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean
V_1	1912.3	1735.1	1425.3	1328.4	1678.2	**1615.8**
V_2	1769.2	1536.1	1410.4	1267.4	1501.3	**1496.8**
Mean	**1840.7**	**1635.6**	**1417.8**	**1297.9**	**1589.7**	**1556.3**

For comparing means of	S.Em.±	CD at 5%
Varieties	33	98
Nutrients	52	155
V × F	74	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 13: Influence of different levels of Nutrients on harvest index at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)					
	Harvest index					
	F_1	F_2	F_3	F_4	F_5	Mean
V_1	0.37	0.32	0.29	0.23	0.24	**0.28**
V_2	0.29	0.28	0.25	0.22	0.26	**0.26**
Mean	**0.33**	**0.30**	**0.27**	**0.23**	**0.26**	**0.28**
For comparing means of	**S.Em.±**			**CD at 5%**		
Varieties	0.01			0.03		
Nutrients	0.01			0.05		
V × F	0.02			NS		

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties evaluation

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

4.3 Quality parameters

4.3.1 Protein content

The data mentioned in Table 14 indicates that, per cent protein of seed at harvest significantly influenced by varieties and different nutrient management practices. Significantly higher protein percent (0.58 %) in variety Arka Suman as compare to Arka Garima (0.46 %) at harvest respectively

The variation in per cent protein due to nutrient management practices was significant at all the growth stages. Application of 125 per cent RDF (F_1) resulted in significantly higher per cent of protein (0.61 %) over all other nutrients tested at harvest expect F_2- 50 per cent RDF F_5 – 100 per cent N supply through vermicompost which was on par with F_1 treatment at harvest respectively.

Interaction effect of varieties and nutrient management practices on per cent protein did not differ significantly at all growth stages.

4.3.2 Influence of varieties and different nutrient management practices on soil properties like pH, EC and organic carbon

The data mentioned in (Table 15 & 15 a) indicates that, soil properties like pH, EC, organic carbon, nitrogen, phosphorus and potassium content of cowpea plant was not significantly influenced by varieties and different nutrient management practices during crop growth period.

Interaction effect of varieties and nutrient management practice on pH, EC and organic carbon did not differ significantly irrespective of growth stages.

4.3.3 Influence of varieties and different nutrient management practices on N, P and K nutrients content in plant sample

Nitrogen content in plant was significantly differed by the varieties and different nutrient management practices (Table 16 a & b). Significantly higher nitrogen per cent in stem (0.98 %), root (0.91 %), leaves (2.69 %) and pod (2.63 %) were recorded in variety Arka Suman as compare to Arka Garima in stem (0.93 %), root (0.83 %), leaves (2.31 %) and pod (2.47 %) after harvest respectively.

Table 14: Influence of different levels of nutrients on protein percent at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)					
	Protein Percent (%) at harvest					
	F_1	F_2	F_3	F_4	F_5	Mean
V_1	0.74	0.50	0.61	0.39	0.67	**0.58**
V_2	0.48	0.47	0.52	0.33	0.52	**0.46**
Mean	**0.61**	**0.48**	**0.57**	**0.36**	**0.60**	**0.52**

For comparing means of	S.Em.±	CD at 5%
Varieties	0.01	0.05
Nutrients	0.04	0.08
V × F	0.08	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties evaluation

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

The variation in per cent nitrogen due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed significantly highest per cent of nitrogen in stem (1.02 %), root (0.94 %), leaves (2.71 %) and pod (2.66 %) over all other nutrient management practices expect F_2- 100 per cent RDF, F_5-100 per cent N supply through vermicompost and F_3- 75 per cent RDF treatment after harvest.

Interaction effect of varieties and nutrient management practices on per cent nitrogen did not differ significantly at all growth stages.

Phosphorus content in plant was significantly influenced by varieties and different nutrient management practices (Table 16 c &d). Significantly higher per cent phosphorus in stem (0.24 %), root (0.45 %), leaves (0.44 %) and pod (0.82 %) were recorded in variety Arka Suman as compare to Arka Garima in stem (0.20 %), root (0.42 %), leaves (0.39 %) and pod (0.76 %) after harvest respectively.

The variation in phosphorus per cent due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed highest per cent of phosphorus in stem (0.27 %), root (0.48 %), leaves (0.49 %) and pod (0.82 %) over all other nutrient management practices expect F_2- 100 per cent RDF and F_5-100 per cent N supply through vermicompost treatment after harvest.

Interaction effect of varieties and nutrient management practice on per cent phosphorus per cent did not differ significantly at all growth stages.

The data mentioned in (Table 16 e & f) indicates that, per cent potassium in plant sample significantly differed by varieties and different nutrient management practices. Significantly higher per cent potassium in stem (1.12 %), root (0.63 %), leaves (0.60 %) and pod (0.79 %) were recorded in variety Arka Suman as compare to Arka Garima in stem (0.92 %), root (0.53 %), leaves (0.56 %) and pod (0.75 %) after harvest.

The variation in potassium per cent due to nutrient management practices was significant at all the growth stages. Application of 125 per cent of RDF (F_1) showed highest per cent of potassium in stem (1.28 %), root (0.64 %), leaves (0.61 %) and

Table 15 (a): Soil properties as influenced by varieties and nutrient management practices after harvest of vegetable cowpea

Varieties (V)	Nutrient management practices (N)																			
	Organic carbon (%)						pH							EC (ds/m^{-1})						
	F_1	F_2	F_3	F_4	F_5	Mean	Varieties (V)	F_1	F_2	F_3	F_4	F_5	Mean	Varieties (V)	F_1	F_2	F_3	F_4	F_5	Mean
V_1	0.24	0.23	0.21	0.20	0.21	**0.218**	V_1	6.34	6.32	6.32	6.31	6.33	**6.32**	V_1	0.88	0.87	0.85	0.83	0.86	**0.85**
V_2	0.23	0.22	0.21	0.20	0.22	**0.215**	V_2	6.32	6.31	6.31	6.30	6.32	**6.31**	V_2	0.85	0.85	0.83	0.81	0.84	**0.83**
Mean	**0.24**	**0.22**	**0.21**	**0.20**	**0.22**	**0.22**	**Mean**	**6.33**	**6.32**	**6.32**	**6.31**	**6.33**	**6.32**	**Mean**	**0.87**	**0.86**	**0.84**	**0.82**	**0.84**	**0.85**
For comparing means of	**S.Em.±**			**CD at 5%**			**For comparing means of**	**S.Em.±**			**CD at 5%**			**For comparing means of**	**S.Em.±**			**CD at 5%**		
Varieties	0.01			NS			**Varieties**	0.01			NS			**Varieties**	0.04			NS		
Nutrients	0.01			NS			**Nutrients**	0.01			NS			**Nutrients**	0.06			NS		
V × F	0.01			NS			**V × F**	0.02			NS			**V × F**	0.08			NS		

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties evaluation

V_1- Arka Suman
V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100 % Recommend dose of N supply through Vermicompost

Table 15 (b): Influence of varieties and nutrient management practices on nutrients in soil after harvest of vegetable cowpea

Varieties (V)	Nutrient management practices (N)																			
	Nitrogen N_2 (kg/ha)						Phosphorus $P_2 O_5$ (kg/ha)							Potassium $K_2 O$ (kg/ha)						
	F_1	F_2	F_3	F_4	F_5	Mean	Varieties (V)	F_1	F_2	F_3	F_4	F_5	Mean	Varieties (V)	F_1	F_2	F_3	F_4	F_5	Mean
V_1	320	319.6	319	318	318.6	**319.4**	**V_1**	45.3	45.20	42.6	43	42	**43.6**	**V_1**	323.30	323.27	323.24	323.23	323.26	**323.26**
V_2	320	317.4	320	317	319.8	**318.9**	**V_2**	42.3	42	43	42	44	**42.6**	**V_2**	323.26	323.22	323.20	323.19	323.21	**323.21**
Mean	**320**	**318**	**319**	**318**	**319**	**319.2**	**Mean**	**43.83**	**43.67**	**42.83**	**42.50**	**43**	**43.17**	**Mean**	**323.28**	**323.25**	**323.22**	**323.21**	**323.24**	**323.24**
For comparing means of	**S.Em. ±**			**CD at 5%**			**For comparing means of**	**S.Em. ±**			**CD at 5%**			**For comparing means of**	**S.Em. ±**			**CD at 5%**		
Varieties	0.36			NS			**Varieties**	0.44			NS			**Varieties**	0.45			NS		
Nutrients	0.56			NS			**Nutrients**	0.69			NS			**Nutrients**	0.71			NS		
V × F	0.80			NS			**V × F**	0.98			NS			**V × F**	1.01			NS		

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties evaluation

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 16 (a): Influence of different levels of Nutrients on nitrogen in plant sample (stem and root) at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Nitrogen (%) in cowpea stem						Nitrogen (%) in cowpea root					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	1.05	0.97	0.96	0.94	1.02	**0.98**	1.10	0.92	0.91	0.86	0.87	**0.91**
V_2	0.98	0.96	0.92	0.89	0.92	**0.93**	0.85	0.84	0.83	0.82	0.84	**0.83**
Mean	**1.02**	**0.97**	**0.94**	**0.92**	**0.97**	**0.96**	**0.94**	**0.88**	**0.87**	**0.84**	**0.86**	**0.87**

For comparing means of	S.Em.±	CD at 5%	S.Em.±	CD at 5%
Varieties	0.01	0.03	0.01	0.03
Nutrients	0.02	0.05	0.02	0.05
V × F	0.02	NS	0.03	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 16 (b): Influence of different levels of Nutrients on nitrogen in plant sample (leaves and pod) at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Nitrogen (%) in cowpea leaves						Nitrogen (%) in cowpea pods					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	2.73	2.71	2.68	2.66	2.70	**2.69**	2.70	2.64	2.62	2.58	2.65	**2.63**
V_2	2.69	2.65	2.63	2.58	2.61	**2.31**	2.60	2.56	2.42	2.33	2.45	**2.47**
Mean	**2.71**	**2.68**	**2.66**	**2.62**	**2.65**	**2.65**	**2.66**	**2.60**	**2.52**	**2.46**	**2.55**	**2.56**

For comparing means of	S.Em.$\pm$	CD at 5%	S.Em.$\pm$	CD at 5%
Varieties	0.02	0.06	0.02	0.07
Nutrients	0.03	0.10	0.04	0.11
V × F	0.05	NS	0.05	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 16 (c): Influence of different levels of Nutrients on phosphorus in plant sample (stem and root) at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Phosphorus (%) in cowpea stem						Phosphorus (%) in cowpea root					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	0.30	0.24	0.22	0.20	0.25	**0.24**	0.49	0.48	0.46	0.41	0.45	**0.45**
V_2	0.24	0.21	0.18	0.15	0.23	**0.20**	0.47	0.39	0.40	0.38	0.46	**0.42**
Mean	**0.27**	**0.23**	**0.20**	**0.18**	**0.24**	**0.22**	**0.48**	**0.44**	**0.43**	**0.40**	**0.46**	**0.44**

For comparing means of	S.Em.$\pm$	CD at 5%	S.Em.$\pm$	CD at 5%
Varieties	0.01	0.03	0.01	0.03
Nutrients	0.01	0.04	0.02	0.05
V × F	0.02	NS	0.02	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 16 (d): Influence of different levels of Nutrients on phosphorus in plant sample (leaves and pod) at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Phosphorus (%) in cowpea leaves						Phosphorus (%) in cowpea pod					
	F_1	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**
V_1	0.54	0.45	0.41	0.35	0.47	**0.44**	0.85	0.84	0.82	0.79	0.84	**0.82**
V_2	0.45	0.39	0.37	0.34	0.43	**0.39**	0.79	0.75	0.76	0.72	0.78	**0.76**
Mean	**0.49**	**0.42**	**0.39**	**0.34**	**0.45**	**0.42**	**0.82**	**0.80**	**0.79**	**0.76**	**0.81**	**0.79**

For comparing means of	S.Em.±	CD at 5%	S.Em.±	CD at 5%
Varieties	0.01	0.04	0.01	0.02
Nutrients	0.02	0.07	0.01	0.04
V × F	0.03	NS	0.02	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 16 (e): Influence of different levels of Nutrients on potassium in plant sample (stem and root) at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Potassium (%) in cowpea stem						Potassium (%) in cowpea root					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
V_1	1.58	1.34	0.85	0.87	0.98	**1.12**	0.71	0.67	0.60	0.58	0.61	**0.63**
V_2	0.98	0.87	0.94	0.89	0.96	**0.92**	0.56	0.55	0.52	0.51	0.54	**0.53**
Mean	**1.28**	**1.11**	**0.89**	**0.88**	**0.97**	**1.03**	**0.64**	**0.61**	**0.56**	**0.55**	**0.58**	**0.59**

For comparing means of	Stem S.Em.±	Stem CD at 5%	Root S.Em.±	Root CD at 5%
Varieties	0.06	0.18	0.01	0.03
Nutrients	0.10	0.29	0.02	0.05
V × F	0.14	NS	0.02	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

Table 16 (f): Influence of different levels of Nutrients on potassium in plant sample (leaves and pod) at harvest of vegetable cowpea varieties

Varieties (V)	Nutrient management practices (N)											
	Potassium (%) in leaves						Potassium (%) in pod					
	F_1	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**
V_1	0.63	0.62	0.60	0.57	0.61	**0.60**	0.85	0.82	0.78	0.73	0.79	**0.79**
V_2	0.59	0.58	0.56	0.54	0.57	**0.56**	0.77	0.76	0.79	0.72	0.77	**0.75**
Mean	**0.61**	**0.60**	**0.58**	**0.56**	**0.59**	**0.59**	**0.81**	**0.79**	**0.78**	**0.72**	**0.77**	**0.77**

For comparing means of	S.Em.$\pm$	CD at 5%	S.Em.$\pm$	CD at 5%
Varieties	0.01	0.02	0.01	0.03
Nutrients	0.01	0.03	0.02	0.05
V × F	0.01	NS	0.02	NS

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

pod (0.81 %) over all other nutrient management practices expect F_2- 100 per cent RDF and F_5-100 per cent N supply through vermicompost treatment after harvest.

Interaction effect of varieties and nutrient management practice on per cent potassium did not differ significantly at all growth stages.

4.3.4 Influence of varieties and different nutrient management practices on organoleptic evaluation of cowpea varieties

The data presented in table 17 obviously indicates that, colour, taste and overall acceptability of cowpea varieties was not significantly differed by influence of varieties and different nutrient management practices at all growth stages.

Interaction effect of varieties and nutrient management practice on colour, taste and overall acceptability of cowpea varieties did not differ significantly at all growth stages.

Table 17: Influence of varieties and nutrient management practices on organoleptic evaluation of cowpea varieties after harvest

Varieties (V)	Nutrient management practices (N)																			
	Colour						Taste							Over all acceptability						
	F_1	F_2	F_3	F_4	F_5	Mean	Varieties (V)	F_1	F_2	F_3	F_4	F_5	Mean	Varieties (V)	F_1	F_2	F_3	F_4	F_5	Mean
V_1	7.69	7.64	7.65	7.63	7.69	**7.66**	V_1	8.00	8.00	7.97	7.96	8.00	**7.98**	V_1	8.00	7.98	8	7.94	8.01	**7.98**
V_2	7.65	7.63	7.65	7.62	7.69	**7.64**	V_2	7.98	7.96	7.94	7.94	7.96	**7.95**	V_2	8.00	8.00	7.96	7..93	7.98	**7.97**
Mean	**7.67**	**7.64**	**7.65**	**7.63**	**7.69**	**7.65**	**Mean**	**7.99**	**7.98**	**7.96**	**7.95**	**7.98**	**7.97**	**Mean**	**8.00**	**7.99**	**7.98**	**7.94**	**8.00**	**7.98**
For comparing means of	**S.Em.±**			**CD at 5%**			**For comparing means of**	**S.Em.±**			**CD at 5%**			**For comparing means of**	**S.Em.±**			**CD at 5%**		
Varieties	0.10			NS			**Varieties**	0.10			NS			**Varieties**	0.10			NS		
Nutrients	0.15			NS			**Nutrients**	0.15			NS			**Nutrients**	0.15			NS		
V × F	0.21			NS			**V × F**	0.21			NS			**V × F**	0.21			NS		

NS- Non-Significant

DAS – Days After Sowing

Factor I: Varieties evaluation

V_1- Arka Suman

V_2- Arka Garima

RDF- Recommend dose of Fertilizer (25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1} + PSB (10g/ kg of seed)

Factor II: Nutrient management practices

F_1-125 % RDF

F_2-100 % RDF

F_3-75 % RDF

F_4-50 % RDF

F_5- 100 % Recommend dose of N supply through Vermicompost

5. DISCUSSION

The results of the field experiment on "**Nutritional studies on vegetable cowpea in northern dry zone of Karnataka"** conducted during 2016-17 at Haveli farm, Bagalkot district are discussed in this chapter.

The crop growth is mainly dependent on environmental factors. Fluctuations in weather conditions greatly influence the crop growth, development, yield and quality. During the experimentation, 331.00 rainfall was received during cropping period from August-2016 to October- 2016. The mean maximum temperature was 30.90°C and the mean temperature was 17°C. In this investigation, an attempt was made to study the

5.1 Optimum dose of N, P, K in vegetable cowpea in northern dry zone of Karnataka

5.2 Assess the nutrition quality (protein and nutrient content) of vegetable Cowpea as influenced by the nutrition management practices.

5.3 Organoleptic test of vegetable cowpea varieties.

5.1 Find out the optimum dose of N, P, K in vegetable cowpea in northern dry zone of Karnataka

5.1.1 Effect on growth parameters

Among growth parameters, the plant height, number of leaves per plant, leaf area index and dry matter production was studied in cowpea**.**

The results revealed that among varieties variety Arka Suman recorded significantly higher plant height of (13.51 cm) as compared to Arka Garima (12.64 cm) at 30 DAS. Similarly, at 60 DAS significantly higher plant height was recorded in Arka Suman (25.21 cm) as compared to Arka Garima (23.42 cm). This may be due to application of major nutrients through different levels of chemical fertilizers, increased the photosynthetic activity, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant height. These results are in line with findings of Baboo and Mishra (2004) reported that the plant height increased with

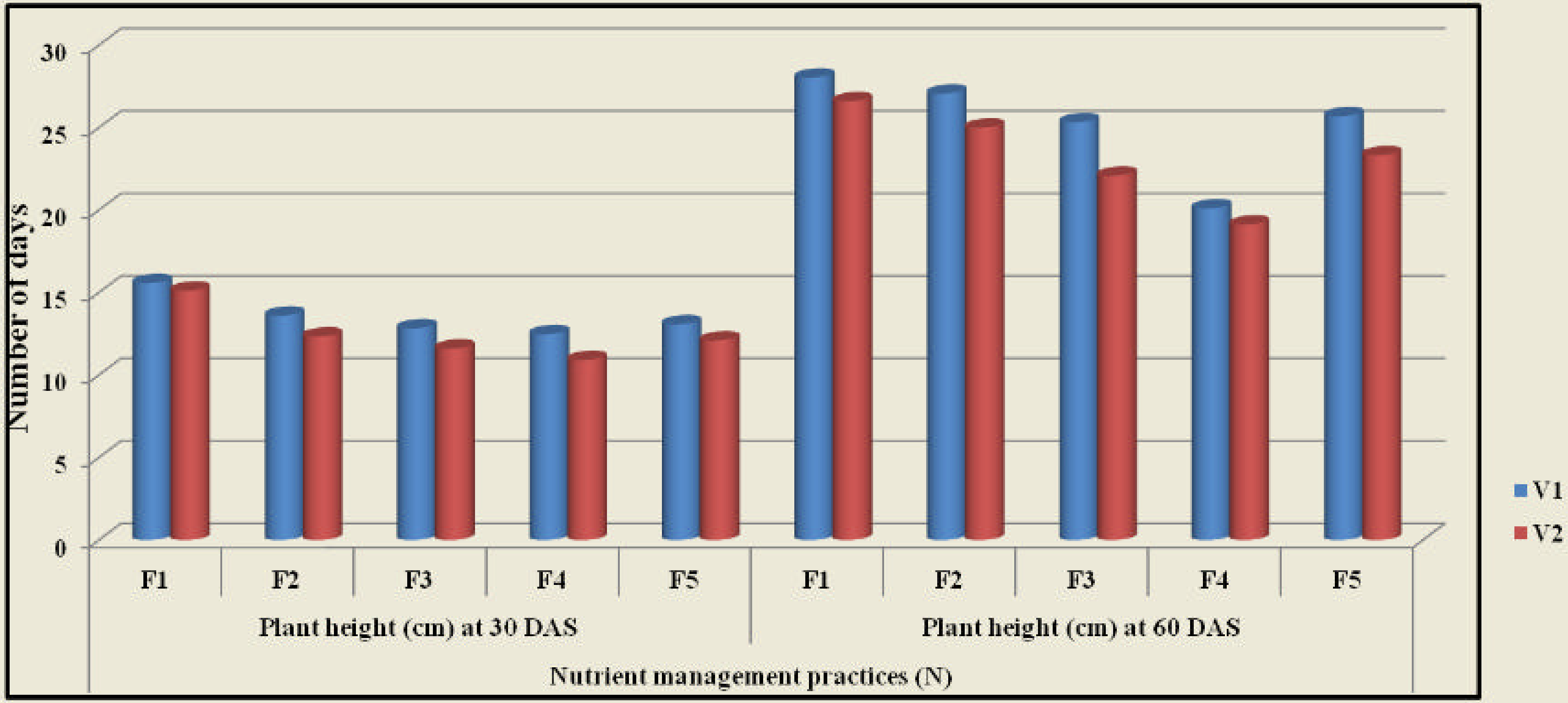

Fig 2. Response of varieties and nutrient management practices on plant height

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+ PSB (10g/ kg of seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

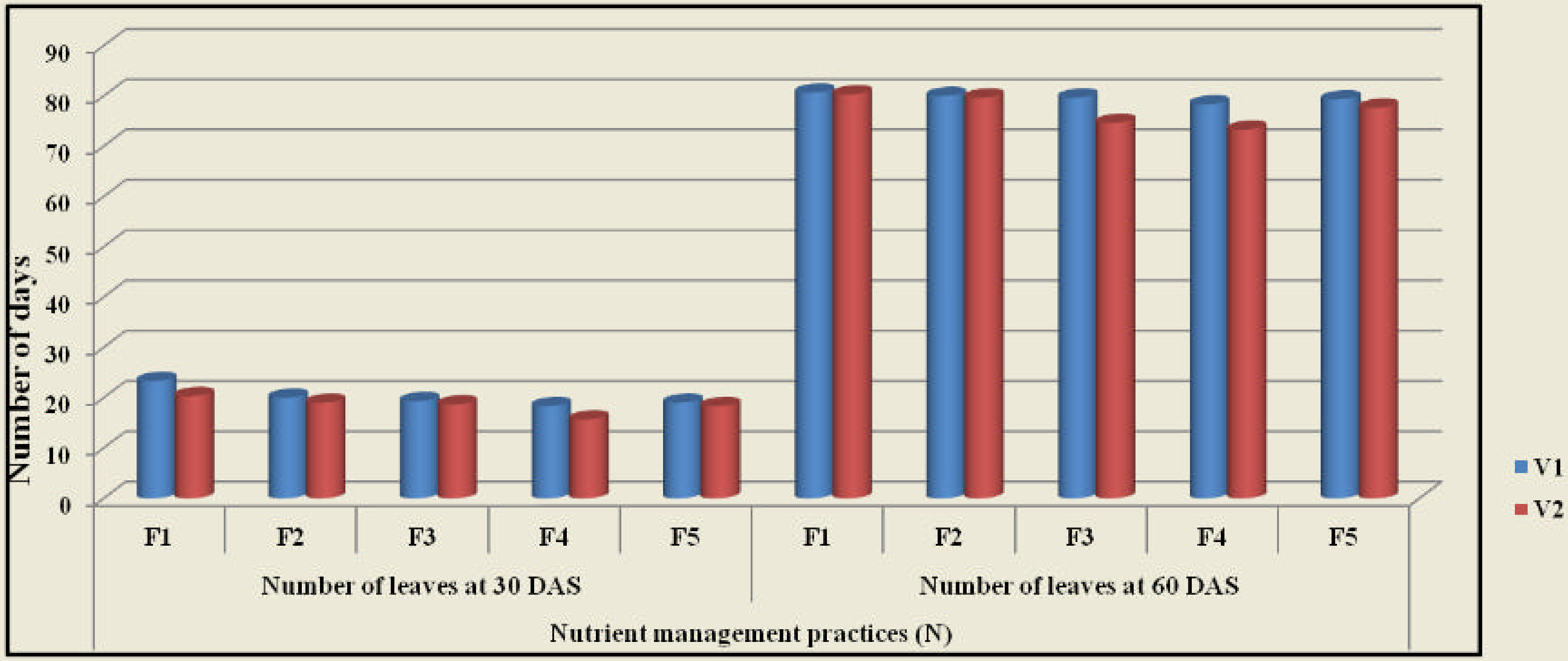

Fig 3. Response of varieties and nutrient management practices on number of leaves

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+ PSB (10g/ kg of seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

increasing levels of N (40 kg N/ha) and P (90 kg/ha). Choudhary *et al.* (2013) reported that the application of fertilizers upto 100% RDF recorded significantly higher plant height over its preceding levels. Chandraker *et al.* (2001) reported that plant height increased maximum under the treatments 25:70:60 kg NPK/ha and 25:70:60 kg NPK + 25 t FYM/ha as compared to all other treatments. Shivarn and Yadava, (2015) reported similar results application of nitrogen and phosphorus @ 40 and 80 kg per ha resulted in maximum and significantly higher plant height, dry matter accumulation, chlorophyll content, total effective fresh and dry weight of nodules per plant. Amujoyegbe and Alofe, (2003) reported application Nitrogen at 40 kg/ha to cowpea plants significantly increased in plant growth, dry matter content, yield and its quality as well as the nutritional value of seeds. Meera *et al.* (2010) opined that application of poultry manure in two split doses along with inorganic fertilizers at 20:30:10 kg N, P and K per hectare shows significant increase in plant height, dry matter production, number of branches per plant and seed yield respectively.

The results revealed that among varieties variety Arka Suman recorded significantly higher number of leaves and leaf area index (20) and (0.64) as compared to Arka Garima (18.40) and (0.56) at 30 DAS. Similarly, at 60 DAS significantly higher number of leaves and leaf area index was recorded in Arka Suman (79.60) and (0.72) as compared to Arka Garima (77.13) and (0.67). Probable reasons for enhanced more number of leaves, may be due to promotive effects of macro nutrients on vegetative growth which ultimately lead to more photosynthetic activities. And in case of higher leaf area index could be due to the higher uptake of nutrients from the soil resulting in greater photosynthetic activity cause an increased leaf area index. These findings are in agreement with the findings of Wagh *et al.* (2011) reported that the growth parameters the plant height, number of leaves, leaf area and leaf area index were significantly increased to a greater extent by the treatment 75 per cent RDF + Vermicompost + Rhizobium + PSB as compared to RDF alone. Abayomi *et al.* (2008) reported application higher doses of 150 kg NPK per ha-^{1} significantly increase the plant height, number of leaves per plant, leaf area index, total number of flowers and total dry matter as compare to different level of fertilizer treatments. Nkaa *et al.* (2014) reported that 50 kg phosphorus application showed significant increase on Plant height, leaf area index, number of leaves per plant and number of branches in all

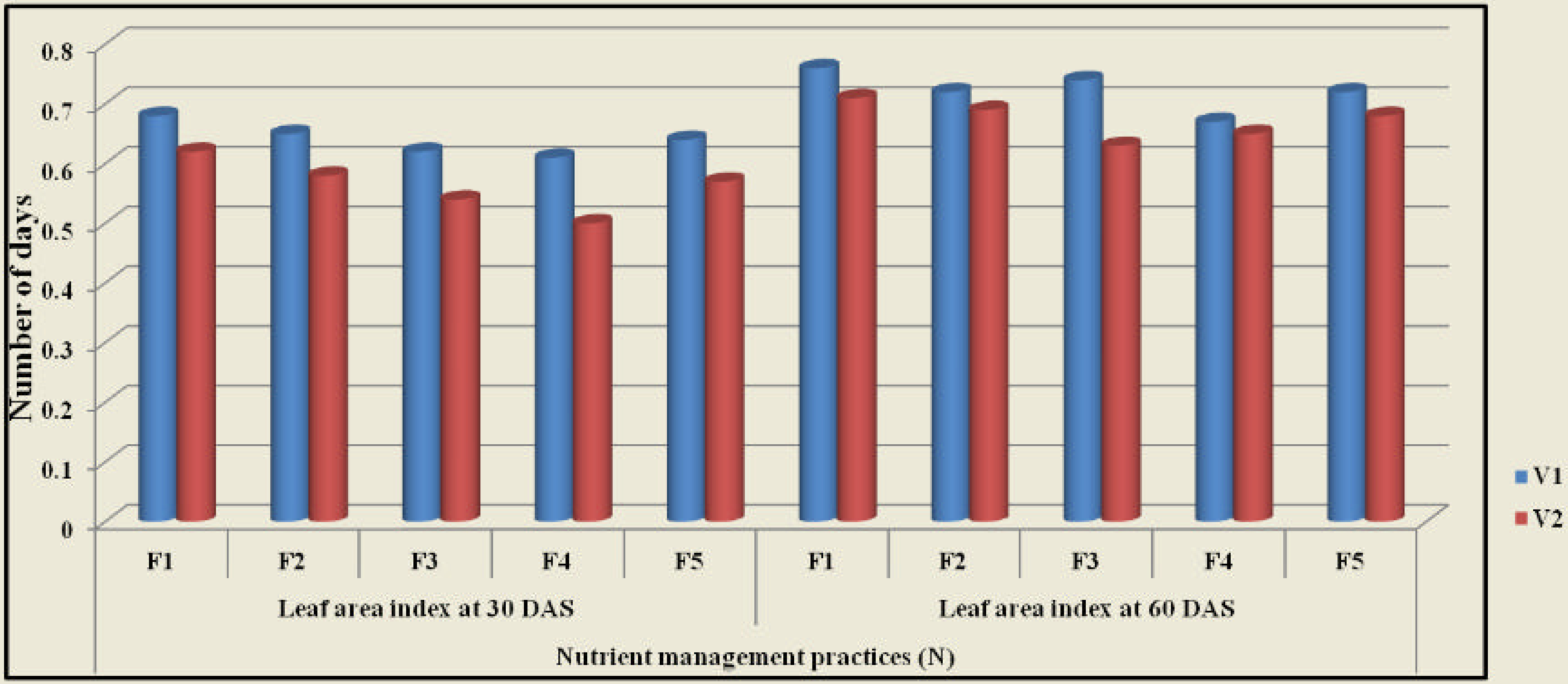

Fig 4. Response of varieties and nutrient management practices on leaf area index

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+ PSB (10g/ kg of seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

the weeks. Further the same results reported by Msaakpa *et al.* (2016) reported that application of 40 kg N/ha and 60 kg P/ha significantly increase in leaf are index at 30, 60 and 90 days respectively.

The results revealed that among varieties Arka Suman (V_1) recorded significantly higher dry matter production of stem, (12.39 g/plant), leaves (12.29 g/plant), root (2.03 g/plant) and pod (8.27 g/plant as compared to Arka Garima (V_2) with (12.10 g/plant), (11.63 g/plant), (1.96 g/plant) and (7.62 g/plant) at harvest respectively. This could be due to the higher uptake of nutrients from the soil resulting in greater photosynthetic activity to the increased the dry matter production. These results are in line with findings of Amujoyegbe and Alofe, (2003) reported application Nitrogen at 40 kg/ha to cowpea plants significantly increased in plant growth, dry matter content, yield and its quality as well as the nutritional value of seeds. Kabir *et al.* (2007) opined that application of 0 + 60 + 40 kg NPK per ha^{-1} showed maximum number of nodules and higher dry matter production respectively. Shivarn *et al.* (2015) reported similar results application of nitrogen and phosphorus @ 40 and 80 kg per ha^{-1} resulted in maximum and significantly higher plant height, dry matter accumulation, chlorophyll content, total effective fresh and dry weight of nodules per plant, seed and stover yield. The similar results reported by Anilkumarsingh *et al.* (2007) revealed that application of 30 kg N and 60 kg P_2O_5 per ha and Rhizobium inoculation significantly increased in number of nodules, dry matter production, leaf area index and number of pods per plant. Meera *et al.* (2010) opined that application poultry manure in two split doses along with inorganic fertilizers at 20:30:10 kg N, P and K per hectare shows significant increase in plant height, dry matter production, number of branches per plant and seed yield.

5.1.2 Effect of varieties and different levels of nutrient management practices on yield parameters of cowpea

The results revealed that among varieties and different nutrient management practices cause there is a no significant difference in number of pods per cluster at harvest respectively. But number of cluster per plant was significantly influenced by varieties and different nutrient management practices. Results revealed that higher number of cluster per plant (4.73) was observed in variety Arka Suman as compare Arka Garima (3.86) at harvest respectively. This may be due to increased supply of

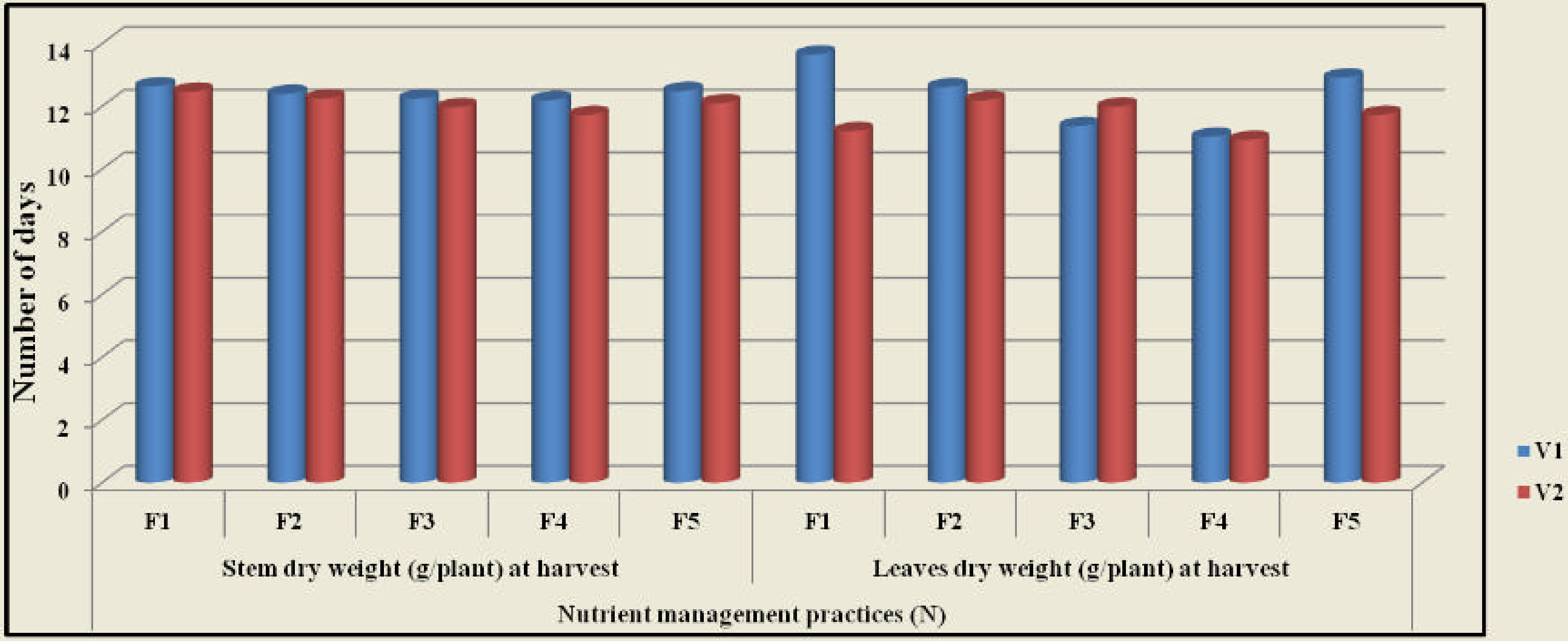

Fig 5. Response of varieties and nutrient management practices on stem and leaves dry weight

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+ PSB (10g/ kg of seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

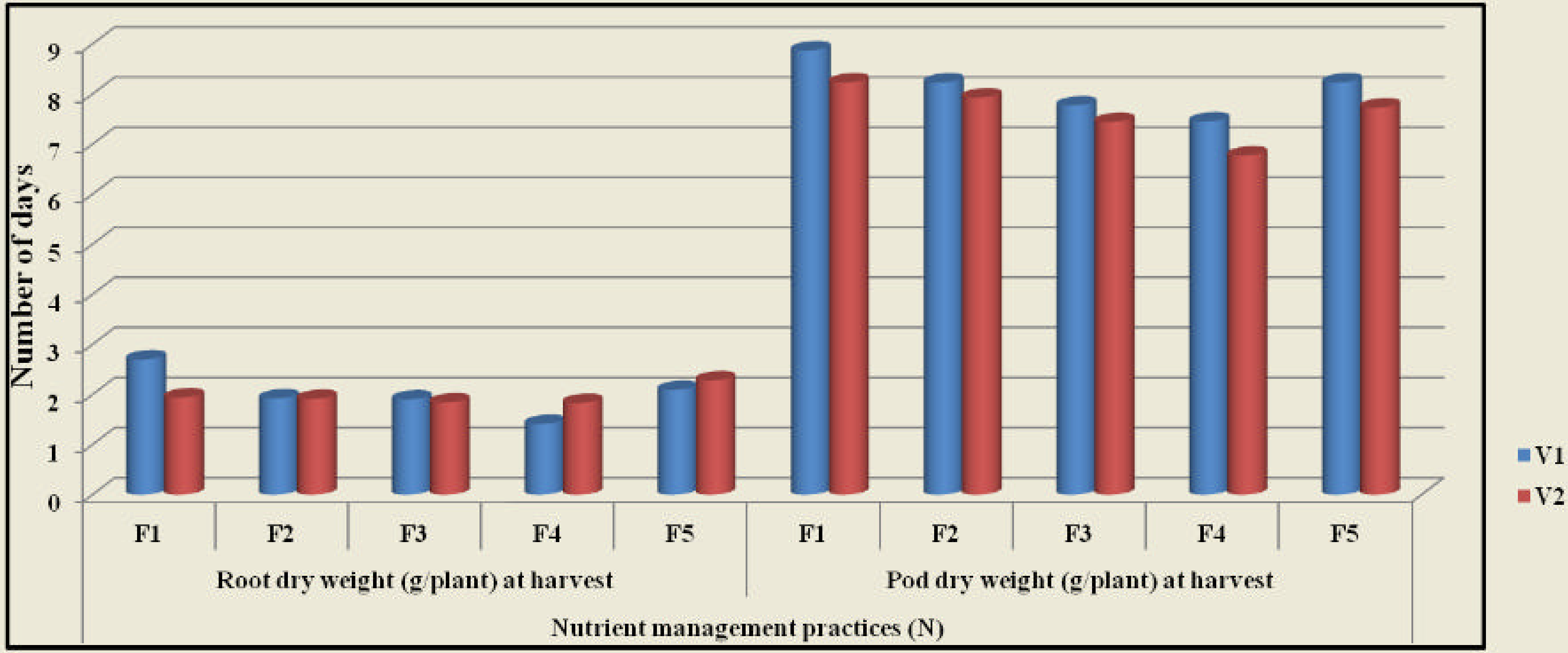

Fig 6. Response of varieties and nutrient management practices on root and pod dry weight

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+PSB (10g/ kg seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

major plant nutrients and are required in larger quantities for growth and development of plants.

And in case of pod yield per plant and number of pods per plant, significantly higher pod yield per plant (9.45 g/plant) and number of pods (9.50) was observed in variety Arka Suman as compare Arka Garima with pod yield per plant (8.27 g/plant) and number of pods (8.37) at harvest respectively. This may be due to favourable effects of nitrogen on overall metabolic processes of the plant and beneficial effects on growth. These findings are in agreement with the findings of Kumar *et al.* (2001) reported that the application of 50 kg P_2O_5/ha as di-ammonium phosphate (DAP) is the best source for getting higher pod yield per plant. Baboo and Mishra (2004) reported that the highest pod yield per plant and number of pods were highest with the application of 20 kg N/ha in combination with rhizobacterium inoculation. Kishanswaroop *et al.* (2006) opined that maximum number of pods, pod yield per plant, length of root and seed yield was obtained with the application of 80 kg, P, 60 kg K, 20 kg N/ha + *Rhizobium* inoculation. Patel and Singh, (2009) revealed that application of 20 kg N + 40 kg P_2O_5 per ha along with *Rhizobium* seed inoculation gave significantly higher number of cluster per plant, number of pods per plant, pod yield per plant and 50 per cent flowering compare to other nutrient treatments. Choudhary *et al.* (2013) reported that the application of fertilizers up to 100% RDF recorded significantly higher pod yield per plant over its preceding levels.

Results revealed that significantly higher pod length (18.34 cm) was observed in variety Arka Garima as compare Arka Suman (13.96 cm) at harvest respectively. This may be due to increased supply of major plant nutrients. Nitrogen accelerates the development of growth and reproductive phases and protein synthesis, thus promoting pod length. Similar results have been reported by Kumar *et al.* (2001) reported that the application of 50 kg P_2 O_5/ha as diammonium phosphate (DAP) is the best source for getting higher pod length. Singh *et al.* (2011) showed that *Rhizobium* inoculation, 30 kg N and 60 kg P_2 O_5/ha produced significantly higher length per pod of cowpea over control. Further, Nandi (2005) reported that the highest pod length was obtained in T_1 (full recommended dose of NPK) followed by T_5 (Neem cake 2.5 q/ha + Half NPK) and T_3 (FYM 10 t/ha + half NPK). Further, similar results reported by Subbarayappa *et al.* (2009) revealed that the application of 100 per cent RDF + FYM

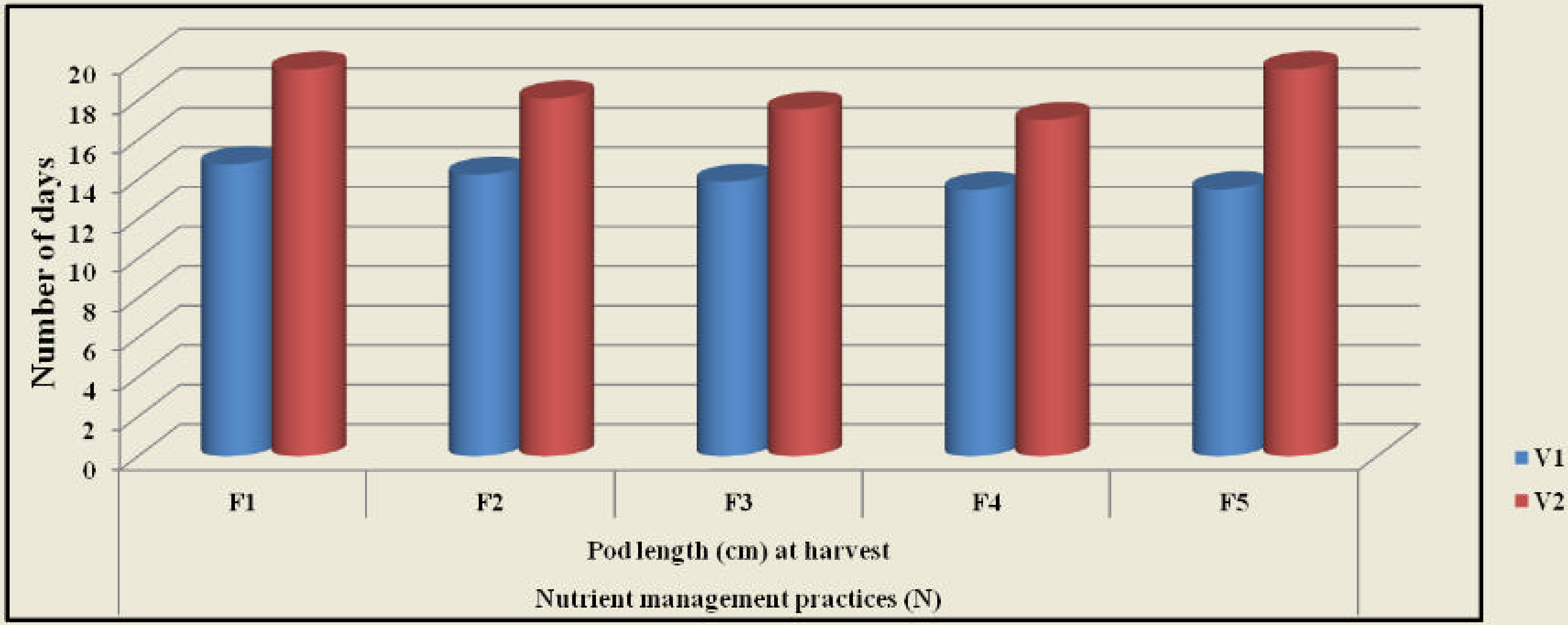

Fig 7. Response of varieties and nutrient management practices on pod length

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+PSB (10g/ kg of seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

Arka suman V_1 **Arka garima- V_2**

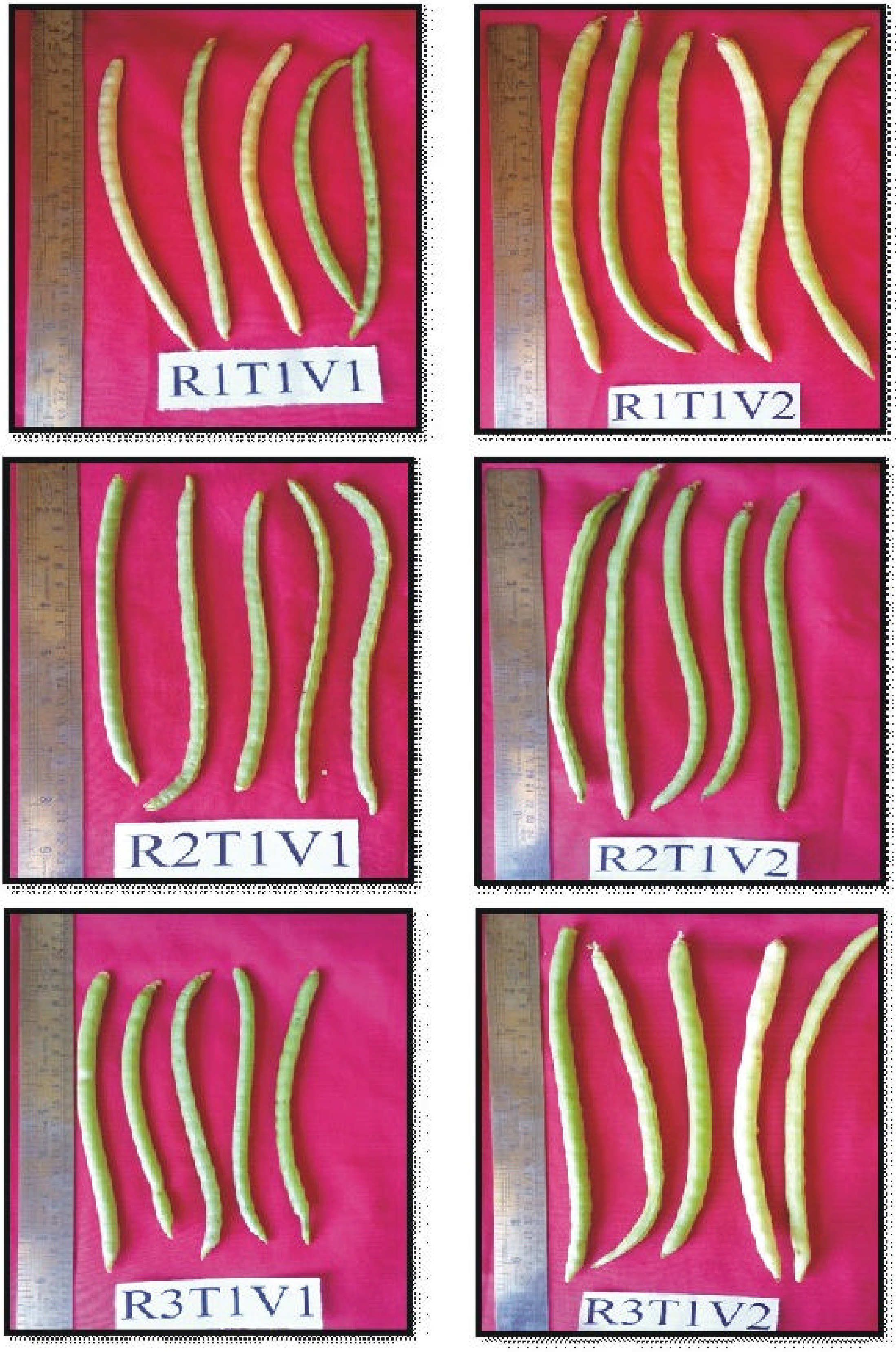

Plate 2: Effect of varieties and nutrient management practices on pod length of vegetable cowpea at harvest

significantly increased the pod length. Wagh *et al.* (2011) reported that the yield contributing factors, such as length of pods, was found significant in the treatment of 75 per cent RDF + Vermicompost + *Rhizobium* + PSB over control and RDF alone.

Results revealed that significantly higher fresh weight of pod (24.28 g/plant) was observed in variety Arka Suman as compare Arka Garima (16.88 g/plant) at harvest respectively. And significantly higher seed weight (10.51 g) reported in variety Arka Suman as compare to Arka Garima (9.74 g/plant) at harvest respectively. This may be due to favourable effects of nitrogen on overall metabolic processes of the plant and beneficial effects on growth. The findings are in agreement with the findings of Chandrakar *et al.* (2001) reported that application of FYM or cattle dung slurry played a great role for enhancing the weight of 1000 pods and low 100 seed weight. Gohari *et al.* (2010) reported that the greatest seed yield, 100 seed weight, number of pods per plant and number of leaves per plant was showed highest by the use of 30 kg per ha nitrogen fertilizer. Further, the same results reported by Samawat and Borah (2001) reported that the application of chemical fertilizers and vermicompost had a significant effect on pod weight. Further, Singh *et al.* (2011) revealed that application of 60 kg P ha^{-1} showed significant response to pods per plant, grain and stover yield and 100-seed weight was highest in both the varieties (KVX303096G and TN5-78) with the application of 60 kg P ha^{-1}.

Results revealed that significantly higher total bio mass (3072.0 kg/ha), pod yield (1456.1 kg/ha), seed yield (1409.2 kg/ha) and stover yield (1615.8 kg/ha) was observed in variety Arka Suman as compare Arka Garima (2922.0 kg/ha), pod yield (1425.1 kg/ha), seed yield (1353.2 kg/ha) and stover yield (1496.8 kg/ha) at harvest respectively. This may be due to favourable effects of nitrogen on overall metabolic processes of the plant and beneficial effects on growth. The findings are in agreement with the findings of Abayomi *et al.* (2008) opined that application of 150 kg NPK per ha^{-1} significantly increase the plant height, number of pods per plant, pod yield, seed yield, number of flowers and total dry matter respectively. Nkaa *et al.* (2014) reported that 50 kg phosphorus application showed significant increase on Plant height, leaf area, number of leaves per plant and number of branches in all the weeks of measurement and also had a significant effect on seed yield, pod yield, number of nodules and total above ground dry matter in all varieties used. Danielnyoki and

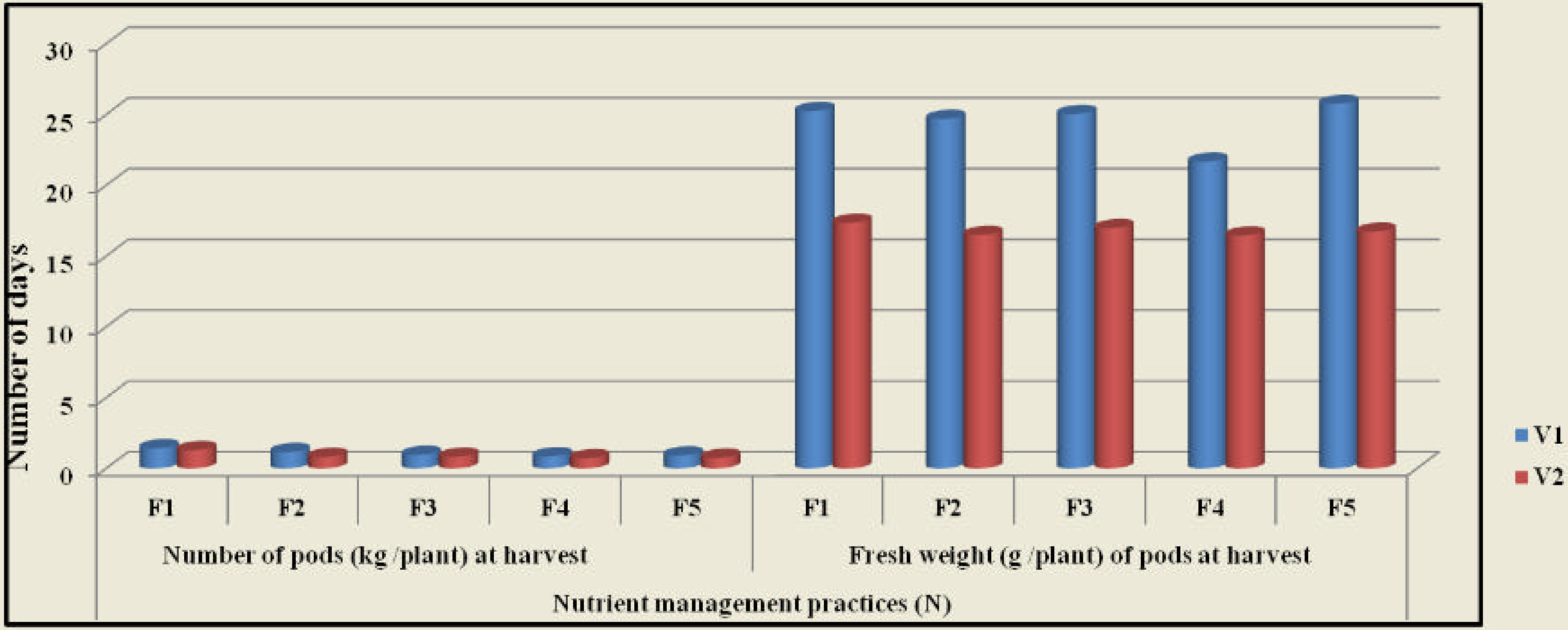

Fig 8. Response of varieties and nutrient management practices on pods per plant and fresh weight of pod

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+ PSB (10g/ kg of seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

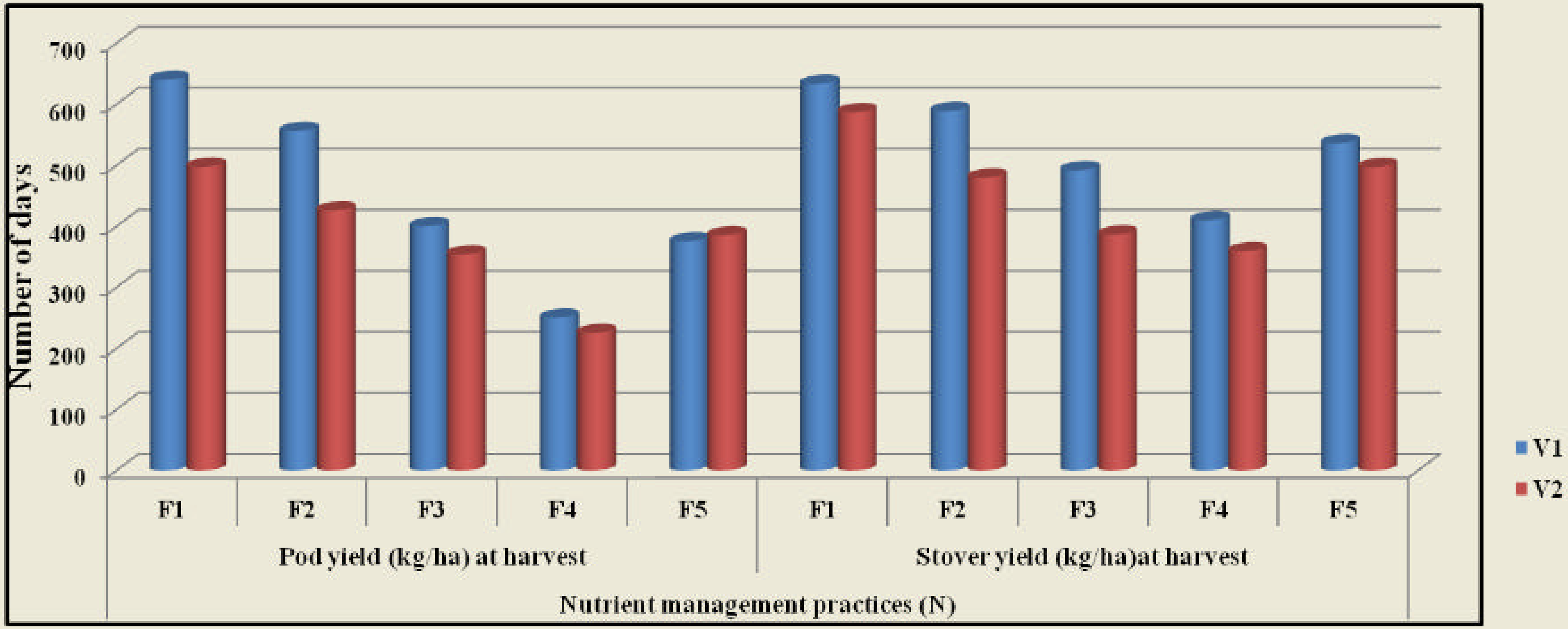

Fig 9. Response of varieties and nutrient management practices on pods yield and stover yieid

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+PSB (10g/ kg of seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

Patrick, (2014) revealed that *Rhizobium* inoculation and supplementation of phosphorus independently or in combination had positive effects on seed yield and stover yield as compare to control. Rahelehjenabi *et al.* (2015) revealed that application of 30 kg of nitrogen and potassium fertilizers per hectare showed highest amount of seed yield and higher pod yield.

Results revealed that significantly higher harvest index (0.28) was observed in variety Arka Suman as compare Arka Garima (0.26) at harvest respectively. This may be due to adoption of higher levels of nutrient management practices was attributed to better growth and development of cowpea varieties. The findings are in agreement with the findings of Daramy *et al.* (2017) revealed that application of nitrogen (40 kg N/ha) and phosphorus (45 kg P_2O_5/ha) fertilizers showed significant effect on total bio mass, number of pods, pod yield and harvest index of cowpea in a cultivar of Asontem. In Hussein *et al.* (2014) reported that addition of K incorporation with P increased in plant height, no of leaves, no of pods per plant, seed yield total bio mass and harvest index and dry matter production.

5.1.3 Effect of different varieties and different levels of nutrient management practices on quality parameters of cowpea.

Results revealed that significantly higher per cent of protein (0.58 %) was observed in variety Arka Suman as compare Arka Garima (0.46 %) at harvest respectively. This may be due to adoption of higher levels of nutrient management practices was attributed to better growth, higher crude fiber development of cowpea varieties. These results are confirmed with findings of Anuja *et al.* (2006) opined that application of 70 kg phosphorus and 70 kg per ha potassium significantly increased the pod yield per plot, higher crude protein content and total dry matter content. Magani and Kuchinda (2009) reported that application of 37.5 kg P was the most economical level for maximum grain yield and crude protein content. Further similar results reported by Jadhav *et al.* (2011) reported that plant height, seed yield, maximum nodulation and protein content were found significantly increase with 20 kg N + 40 kg P_2O_5 per ha. Odedeji and Okyeleke, (2011) revealed that dehulled cowpea showed higher crude protein, carbohydrates, fat, ash, fibre and moister as compare to whole cowpea flour respectively. The same results reported by Ogundele *et al.* (2015) reported that nutritional composition of soyabean showed higher

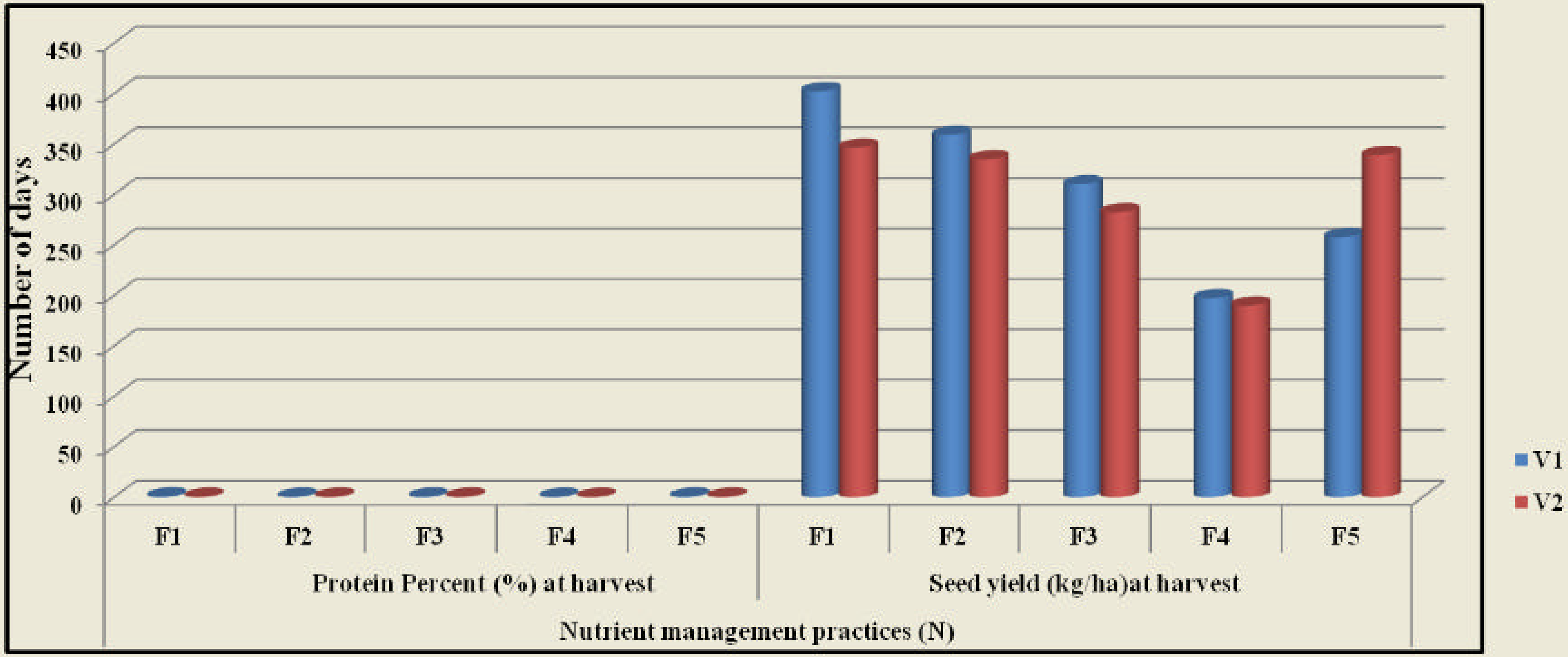

Fig 10. Response of varieties and nutrient management practices on protein percent and seed yield

V_1- Arka Suman
V_2- ArkaGarima

RDF-Recommend dose of Fertilizer
(25:75:60 kg NPK /ha^{-1} + *Rhizobium* 375 kg/ha^{-1}+ PSB (10g/ kg of seed)

F_1-125 % RDF
F_2-100 % RDF
F_3-75 % RDF
F_4-50 % RDF
F_5- 100% Recommend dose of N supply through Vermicompost

moisture content of, protein content, ash, crude fat, crude fiber and carbohydrate as compare to cowpea fresh seeds.

5.2 Effect of nutrient management practices on pH, EC, organic carbon, N, P and K after harvest

Results revealed that different nutrient management practices was not significantly influence on organic carbon, pH, EC, N, P and K content in soil. These results are confirmed with findings of Kumara *et al.* (2012) opined that addition of organic manures (FYM, poultry manure, press mud) alone or in combination with N or NP fertilizers for 16 years brought variations in soil pH, EC, organic carbon, N, P and K over the initial value but goes on days there is a decrease in soil pH, organic carbon, EC, N, P and K content in Under pearl millet-wheat cropping sequence. Nandi (2005) found that 100% NPK to both crops increased organic carbon and available P content by 0.06% and 3.5 kg ha^{-1} respectively, while available K content decreased by 3.5 kg ha^{-1}. Russell *et al.* (1961) reported an increase in organic carbon, available N, P and K status in soil with increase in fertilizer levels. Risikesh *et al.* (2011) reported that continuous application of 100% NPK–S treatment caused a continuous depletion in soil pH, EC and organic carbon status over initial value. Babbu *et al.* (2015) reported that pH was significantly reduced to 7.25 with 150% NPK application compared to 50% NPK treatment. No significant decrease in pH was observed with increase in fertilizer rate from 50% NPK to 100% NPK.

5.3 Influence of varieties and different nutrient management practices on of N, P and K per cent after harvest of vegetable cowpea

Results revealed that applying different nutrient management significantly influence on uptake nutrients in cowpea varieties. Results revealed that higher per cent of nitrogen, phosphorus and potassium in stem (0.98, 0.24 and 1.12 %), leaves (2.69, 0.44 and 0.60 %), root (0.91, 0.45 and 0.63%) and pod (2.63, 0.82 and 0.79 %) was observed in variety Arka Suman as compare Arka Garima in stem (0.93, 0.20 and 0.92 %), leaves (2.31, 0.39 and 0.56 %), root (0.83, 0.42 and 0.53 %) and pod (2.47, 0.76 and 0.75 %) at harvest respectively. This may be due to adoption of higher levels of nutrient management practices was attributed to better growth and development and indirectly influence on better uptake of nutrients. The present results are in accordance with those of Verma *et al.* (2015) reported that application of nitrogen @ 40 kg per ha and phosphorus @ 80 kg per ha showed significantly increase in higher N, P and K uptake. Jamadagni and Birari, (1994) reported that Phosphorus application 0, 20 and 40 P kg^{-1} significantly enhanced shoot and root dry weight, total biomass, number of nodule, nodules dry weight, and higher N and P uptake in the genotype (IT92KD-405.2) compare to other genotypes. Further similar results reported by Maneeshkumar *et al.* (2013) opined that the application of phosphorus 60 kg and molybdenum 10 mg had a significant influence on plant height, green forage and nutrient uptake N, P and K respectively. The same results reported by Kishanswaroop (2006) revealed that maximum yield of green pods per ha was obtained with the application of 80 kg, P, 60 kg K, 20 kg N/ha + *Rhizobium* inoculation and uptake of phosphorus, uptake of N and P per ha in soil was recorded maximum with the application of 120 kg P, 120 kg K and 20 kg N + Rhizobium inoculation.

Future line of work

1. There is a need to find out cheap and best method of fertilizer application with commercial recommended practices.

2. A long term field investigations need to be conducted to a certain recommended practice on yield, quality and economics.

6. SUMMARY AND CONCLUSIONS

A field experiment was conducted at Haveli farm, Bagalkot district, during 2016-17 to study the **Nutritional studies on vegetable cowpea in northern dry zone of Karnataka.** The experiment consisted of two factors. Namely, Varieties [Arka Suman (V_1) and Arka Garima (V_2)] and different levels of nutrient practices [F_1- 125 % Recommend dose of Fertilizer; F_2- 100 % Recommend dose of Fertilizer; F_3- 75 % Recommend dose of Fertilizer; F_4- 50 % Recommend dose of Fertilizer; F_5- 100% Recommend dose of N supply through Vermicompost + PSB]. The experiment was replicated thrice in a randomized complete block design with factorial concept. The salient findings of the present investigation summarized below.

Adoption of varieties and different levels nutrient management practices were studied in vegetable cowpea plant. Among different levels of nutrient management practices 125 per cent RDF is considered to be most beneficial as evident from higher yields obtained from cowpea varieties. Among two varieties Arka Suman (V_1) proved to best for better growth, higher yield and quality. Interaction effect of varieties and different levels of nutrient management practices proved to be non significant for most of the characters. However, variety Arka Suman (V_1) along with 125 per cent RDF resulted in better growth and development which is manifested in higher yields.

The quality parameters like protein per cent and stover yield were also influenced by both varieties and different nutrient management practices. The combination of variety Arka Suman (V_1) along with 125 per cent RDF resulted significantly increase in quality parameters compare to other variety and different levels of nutrient management practices.

Conclusions

1. As the experiment was conducted for only one season, adoption variety Arka Suman (V_1) along with 125 RDF (F_1) found superior over other variety and different nutrient management practices. Nevertheless, a significant increase in yield of cowpea was recorded with the combined use of particular variety and particular recommend doses of fertilizer.

2. Adoption of particular variety and proper recommended dose of fertilizer resulted in higher quality over other practices.

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Appendix I: Physical and chemical properties of soil of the experimental site

Sl. No	Parameters	Values
1	**Particle size distribution (%)**	
a	Sand	25 %
b	Silt	38 %
c	Clay	37 %
d	Soil type	Reddish loamy
2	**Chemical Properties**	
a	pH (1:2.5)	6.33
b	Electrical conductivity (dSm^{-1})	0.85
c	Organic carbon (%)	0.21
d	Available Nitrogen (kg ha^{-1})	286
e	Available phosphorus (kg ha^{-1})	28.27
f	Available Potassium (kg ha^{-1})	196

Appendix II: Meteorological data recorded during the experimental period (2016) at Haveli farm, UHS, Bagalkot

Month	Temperature (°C)		Mean relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
August 2016	29.00	21.00	86.00	70.00
September 2016	28.00	21.00	85.00	139.00
October 2016	30.90	18.00	84.00	93.00
November 2016	28.00	17.00	70.00	29.00

Appendix III: Cost of cultivation of vegetable cowpea during (2016- 2017)

Sl. No.	Particulars	Required units/ha	Unit price (Rs)	Total cost (Rs)
1	**Land preparation:** (tractor ploughing) M. B plough Cultivator	1 hrs 1 hrs	600/hr 600/hr	600.00 600.00
	b. Vermicompost	50 kg	250/50 kg	500.00
	labour	WL 4	200/l	800.00
	Ploughing tractor	1 hr	600/hr	600.00
2	**Seed and inputs**			
	a. Seed material	15 kg	250/kg	3750
	b. Bullock pair	2 hr	100/hr	200.00
	c. Labour (seed treatment sowing)	WL 5	200/L	1000.00
	C. Fertilizer			
	a. Urea	82 kg	281/50 kg	697.2
	b. SSP	2588 kg	262/50 kg	22,256
	c. MOP	190.7kg	566/50 kg	3,221
	d. Vermicompost	1304 kg	250/50 kg	5170
	e. Rhizobium	3.75 kg	60/kg	225.00
	f. Labour for fertilizer application	WL 5	200/L	1000
3	**Intercultivation**			
	a. Weeding	WL 5 labours	200	1000
	b. Harrowing by bullock pair	5 hr	100/hr	500.00
4	**Plant protection chemicals**			
	a. Bavistin	1 kg	350/kg	350.00
	b. Mancozeb	1 kg	290/kg	290.00
	c. Imidachloprid	250 ml	290/l	275.00
	d. Chloropyriphos	1 lit	480/l	480.00
	e. Labour for spraying	ML 3-times)	200/L	600.00
5	**Harvesting and grading**			
	Pod harvesting	WL 5	200/l	1000.00
	Threshing and grading	WL 5	200/l	1000.00
	Bullock pair	3 hr	100/hr	300.00
6	**Bagging and transportation**	ML 2 labour	200/l	400.00
7	Land tax	1250		1250
Total approximate cost/ha Rs:				48,064.00

Appendix IV: Cost of fertilizers and manures for cowpea cultivation as per the prevailing market prices during May, 2017

Sl. No	Particulars	Dosage	Cost (₹)/ha
I.	**Inorganic fertilizers**		
	1. Nitrogen (urea ₹ 5.62/kg)		
	a) 125 % N	30 kg N ha^{-1}	168.6
	b) 100 % N	24 kg N ha^{-1}	134.8
	c) 75% N	18 kg N ha^{-1}	101.1
	d) 50 % N	12 kg N ha^{-1}	67.44
	2. Phosphorous (SSP ₹ 5.25/kg)		
	a) 125 % P	925 kg P ha^{-1}	4856.2
	b) 100 % P	740 kg P ha^{-1}	3885
	c) 75% P	554 kg P ha^{-1}	2908.5
	d) 50 % P	369 kg P ha^{-1}	1937.2
	3. Potassium (MOP ₹ 11.32/kg)		
	a) 125 % K	68.1 kg K ha^{-1}	771.7
	b) 100 % K	54.5 kg K ha^{-1}	616.9
	c) 75% K	40.9 kg K ha^{-1}	462.9
	d) 50 % K	27.2 kg K ha^{-1}	307.9
II	**Organic manures**		
	1. Vermicompost (₹ 5/kg)		
	a) 100 % VC	1034 kg ha^{-1}	5071

Appendix V. Cost benefit ratio of cowpea cultivation

Cost benefit ratio of Arka Suman (V_1)

Sl. No.	Treatment	Pod Yield (kg/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs)	Net return (Rs)	B : C ratio
1	V_1 F_1 : 125 % Recommended dose of N:P:K	1742.4	16346.5	43560.6	27214.1	2.66:1
2	V_1 F_2: 100 % Recommended dose of N:P:K (25:75:60 kg/ha)	1545.4	15186.7	38636.3	23449.6	2.54:1
3	V_1 F_3: 75 % Recommended dose of N:P:K	1242.4	12862.5	31060.6	18198.1	2.41:1
4	V_1 F_4: 50 % Recommended dose of N:P:K	1210.1	12862.5	30252.5	17390	2.35:1
5	V_1 F_5: 100 % N through Vermicompost	1540.4	15621	38510	22964	2.47:1

Cost benefit ratio of Arka garima (V_2)

Sl. No.	Treatment	Pod Yield (kg/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs)	Net return (Rs)	B : C ratio
1	V_2 F_1 : 125 % Recommended dose of N:P:K	1645.4	16346.5	41135	24788.5	2.51:1
2	V_2 F_2: 100 % Recommended dose of N:P:K (25:75:60 kg/ha)	1493.9	15186.7	37347.5	22160.8	2.45:1
3	V_2 F_3: 75 % Recommended dose of N:P:K	1342.4	12862.5	33560	19537.5	2.39:1
4	V_2 F_4: 50 % Recommended dose of N:P:K	1187.5	12862.5	29687.5	16825	2.30:1
5	V_2 F_5: 100 % N through Vermicompost	1456.6	15621	36415	20794	2.33:1

NUTRITIONAL REQUIREMENT OF VEGETABLE COWPEA IN NORTHREN DRY ZONE OF KARNATAKA (*Vigna unguiculata* L.)

KAVIRAJA. H **2017** **Dr. C. P MANSUR**
Major Advisor

ABSTRACT

An investigation on "Nutritional requirement of vegetable cowpea in northren dry zone of karnataka" (*Vigna unguiculata* L.) was undertaken during *kharif* season of 2016. The experiment involving two varieties and five different combinations of chemical fertilizers was laid out in randomized complete block design with factorial concept and replicated thrice in Haveli farm under University of Horticultural Sciences, Bagalkot. To assess the performance of cowpea varieties for vegetative, yield and quality parameters.

Analysis of variance revealed highly significant difference between varieties and treatment combinations. The variety Arka Suman (V_1) found better for growth parameters (plant height, number of leaves, leaf area index and dry matter production) as well as yield parameters (number of pods per cluster, pod yield per plant, pod yield per plot, total bio mass and seed yield) and for quality traits like protein content and stover yield were found superior in Arka Suman (V_1) as compare to Arka Gariam (V_2).

Among different chemical fertilizer treatments, the treatment F_1 (125 % RDF of NPK) recorded significantly higher growth, yield and quality parameters.

Gross returns, net returns and B: C ratios were found significantly higher due to adoption of 125 % RDF of NPK along with variety Arka Suman (V_1) proved to be most productive as well more economical which results in higher gross return (43560.6 Rs.), net return (272141.1 Rs.) and B: C ratio (2.66:1).

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vÀÄgÀPÁj C®¸ÀA¢ («UÁß CAUÀÄåPÀÄ¯ÉÃmÁ) ¨É¼ÉAiÀÄ°è ¥ÉÆÃµÀPÁA±ÀUÀ¼À CzÀåAiÀÄ£À PÀ¸ÀªÀÄUÀ¼À ªÀiË®åªÀiÁ¥À£ÀªÀ£ÀÄß ±ÀÄµÀÌ ¥À¸ÉÃ±ÀªÁzÀ ¨ÁUÀ®PÉÆÃl (PÀ£ÁðlPÀ) ºÀªÉÃ ¥ÁªÀÄð 2016gÀ ªÀÄÄAUÁgÀÄ IÄvÀÄ«£À°è PÉÊUÉÆ¼Àî¯Á¬ÄvÀÄ. ¸ÀA±ÉÆÃzÀ£ÉAiÀÄ£ÀÄß vÀÄgÀPÁj C®¸ÀA¢ vÀ½UÀ¼ÁzÀ CPÁð ¸ÀÄªÀÄ£ï ªÀÄvÀÄÛ CPÁðUÀjÃªÀÄzÀ ¨É¼ÀªÀtUÉ, E¼ÀÄªÀj ªÀÄvÀÄÛ UÀÄt®PÀë tUÀ¼À §UÉÎ AiÀiÁzÀÈaÒPÀ¨ÁèPï (gÁåAqÀªÉÄÊdqï ¨ÁèPï r¸ÉÊ£ï) «£Áå¸ÀzÀ°è ªÀÄÆgÀÄ ¥ÀwPÀÈwUÀ¼À£ÁßV «¨ÁV¹ ªÀiË®åªÀiÁ¥À£À ªÀiÁqÀ¯Á¬ÄvÀÄ. ªÀåvÁå¸À «±ÉèÃµÀuÉAiÀÄÄ aQvÁì ¸ÀAAiÉÆÃd£ÉUÀ¼À £ÀqÀÄ«£À ªÀåvÁå¸À UÀªÀÄ£ÁºÀðªÁVzÀÄÝ PÀAqÀÄ§A¢vÀÄ. ¸ÀªÀÄUÀæ ¥ÉÆÃµÀPÁA±À ¤ªÀðºÀuÉ PÀæªÀÄªÀÄ ºÉZÀÄÑ G¥ÀAiÀÄÄPÀÛªÁzÀÄzÉÝAzÀÄ PÀAqÀÄ§A¢vÀÄ. ¨É¼ÀªÀtUÉAiÀÄ UÀÄt®PÀëtUÀ¼ÁzÀ (VqÀzÀ JvÀÛgÀ, J¯ÉUÀ¼À ¸ÀASÉåAPÀ, MtV¹zÀ VqÀzÀ vÀÆPÀ) ºÁUÀÆ E¼ÀÄªÀj UÀÄt®PÀëtUÀ¼ÁzÀ (¥Àw VqÀzÀ°ègÀÄªÀ PÁ¬ÄAiÀÄ ¸ÀASÉå, PÁ¬ÄAiÀÄ GzÀÝ, PÁ¬ÄAiÀÄ ªÀÄvÀÄÛ ©ÃdzÀ ºÀ¹vÀÆPÀ, ¥Àw VqÀzÀ E¼ÀÄªÀj) EvÁå¢UÀ¼ÀÄ ¸ÀªÀÄUÀæ ¥ÉÆÃµÀPÁA±À ¤ªÀðºÀuÉ PÀæªÀÄUÀ½AzÀ ¤RgÀªÁV ¥Àæ¨ÁªÀPÉÆArÀUÁVgÀÄªÀÅzÀÄ PÀAqÀÄ§A¢zÉ. gÁ¸ÁAiÀÄ¤PÀ UÉÆ§âgÀzÀ ««zÀ ¥ÀæªÀiÁtzÀ ¥ÉÆÃµÀPÁA±ÀUÀ¼À vÁPÀÄUÀ¼À£ÀÄß ¥Àj²Ã°¹zÁUÀ ¨É¼ÉAiÀÄ ¨É¼ÀªÀtUÉ, E¼ÀÄªÀj ªÀÄvÀÄÛ UÀÄtªÀÄlÖªÀÅ ¤RgÀªÁzÀ gÁ¸ÁAiÀÄ¤PÀ (125 %) UÉÆ§âgÀzÀ°è EgÀÄªÀÅzÀÄ PÀAqÀÄ§A¢zÉ.

gÁ¸ÁAiÀÄ¤PÀ UÉÆ§âgÀzÀ ««zÀ ¥ÀæªÀiÁtzÀ ¥ÉÆÃµÀPÁA±ÀUÀ¼À vÁPÀÄUÀ¼À£ÀÄß C¼ÀªÀr¹PÉÆAqÁUÀ MlÄÖ DzÁAiÀÄ, ¤ªÀé¼À DzÁAiÀÄ ºÁUÀÆ ¯Á¨À, ªÉZÀÑ C£ÀÄ¥ÁvÀªÀ£ÀÄß (43560.6 gÀÆ, 27214.1 gÀÆ ªÀÄvÀÄÛ 2.66) ¤RgÀªÁzÀ gÁ¸ÁAiÀÄ¤PÀ (125%) UÉÆ§âgÀzÀ°è EgÀÄªÀÅzÀÄ w½zÀÄ§A¢zÉ.