PERFORMANCE OF BLACK AND WHITE BASIL *(Ocimum sp.)* AS INFLUENCED BY DIFFERENT ORGANIC MANURES

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CERTIFICATE

This is to certify that thesis entitled, "**PERFORMANCE OF BLACK AND WHITE BASIL *(Ocimum sp.)* AS INFLUENCED BY DIFFERENT ORGANIC MANURES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in HORTICULTURE, embodies the result of a piece of *bona fide* research work carried out by **ABDULLAH-AL-MAMUN**, Registration No.**06-01983** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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The Author

Dedicated to

My

Beloved Parents

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BY

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ABSTRACT

An experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka during November 2012 to June 2013. The experiment consisted of two factors viz. A: Two species of Basil, white basil (V_1) and black basil (V_2), B: Four levels of organic manures, control (F_0), cowdung (F_1), neem cake (F_2) and vermicompost (F_3). The experiment was laid out in Randomized Complete Block Design with three replications. From the result it was found that species and organic manures individually and combindly had significant effect on growth and yield of basil. It was observed that V_1 gave better performances for all growth and yield contributing characters than V_2. In case of marketable yield, V_1 gave the highest total leaf fresh weight (4.35 t ha^{-1}) with the highest total dry seed weight (74 kg ha^{-1}) and V_2 gave the lowest total leaf fresh weight (4.1 t ha^{-1}) with the lowest total dry seed weight (66.4 kg ha^{-1}). Among the organic manures, F_2 attained the highest result concerning all growth and yield contributing characters and F_0 attained the lowest result in all cases. In case of marketable yield, F_2 gave the highest total fresh leaf weight (5.61 t ha^{-1}) with the highest total dry seed weight (104.4 kg ha^{-1}) and F_0 gave the lowest total fresh leaf weight (3.62 t ha^{-1}) with the lowest total dry seed weight (46.4 kg ha^{-1}). In case of combined effect, V_1F_2 gave the highest total marketable fresh leaf weight (6.28 t ha^{-1}) and the highest total marketable dry seed weight (116.4 kg ha^{-1}).

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LIST OF ABBREVIATIONS

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV	Coefficient of Variance
DMRT	Duncan's Multiple Range Test
DAT	Days after transplanting
ETL	Economic Threshold level
FAO	Food and Agriculture Organization of the United Nations
FYM	Farm yard manure
RRGH	Retractable Roof Greenhouse
IRRI	International Rice Research Institute
LSD	Least Significant Difference
MAP	Medicinal and Aromatic Plants
OM	Organic matter
PDA	Potato Dextrose Agar
RCBD	Randomized Completely Block Difference
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource Development Institute
TDM	Total Dry Matter
UNDP	United Nations Development Program

CHAPTER I
INTRODUCTION

The basil is an important high value medicinal crop in Bangladesh. The scientific name of white basil is *Ocimum basilicum* L. and scientific name of black basil is *Ocimum sanctum* L. (Amin, 1997). The genus of *Ocimum* belongs the family Laminaceae (Labiatae) included about 3500 species among 210 genera and numerous varieties (Blank *et al*, 2004). It is native to Indian subcontinent, China, Southeast Asia, and New Guinea (Kew garden). It was originally domesticated in India, having been cultivated there for more than 5,000 years, but was thoroughly familiar to Theophrastus. It is an annual aromatic herb; cultivated extensively in Indonesia, Thailand, Vietnam, Cambodia, Laos, the cuisine of Taiwan, France, Egypt, Hungary, Morocco, USA, Greece, Israel and many other regions of the world (Wikipedia). Basil is an erect, herbaceous, much branched, soft hairy plant. It is commonly found in open plateaus and in moist and deciduous forests; also grows around habitations and wasteland as a weed.

The product is used both in fresh form and processesed form in the industry. The aromatic leaves are used fresh and dried as flavorings or spices in sauces, stews, salad dressings, vegetables, meat, pizza, vinegar, confectionery products, soups and seafood. The basil contains different types of nutrient elements such as Eugenol, its methyl ether, nerol, caryophyllene, terpeinen-4-ol, deccylaldehyde, γ-selinene, β-pinene, camphene and α-pinene from essential oil. Plant also possesses citric, tartaric and malic acids (Joshi, 2000.). Basil extract has been reported to have antioxidant activity. Cultivars with purple foliage, such as 'Dark Opal' and var. *auranascens*, are grown as ornamentals, but can also be used as flavorings. (online data).

In Bangladesh herbal medicine is widely used in traditional healthcare system such as Ayurvedic, Unani, Hekimi and other form of folk treatments. (Ghani, 2003). As medicinal plants are gaining more importance in Pharmaceutical industries for the preparation of new phytomedicines (Sule *et al.* 2010). Basil has enormous medicinal values due to it is highly aromatic, carminative, antipyretic and expectorant that can contribute to solve health problem. It has been found to be very effective in treatment of viral encephalitis, common colds, pulmonary diseases, against bite of snake and mosquito, malarial fevers, earache, stomach pain, gastric disorders of children, hepatic affections. It improves appetite, afflictions of ear, destroys intestinal worms and cures skin diseases. Seeds are demulcent, given in disorders of genito-urinary system. The oil extracted from leaves has the property to destroy insects and bacteria (Joshi, 2000).

Organic farming is a production system, which avoids or largely excludes the use of synthetically compound fertilizers, pesticides, growth regulators. Organic manures play major role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improving physical and chemical properties of soils (Chaterjee *et al.*, 2005). Many workers in the past (Saheed, 1994; Karim *et al.*, 1997) have noticed declining crop productivity in Bangladesh due to degradation of soil fertility. As the global demand of crop product is increasing and as the conventional agriculture is at stake, there is no alternative to start organic farming system in Bangladesh.

Cowdung increases the efficiency of mineral fertilizers by improving properties of the soil. Long term use of cowdung increased aggregate stability, pore space, bulk density and available water range. (Vanlauwe *et al.*, 2001). A great part of the virtue of animal manures shows their slow mineralization and the addition of organic matter to the soil, which they produced, offers a definite advantage over soluble fertilizers (Lakshmikathan, 1983). Gupta and Tripathi found in 2004 that the yield of sugarcane was significantly influenced by organic matter, cation exchange capacity and pH of soil as a result of cow dung incorporated.

Neem cake which is obtained from the seed kernels after extraction of the oil is needed for agricultural uses and soap production. Neem cake applications in soil have shown a stimulating effect on the blue-green algal growth, mainly by depressing predator’s activity in the soil. Algae biomass was higher in treated soil than untreated situations (Aziz, 1981). A similar effect is observed with *Azolla pinata* (a water fern used more particularly as natural soil amendment) by reducing the detrimental effect of soil salinity and enhancing the survival in summer conditions (Purseglove, 1987). Populations of *Nitrosomonas* and *Nitobacter* (ammonium and nitrite oxidizers) are reduced by neem cake applications and treatments are beneficial in terms of nitrogen supply in the soil (Santhi *et al.*, 1986). It has also been proved that coating of urea with neem cake is effective in slowing ammonitrification and nitrification (Sarkunan, 1981).

Vermicompost, which is produced by earthworms, is a rich source of both macro and micro nutrients, vitamins, growth hormones, and enzymes (Bhavalkar, 1991). Vermicompost increases the surface area, provides strong absorbability and retention of nutrients as well and retain more nutrients for a longer period of time. It has been found that soil amended with vermicompost had significantly greater soil bulk density and the soil does not become compacted (Lunt and Jacobson, 1994). Humic acids isolated from vermicompost enhanced root elongation and formation of lateral roots in maize. Vermicompost enhance the nutrient uptake by the plants by increasing the permeability of root cell membrane, stimulating root growth and increasing proliferation of root hairs (Pramanik *et al.*, 2007).

Therefore, the present study was undertaken with the following objectives:

I. To find out the effects of the two species (black and white) on plant growth and yield of basil.

II. To investigate the effect of organic manures on growth and yield of basil.

III. To find out the interaction effect of the two species of basil (black and white) and organic manures on growth and yield of basil.

CHAPTER II

REVIEW OF LITERATURE

Basil is one of the important medicinal plants all over the world including Bangladesh. Its medicinal value is increasing day by day. The literature regarding growth, yield and chemical components of basil as influenced by species and organic manures are very scanty. However, the relevant information available on this area generated from different studies has been reviewed in this chapter.

2.1Effect of species on plants

Pirkouhi *et al*. (2012) conducted two field experiments in spring and summer of 2009 to the factorial and randomized complete block design with three replications. Two varieties of green and purple, two planting pattern single row and double rows and plant densities of 40, 60, 80 and 100 plants per square meter were considered. Research results showed that the 4-6 leaves stage cultivar interaction, plant density and varieties of all simple effects, planting pattern and plant density on this trait were significant. Results showed that the days to 10% flowering cultivars simple planting pattern and also on the triple interaction was significant trait. Meanwhile research at days to 90% flowering showed that the simple effect of planting pattern and plant density was significant. Days to 50% seed showed that varieties simple effects, planting pattern and plant density was significant. Results of days to maturity showed that the simple variety, planting pattern and plant density and the triple interaction was significant. More days for 4-6 leaves stage and days to 10% flowering and days to 90% flowering in the cultivated treatment purple basil and single row planting pattern with 40 plants per square meter respectively with an average 11.33, 33.67 and 56.33. For the most case, days to 50% seed the purple basil seeds in cultivation and planting pattern of single row with 40 plants per square meter per day and the highest average days to maturity 76.33 to handle.

Kwiatkowski and Juszczak (2011) conducted a field experiment on growing sweet basil during the period of 2008-2010 in Fajslawice (Lublin region), on podzolic soil. The study evaluated the biometric traits of the plants, yield, the qualitative parameters of herbal raw material and weed infestation of the crop in dependence on growth stimulators (Asahi SL, Bio-algeen, Titanit) and the forecrop (winter wheat or spring barley + white mustard cover crop). The best quantitative parameters of sweet basil raw material and the highest reduction in air-dry weight of weeds in the crop were observed after the application of the growth stimulators. The forecrop- spring barley + a white mustard cover crop that is ploughed in- also had a beneficial effect on yield and weed infestation of the plant in question. The traditional crop protection method used in the basil crop, without the application of the growth stimulators, resulted in a lower plant height and a smaller number of shoots per plant. This caused higher weed infestation of the crop and a decrease in yield. The positive side of the non-application of growth stimulators was a better chemical composition of basil raw material. Asahi SL (Atonik 0.1%) and Tytanit (0.05%) yielded the best growth and productivity of the basil plants.

Svecova and Neugebauerova (2010) conducted field experiment on 34 cultivars of basil (*Ocimum* L.) were grown in two different years at the Faculty of Horticulture in Lednice, Czech Republic. The cultivars were divided into groups according to leaf colour and leaf size. The cultivars displayed a wide diversity of morphological, biological and economic characteristics. The groups of green small-leafed and purple-leafed varieties were judged to be the most decorative. Fresh weight yields varied from 14 to 713 g per plant. The highest fresh weight yield by *O. basililcum* ‘Fino Verde’ and the lowest was given by *O. americanum* ‘Lime’. Dry weight yields varied from 5 to 499 g per plant. The highest dry weight yield was given by the cultivar by `Fino Verde' and the lowest by `Spicy Bush'.

Kandil *et al*. (2009) conducted two field experiments on the farm of the National Research Center in Giza during two successive seasons in 2003 and 2004. The investigation yielded the following main result: increasing NPK rates increased the growth and yield of Genovese basil but the application of only 50% from recommended NPK gave already about 80% of the yield of 100% recommended NPK. Compost as a source of nutrients gave similar yield but higher quality than fertilization with chemical NPK fertilizers alone.

Kumari and Tomar (2009) conducted a study to determine the effect of simulated rain on yield and carbohydrate contents of two cultivars of *Ocimum sanctum* L. (cv. IC-75730 and cv. Local) in laboratory and field condition. Number of flowers, number of spikes and weight of seeds and total yield per plant reduced in treated plants pH 4.5, 3.5, and 2.5 of simulated acid rain. Carbohydrate contents of leaves fractions were adversely affected. The effect of simulated acid rain becomes more pronounced with increase in acidity of acid and duration of treatments. In both the cultivars, the reduction in yield carbohydrate content was greater in cv. Local than cv. IC-75730.

Zheljazkov *et al*. (2008) conducted field experiment on Sweet basil (*Ocimum basilicum* L.) and holy basil (*Ocimum sanctum* L.) The objective of this study was to evaluate biomass productivity, oil content and oil composition of sweet basil (*O. basilicum* L.) cvs. German and Mesten and holy basil (*O. sanctum* L.) cv. Local grown at four locations in Mississippi. Overall, the three basil cultivars grew well. Essential oil content in air dry herbage and the essential oil yields were as follows: 0.07% to 0.50% and 0.7 to 11.0 kg ha^{-1} in sweet basil cv. Mesten, 0.2% to 0.5% and 1.4 to 13.0 kg ha^{-1} in sweet basil cv. German, and 0.08% to 0.40% and 0.6 to 5.3 kg ha^{-1} in holy basil cv. Local, respectively. The result from the study suggest sweet and holy basils have a potential as new essential oil crops for Mississippi and possibly the southeastern United States.

Lozykowska and Krol (2008) conducted an experiment in 2005–2006 in the Research Institute of Medicinal Plants in Poznan, Poland and concerned a collection of ten sweet basil (*Ocimum basilicum* L.) cultivars including two Polish cultivars and a cultivar of *Ocimum americanum* L. The content of essential oil in the dried herb without stems ranged from 0.23% to 1.67%. The main component of the oils that came from nine basil cultivars was linalool, (from 37.07% to 76.22%). Considerable amounts of 1,8-cineol, eugenol, β-pinene, α-terpinene and myrcene were also found. Both Polish cultivars were distinguished by high content of geraniol in essential oil.

Rao *et al.* (2007) undertaken some studies on red sandy loam soil (Kandiustalf) in a semi-arid tropical climate at Bangalore (Karnataka) to find out the effect of fertilizer application in influencing oil production, quality and soil fertility in French basil (*Ocimum basilicum*). The study showed that yield increases were accompanied by higher removal of nitrogen, phosphorus and potassium from soil (by 247%, 23% and 94%, respectively) by the crop and lower amounts of exchangeable potassium (by 37.8%) in soil. Due to the depletion of soil potassium, interactions between nitrogen and potassium were significant in the second crop of basil. Application of 100 kg nitrogen ha^{-1} and 80 kg potassium ha^{-1} gave optimum yield and quality of oil.

Khalid *et al.* (2006) conducted two field experiments to know the effect of static compost (turned compost), tea of static compost (tea of turned compost) and their interactions on the vegetative growth characters, essential oil, total flavonoides, and nutrient content of *Ocimum basilicum* L. The experiments were conducted at the Experimental Farm, National Research Center (NRC), Dokki, Cairo, Egypt in two successive seasons of 2004 and 2005. It was recommended from the study that using of static compost with tea of static compost gave better yield because it increased the production (quantity and quality) and medicinal properties also. It is very cheap and expressed cash money improving the income of farmer. In addition, use of the organic materials is safe for human health.

Nelkin and Schuch (2003) conducted experiment on production of high quality herbs for fresh culinary markets which was evaluated in a retractable roof greenhouse (RRGH) under semi-arid climate conditions. Two basil cultivars, ‘Genovese’ and ‘Purple Ruffles’ and lemon grass were grown in a RRGH under 35% and 50% shade, and in the field. Basil was grown using two production systems in the RRGH, hydroponic rockwool culture and peat-based media in containers. Lemon grass was grown in containers only. Overall, ‘Genovese’ produced 91% more than ‘Purple Ruffles’. Biomass accumulation of basil was affected more by media than by shade. During full production with weekly harvests, ‘Genovese’ and ‘Purple Ruffles’ in hydroponic rockwool culture produced 45% and 44%, respectively, more biomass than plants in containers and 106% and 160%, respectively, more than plants in the field. Lemon grass showed greatest biomass accumulation under 35% shade, producing 0.7 times more than in the 50% shade and 7 times more than in the field. The quality of basil and lemon grass was superior in all RRGH treatments compared to the field. These results indicate culinary herb production in a RRGH can optimize biomass and quality of basil and lemon grass in a semi-arid climate.

Chaves *et al*. (2002) conducted an experiment was installed in Lageado Experimental Farm with aim to verify the influence of organic fertilization (0, 4, 8 and 12 kg of manure m^{-2} with four replications) on leaves and essential oil production of *Ocimum gratissimum*. The harvesting was done twice (May-autumn and August- winter). The leaf production and oil content were calculated on dry mass basis. The results showed no statistical difference for organic fertilization, although significant difference was verified for seasons.

The main constituents of essential oil were eugenol and 1,8- cineole. The amount of the eugenol was higher in autumn, while the presence of other components including 1,8-cineole, β-selinene and trans- caryophyllene were more dominant at winter time.

Caria and Martinetti (1996) studied the effect of organic and mineral fertilization on basil and found that among different N sources, the organic form gave the best results when nitrogen rates exceeded 120 kg ha^{-1} N.

2.2 Effect of organic fertilizers on plants

Sustainable agriculture can be defined as a set of practices that conserve resources and the environment without compromising human needs, and the use of organic fertilizers such as animal manure has been indicated as one of its main pillars (Tilman *et al*., 2002).

Chikwuyu *et al*. (2002) stated that organic materials are valuable nutrient resources for all types of crops, fruit and vegetables. Worldwide interest in the use of organic materials as sources of nutrients in crop production has increased.

A recent study on the changes in soil characteristics in Bangladesh over 27 years during the period 1967-1995 revealed that on an average, the total carbon content in soils has decreased by 11%, the total N by 12%, pH by 4% and the exchangeable acidity increased by 30%. The exchangeable K content of soil has decreased by 30% and the available P declined by 9% during the period (Ali *et al.*, 1997).

Campanhola (1994) stated that the intensive use of chemical fertilizers and pesticides has often resulted in serious degradation of agricultural soils and pollution of the environment from residual agric-chemicals.

Myint (1994) stated that though chemical based conventional farming practices have substantially increased crop yield, they create numerous problems to mankind.

Modern agricultural farming using excessive amounts of chemical fertilizers and pesticides has contributed to the destruction of our natural resources and degradation of the environment (Matsumoto, 1994).

Suetrong and Pairintra (1991) stated that regular addition of organic matters overcomes the extremes physico-chemical properties of the soil which plays a vital role in crop production.

There is a growing worldwide concern that environmental pollution caused by excessive use and abuse of chemical fertilizers and pesticides is directly or indirectly related to human health hazards (Higa, 1989).

Avnimelech (1987) reported that the organic matter forms a very important source of plant nutrients in soil. At one time only organic manures were used to grow crops. Organic manures play a vital role in improving the soil structure as well as also increasing the growth and yield of the crops. The application of organic materials has potential to increase crops yields.

Shaw and Robinson (1980) stated that the benefit of the soil from organic materials is due to their effects on microbial activity followed by increased humus content and an increased supply of available nutrients, particularly NPK.

2.3 Effect of cowdung on plant

Incorporation of crop residue with cowdung increases the organic carbon and nutrient content of soils (Saha *et al.*, 2007) and increases crop yields (Bhatnagar *et al.*, 1983).

The efficacy of cowdung in facilitating the release of phosphate from applied rock phosphate has been reported by Akande *et al*. (2005, 2006).

Akande *et al*. (2006) stated that cowdung, a type of farmyard manure is mainly the excreta collected from cattle. It can be applied as manure in the form of slurry or dried to soils.

Olayinka and Ailenubhi (2001) stated that cow dung applied with inorganic nitrogen (N), increased soil pH and ameliorated acidity.

Forbes and Watson (1994) stated that cowdung has high percentage of nitrogen and potassium, which play an important role in a accelerating the translocation of photosynthates from the leaves and shoots to the tuberous roots for bulking.

Singh *et al*. (1991) reported that farmyard manure has been found to have a strong driving force for the dissolution of phosphate rock thereby increasing the available phosphate for crops.

Vivekanandan and Fixen (1990) have reported that the buildup of phosphorus through application of cow dung is as a result of the mineralization of organic phosphate due to microbial population and the production of organic acids, which make soil P available.

Rayer (1986) conducted a long term manuring experiment on a permanent plot in India. Soil depths observed from 0-15cm and 15-30 cm less variation in their levels of pH, organic carbon, total nitrogen, exchangeable calcium and magnesium indicating some sort of stabilization in the equilibrium, although the availability of Mn, Zn and Cu in the soil increased.

On an average, well rotted cowdung contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O (Yawalkar *et al*., 1984).

2.4 Effect of neem cake on plant

Neem seed cake is the residue obtained after the extraction of oil from neem seed. It contains more nitrogen (2-5%), phosphorus (0.5-1.0%), calcium

(0.5 -3%), magnesium (0.3 – 1 %) and potassium (1 - 2 %) than farm yard manure or sewage sludge (Radwanksi and Wickens, 1981).

Ali (2013) conducted a field experiment in Horticulture Farm, Sher-e-Bangla Agricultural University and found that the higher yield and economic return of carrot could be obtained by cultivating of carrot along with neem leaf powder with cowdung.

Kamal And Yousuf conducted an experiment in 2012 at Spices Research Centre, BARI, Gazipur. on turmeric with different organic fertilizers (cowdung, poultry manure, mustard oil cake, neem cake and control) and found that plant with neem cake application had the taller plant (79.30 cm), maximum number of tillers per plant (5.40), leaf number (5.40), leaf area (44.09) leaf area index (0.429), fresh weight of halum (190.05g), fresh weight of root (49.13 g), fresh weight of rhizome per plant (256.21 g) and dry weight of halum (15.21g), dry weight of root (7.32 g), dry weight of rhizome per plant (40.35 g), total dry matter yield (6.85 t ha^{-1}) than those received other types of manures.

Elnasikh *et al.* (2011) conducted a series of laboratory experiments to evaluate the effects of Neem seed cake on the main groups of soil microflora and some soil properties. The results revealed that Neem seed cake positively affected the population of organic nitrogen users and *Actinomycetes* and affected negatively the population of fungi, *Nocardia*, *Bactoderma* and the whole population of inorganic nitrogen users which include nitrifying bacteria. On the other hand, it exerted fluctuating effects on *Mycobacterium*, *Micromonospora* and *Arthrobacter*. Moreover, Neem seed cake significantly increased electrical conductivity, exchangeable calcium, iron, manganese, copper and zinc content.

Nath and Singh (2011) conducted a study to investigate effect of foliar application of neem (*Azadirachta indica* A. Juss) plant part and neem based pesticide with vermiwash obtained from buffalo dung with barley bran/ vegetable wastes for management various pests injurious to the crop. The combinations of neem (*Azadirachta indica* A. Juss) plant parts and neem based pesticides (Nimbesidine, Achook and multineem) have significant effect on the growth, flowering, productivity and their pest's infestation. The combination of aqueous extract of neem oil with vermiwash of buffalo dung has maximum effect on the growth, flowering, productivity and their pest's infestation of soybean crop. The use of combination of neem oil with vermiwash is eco-friendly and is one of the interesting aspects, since it contribute to a broad relationship among food, environmental quality and safety of human and animal health.

Sayed *et al.* (2011) found in a study that, aqueous neem (*Azadiracta indica*) leaf extract was tested for its effect on *Casuarina equisetifolia* seed germination capacity, growth of *Frankia* and on some dominant rhizosphere microorganisms under casuarinas grown in soil contaminated with sewage water. Analysis was carried out to determine the main micro- and macro element content of different extract amounts. The addition of extract amount with 1- 2 µl ml^{-1} medium selectively stimulated *Frankia* growth and inhibited other non- beneficial bacteria and fungi in the rhizosphere such as *Bacillus subtilis*, *Drechslera* sp. and *Curvularia lunata*. Slight increase was observed in *Casuarina* seed germination capacity with 1- 2 µ ml^{-1} of the extract, but with no significant differences, indicating at least no negative effect of the extract on seed germination. According to the results and as the roots and leaves of both *Casuarina* and neem release their active components in soil, and according to previous recommendations, we suggest a significant synergistic effect between *Casuarina*, rhizosphere microorganisms and neem trees for the benefits of *Casuarina* nodulation, growth performance and nitrogen fixation.

Kimaru *et al.* (2004) conducted a study to investigate effect of Neem Kernel Cake Powder (NKCP) at 1.75, 3.5 and 7g rates on development of tomato *Fusarium* wilt at the National Horticultural Research Center, Thika, Kenya. Inoculum density of *Fusarium oxysporum* f.sp. *lycopersici* (Sacc.) was two

14mm diameter disks per planting hole taken from 10 day old cultures growing on PDA. Plant performance was based on shoot height and weight; stem diameter; number and weight of tomato fruits. Disease assessment was based on wilt index of shoots and length of discoloration of vascular tissues. Performance of plants grown in NKCP amended and non-amended soils was significantly (p=0.05) different (33.3-93.3%). Disease severity based on the wilt index (0.53-2.87) and length of discoloured vascular tissues (7.4cm-25.62cm) differed significantly (p=0.05) among treatments.

Usha and Patra (2003) stated that the use of Azadirachtin (active ingredient of Neem) to coat urea is a common practice as it reduces the loss of nitrogen by preventing the activity of Nitrifiers.

According to Soon and Bottrel, (1994) neem seed cake acts as natural fertilizer with pesticidal properties. This dual activity has made it a favoured input in agricultural production.

Akhter (1994) reported that soil supplement with neem cake (n-hexane from neem seed) at the rate of 1% and 5% w/w produced two and four times higher ammonia nitrogen than unsupplemented soil, respectively after ten days of application. However, nitrogen release was delayed if the soil was supplemented with the ground neem cake. Neem oil did not help in the production of additional nitrogen.

Parmar (1986) reported that neem seed cake exhibits the properties of insecticides, nitrification retardation and inhibiter of pesticide degradation.

Prakasa and Singh (1985) reported that the neem cake coated urea was effective only at higher levels of N *i.e* 300 and 400 kg ha^{-1} $year^{-1}$.

Ketkar (1983) reported that neem seed cake admixed with urea fertilizer significantly improves efficiency of fertilizer utilization in crop production by radual release of nitrogen to crops.

Sharma and Prasad (1980) observed that finely powdered neem cake mixed at 20% of urea increased recovery of urea N by the rice crop from 28% to 47%.

2.5 Effect of vermicompost on plant

Vermicomposts are finely-divided, peat like material, with high porosity, aeration, drainage, water holding capacity and microbial activity which make them excellent as soil conditioner and as plant growth media (Edwards, 1998b; Atiyeh *et al.*, 2002b; Sallaku *et al.*, 2009).

Vermicomposts are finely divided peat like materials with high porosity, aeration, drainage, water-holding capacities, and low C: N ratios produced from organic wastes that have been stabilized by interactions between high earthworm densities and microorganisms without passing a thermophilic stage (Dominguez, 2004; Subler *et al.*; 1998 Edwards, 1998a).

Mamta *et al*. (2012) conducted two separate field studies aimed at understanding the effect of vermicompost on the growth and productivity of brinjal plant. The vermicompost of cow dung, garden waste and kitchen waste in combination were used with brinjal plants under field conditions. The different treatments affected the seed germination of the test crop significantly. Plant height, number of leaves and fruit weight were higher in the vermicompost treated field as compared to control and no disease incidence was observed in the fruits of vermicompost treated plot. The study revealed that vermicompost amendments affected brinjal crop differently and we recommend that while raising brinjal crop farmers should use vermicompost instead of synthetic fertilizers.

Vermicompost is especially rich in microbial diversity. Earthworms further proliferates useful microbes in billions and trillions in soil. Earthworms can modify soil microbial community structure depending on the type of organic matter present in soil (Jack, 2010).

Pritam *et al*. (2010) indicated that application of vermicompost and 50 % of recommended dose of fertilizer helps in increasing the number of leaves per plant compared to control in potato. He also reported that soil amended with 30% vermicompost produced the most flowers on the Marigold (*Tagetes erecta* L.) plants in pot culture experiments, and the largest flower diameter was produced in soil amended with 40% vermicompost. It was also observed that the amount of vermicompost had a significant effect on not only growth and flowering of the Marigold plants, but also on the plant shoot and root biomass, plant height and diameter of the flowers.

Agarwal *et al*. (2010) stated that the production of important vegetable crops like tomato (*Lycopersicum esculentus*), eggplant (*Solanumme langona*) and okra (*Abelmoschus esculentus*) on vermicompost have yielded very good results.

Lazcano *et al.* (2009) stated that the effects of vermicompost have included alterations in seedling morphology such as increased leaf area and root branching of plants.

Some studies showed that vermicomposting leachates or vermicompost water-extracts, used as substrate amendments or foliar sprays, also promote the growth of tomato plants (Tejada *et al*. 2008) and strawberries (Singh *et al*. 2010).

Singh *et al.* (2008) reported that vermicompost increased the yield of strawberries by 32.7 % and also drastically reduced the incidence of physiological disorders like albinism (16.1 - 4.5 %), fruit malformations (11.5 % - 4 %), grey mould (10.4 % - 2.1 %) and diseases like Botrytis rot. By suppressing the nutrient related disorders, vermicompost use increased the yield and quality of marketable strawberry fruits up to 58.6 %.

Chamani *et al.* (2008) reported that vermicompost had significant ($P<0.05$) positive effects on flower numbers, leaf growth and shoot fresh and dry weights of crops compared to both control and peat amended media.

Vijaya *et al.* (2008) conducted a field experiment with an exotic earthworm, *Eudrilus eugeniae* (Kinberg) to prepare coirpith based compost. This vermicomposted coirpith was amended with alkaline soil from an industrial site and compared with coirpith composted with EM (effective microorganisms) as a growth medium for the medicinal plant, *Andrographis paniculata* (Nees) in field plots. Significant plant growth was attained when the same compost was amended with garden soil. The present results suggest vermicomposted coirpith could be helpful for the reclamation of soils from industrial sites for the cultivation of *A. paniculata* in a small scale nursery.

Nourbakhsh (2007) stated that earthworm casts are soil conditioners that have a high nutrient bioavailability for plant growth.

In addition to increasing plant growth and productivity, vermicompost may also increase the nutritional quality of some vegetable crops (Gutierrez-Miceli *et al*., 2007).

Cheng *et al.* (2007) conducted a study and found that perennial rye grass (*Lolium perenne* L.) grown in soils amended with 10 to 20% vermicompost increased chlorophyll content compared with plants from unamended soils.

The variability in the effects of vermicompost may depend on the cultivation system into which it is incorporated, as well as on the physical, chemical and biological characteristics of vermicompost, which vary widely depending on the original feedstock, the earthworm species used, the production process, and the age of vermicompost (Rodda *et al*., 2006).

Sameera *et al*. (2005) conducted a study and found that application of vermicompost and poultry manure subsequently increase yield attributing characters and yield of broccoli.

Vermicompost has been found to have positive effects on some aromatic and medicinal plants (Anwar *et al*., 2005).

Mishra *et al.* (2005) reported that the numerous microorganisms present and growing in the soil are capable of providing the crops all the nutrients at the time they need it. The soil is living only when it will have a microbial population of 108 per cubic centimeter of soil. These microbial populations need adequate quantity of organic manures as feed for their survival and multiplication.

Nagavallemma *et al*. (2004) reported that vermicompost for example, an organic source of plant nutrients, contains a higher percentage of nutrients necessary for plant growth in readily available forms. Vermicompost applied at a rate of 5 t ha^{-1} has also been reported to significantly increase yield of tomato (*L. esculentum* L.)

Vermicompost has also been shown to stimulate plant flowering, increasing the number and biomass of the flowers produced (Atiyeh *et al*., 2002a; Arancon *et al*., 2008), as well as increasing fruit yield (Atiyeh *et al*., 2000b; Singh *et al*., 2008).

Atiyeh *et al.* (2002a) argued that growth promotion of plants may be due to micro flora associated with vermicomposting that induce hormone-like activity on the production of metabolites.
An experiment conducted by Atiyeh *et al*. (2002b) stated that vermicompost applied at a rate of 25% improved stem length by 11 mm and diameter by 40 mm in tomato plants compared with the control plants.

Atiyeh *et al*. (2000a) stated that plant growth and development is affected by the rates of the vermicompost applied to the soil which are in turn affected by agro-climatic conditions of the growing environment.

Positive effects of vermicompost include stimulated seed germination in several plant species such as tomato plants (Atiyeh *et al*., 2000b; Zaller 2007), petunia (Arancon *et al*., 2008).

Nethra *et al*. (1999) reported that application of different levels of vermicompost to *Chrysanthemum chinensis* resulted in increased fresh weight of flowers, number of flowers per plant (26), flower diameter (6 cm) and yield (0.5 t ha^{-1}) with the application of 10 t ha^{-1} of vermicompost.

Edwards (1998b) reported that there is accumulating scientific evidence the vermicompost can influence the growth and productivity of plants significantly.

Subler *et al*. (1998) noted that after converting wastes to vermicompost and compost, some nutrients, especially nitrogen, increased in vermicompost as compared with wastes.

Edwards *et al*. (1998a) reported that vermicompost has a positive effect on vegetative growth, stimulating shoot and root development in crops.

In a study involving a wide range of vegetable and ornamental seedlings, result showed earlier and better germination in vermicompost treatment compared with control (Edwards, 1998b; Gutierrez-Miceli *et al*., 2007).

Orozeu *et al.* (1996) stated that vermicompost contains most nutrients in plant available forms such a nitrates, phosphates and exchangeable calcium and soluble potassium.

Vadiraj *et al.* (1992) observed that application of vermicompost as potting mixture for cardamom gives significant increase in plant height, number of leaves per plant, number of roots per plant and root length.

Kale *et al.* (1991) found that use of vermicompost is helpful reducing basal dose of fertilizer to 25 % in tomato.

Edwards and Burrows (1988) reported that after organic matters breaking down by earthworms, the availability of some nutrients including N, P, K, Ca and Mg increased. As a result, vermicompost has a potential for improving plant growth and dry matter yield when added to the soil (Atiyeh *et al*., 2000; Zaller, 2007).

Application of vermicompost enhanced plant growth and development, root initiation and root biomass and this was attributed to the organisms essential for maintaining vigorous plant growth capable of withstanding environmental stress (Tomati *et al*., 1987; Edwards, 1998b; Atiyeh *et al*., 2002a; Bachman and Metzger, 2008).

Several experiments have demonstrated that vermicompost contain plant-growth regulating materials such as humic acid and plant growth hormones like auxins, gibberellins and cytokinins, which are probably responsible for increased germination, growth and yield of plants, in response to vermicompost applications (Krishnamoorthy and Vajranabhiah, 1986; Tomati *et al.,* 1987; Senesi *et al.,* 1992; Masciandaro *et al.,*1997; Atiyeh *et al.,* 2002b).

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used and followed for conducting the experiment presented under the following headings:

3.1 Site of the experiment

The experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2012 to June 2013. Location of the site was $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989). The map and experimental plot showing the experimental site under study in Appendix I & III.

3.2 Soil

The soil of the experimental field belongs to the Modhupur Tract in AEZ (Agroecological Zone)- 28 (UNDP, 1988). The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resource Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka have been presented in Appendix 1V.

3.3 Climate and weather

Climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Maximum and minimum temperature and rainfall during the study period were collected from the Bangladesh Bureau of Statistics, Agargaon and have been presented in Appendix II.

3.4 Planting materials

Seedlings were collected from National Herbarium Center, Mirpur, Dhaka. Seedlings were transplanted in the Experimental site (Horticulture Farm, Sher-e-Bangla Agricultural University) at 1st November 2012.

3.5 Treatments of the experiment

This experiment was conducted to find out the influence of organic fertilizers on the growth and yield and quality of leaves of basil plants. There were two factors in this experiment. There were as follows:

Factor A: Species

i. V_1 : White Basil.

ii. V_2 : Black Basil.

Cowdung was collected from Horticultural farm at Sher-e-Bangla Agricultural University, neem cake and vermicompost were collected from Neem Laboratories, New DOHS, Mohakhali, Dhaka. Properties of vermicompost and cowdung given in appendix V.

Factor B: Organic fertilizer

Different organic fertilizers have been used. The % of N, P, K and other nutrients (if any) of these organic fertilizers is given in appendix V. The treatments were-

i. F_0 : (Control/ No Manure)

ii. F_1 : Cowdung (15.5 t ha^{-1}).

iii. F_2: Neem cake (5 t ha^{-1}).

iv. F_3 : Vermicompost (14 t ha^{-1}).

3.6 Doses, preparation and methods of application of the organic manure treatments

- Cowdung was applied 4.5 kg $plot^{-1}$ as basal dose in 6 plots. 15.5 t ha^{-1}
- Neem cake was applied 1.5 kg $plot^{-1}$ as basal dose in 6 plots. 5 t ha^{-1}
- Vermicompost was applied 4.25 kg $plot^{-1}$ as basal dose in 6 plots. 14 t ha^{-1}

3.7 Seedling Collection:

The seedlings of white basil and black basil were collected from National Herbarium Center, Mirpur, Dhaka. 30 days old age 200 white basil seedlings and 200 black basil seedlings were purchased on October 30, 2012. All the seedlings showed good vigor without any insect and pest attack.

3.8.Design and layout of the experiment

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 189.75 m^2 with length 16.5 m and width 11.5 m. The total area was divided into three equal replications. Each replication was divided into 8 plots where 8 treatments combination were allotted at randomly. There were 24 unit plots altogether in the experiment. The size of the each plot was 2.5 m × 1.5 m. The distance maintained between two replications and two plots were 1m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.9 Soil Analysis

The analytical data of the soil sample collected from experimental area were determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka on July, 2012. The analytical results of the collected soil before treatments are presented in Appendix IV.

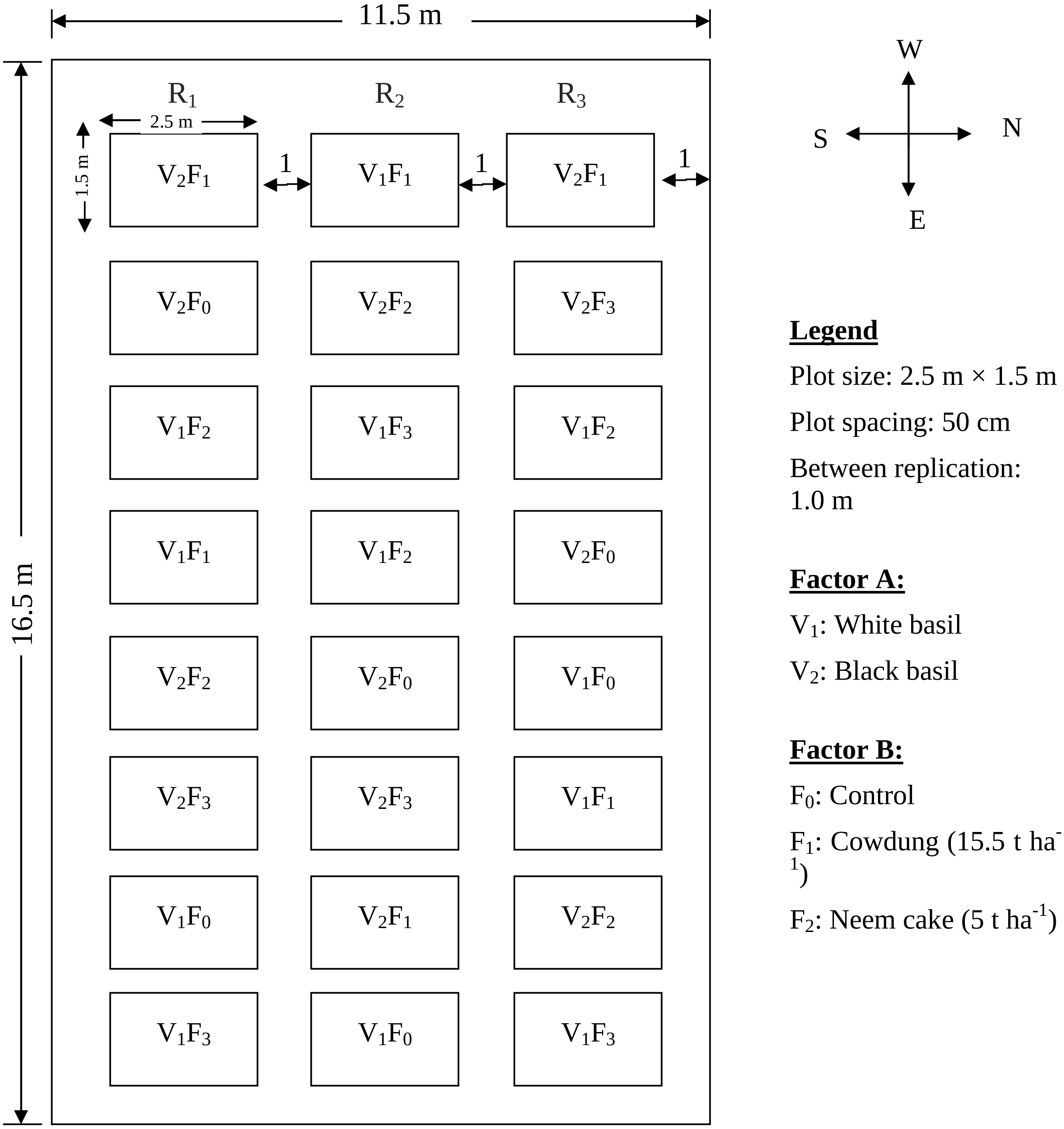

Fig. 1: Layout of experimental field of *Ocimum.*

3.10 Land preparation

The plot selected for conducting the experiment was opened in the second week of October 2012 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil was obtained for transplanting basil seedlings. The experimental plot was partitioned into unit plots in accordance with the design mentioned in Figure 1. All the organic fertilizers were mixed at the soil during final land preparation.

3.11 Production Methodology:

3.11.1 Transplanting of seedlings

Seedlings were transplanted in the main field at 7 cm depth with 50 × 50 cm spacing in 24 plots on 1st November, 2012 at the time of afternoon.

3. 11.2 Weeding

Weeding were done in all the plots as and when required to keep the plant free from weeds**.**

3.11.3 Irrigation

Frequency of watering depended upon the moisture status of the soil. However, water logging was avoided, as it is harmful to plants.

3.11.4 Gap Filling

Gap filling of seedling was done when a seedling died. It was done within 1 month after transplanting.

3.11.5 Staking

Staking was done at 30 DAT with each seedlings to support the plants and to minimize bad effect of wind.

3.11.6 Insect and Pest management

Insects were rarely found but those did not excced Economic Threshold Level No severe disease and insect infestation were found in the experimental plot. Furthermore no insect or pest attack happened to the adjacent experimental plots during the time of the field experiment.

3.11.7 Harvesting of plants

Plants were harvested on 1st June, 2013 at 210 DAT. The fresh leaf was harvested at 30, 75, 120, 165 and 210 DAT and fresh seed was harvested at 75, 120 and 165 DAT from selected plants.

3.11.8 Data collection

Data were collected from each plot. Data were collected in respect of the following parameters:

- ✓ Plant height (at 30, 90, 150 and 210 DAT)
- ✓ Plant base diameter (at 30, 90, 150 and 210 DAT)
- ✓ Branch number plant^{-1} (at 30, 90, 150 and 210 DAT)
- ✓ Fresh leaf weight plant^{-1} (at 30, 75, 120, 165 and 210 DAT; as marketable item)
- ✓ Dry leaf weight plant^{-1} (at 30, 75, 120, 165 and 210 DAT; as marketable item)
- ✓ Whole fresh weight plant^{-1} (At harvest)
- ✓ Fresh stem weight plant^{-1} (At harvest)
- ✓ Fresh root weight plant^{-1} (At harvest)
- ✓ Fresh root length plant^{-1} (At harvest)
- ✓ Fresh seed weight plant^{-1} (at 75, 120 and 165 DAT)
- ✓ Dry seed weight plant^{-1} (at 75, 120 and 165 DAT; as marketable item)

3.11.9 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale at 30, 90, 150 and 210 DAT from the base of stem up to the longest leaf. Average height of 5 plants were taken very carefully from 5 marked plants.

3.11.10 Plant base diameter

To measure the diameter of the stem a slide calipars was used. The diameter of the stem base was measured in centimeter at 30, 90, 150 and 210 DAT. Average stem base diameter of 5 plants were taken very carefully from the selected plants.

3.11.11 Number of branches per plant

Number of branches of 5 selected plants were counted at 30, 90, 150 and 210 DAT. All the branches of each plants were counted separately. Calculation the average number of branches number was recorded.

3.11.12 Fresh weight of leaf (g) per plant

The fresh weight of leaf of 5 selected plants was counted at 30, 75, 120, 165 and 210 DAT. The fresh leaf weight of each plant was taken separately with electric balance and then average value was calculated.

3.11.13 Dry weight of leaf (g) per plant

The oven dried weight of leaf of 5 selected plants was counted at 30, 75, 120, 165 and 210 DAT. The dry leaf weight of was calculated with the help of electric balance and then average value was found.

3.11.14 Whole fresh weight plant^{-1} (g)

At the final harvest, 5 marked plants were uprooted from the base and then the triple beam balance in gram took fresh weight and average value was calculated.

3.11.15 Fresh stem weight (g) per plant

The fresh stem weight of 5 selected plants was measured at final harvest. The fresh stem weight of each plant was taken separately with the help of electric balance and then average value was calculated.

3.11.16 Fresh root weight (g) per plant

The fresh weight of root of 5 selected plants was was measured at final harvest. The fresh root weight of each plant was taken separately with the help of electric balance and then average value was calculated.

3.11.17 Root length (cm) of plant

Before one day of the final harvest, 5 marked plants from each plot was wetted for 12 hours at the base with sufficient water so that the soil and root connection became loose. After harvesting the length of root was measured in centimeter with the help of meter scale from proximal to distal end and the average was calculated.

3.11.18 Fresh seed weight (g) per plant

The fresh seed weight of 5 selected plants was counted at 75, 120 and 165 DAT. The fresh seed weight of each plant was taken separately with the help of electric balance and then average value was calculated.

3.11.19 Dry weight of seed (g) per plant

The oven dry seed weight of 5 selected plants was counted at 75, 120 and 165 DAT. The dry seed weight of was calculated with the help of electric balance and then average value was found.

3.11.20 Marketable yield per plant (g) [fresh leaf and dry seed]

The leaf of 5 marked plants was collected and then weight as per marketable size at 30, 75, 120, 165 and 210DAT. Then total marketable yield of fresh leaf was found by adding the respected yield of mentioned DAT. Marketable dry seed weight of 5 marked plants was measured at 75, 120 and 165 DAT. The total marketable yield of dry seed was found by adding the respected yield of mentioned DAT

3.11.21 Marketable yield per plot (g)

Average value of 5 marked plants was multiplied by total number of plants per plot at each harvest.

3.11.22 Marketable yield per hactare (kg)

The yield per hactare was calculated from the yield per plot.

3.11.23 Statistical analysis

Collected data for various characters were statistically analyzed using MSTAT computer package programme. Mean for all the treatments was calculated and the analysis of variance for each of the characters was performed by F (variance ratio) test. Difference between treatments were evaluated by Duncan’s Multiple Range (DMRT) test (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results have been presented and discussed, and possible interpretations are given under the following headings:

4 Plant growth parameters of Basil

4.1 Plant height (cm)

4.1.1 Effect of species on plant height (cm)

Plant heights were measured at 30, 90, 150, 210 DAT. Result revealed that species had significant influence on plant height at all growth stages (Fig. 1). It is observed from the figure that the plant height increased with the advancement of time upto 210 DAT. The highest plant height at all the growth stages was recorded in V_1 (white basil). In contrast, the lowest plant height was recorded inV_2 (black basil).

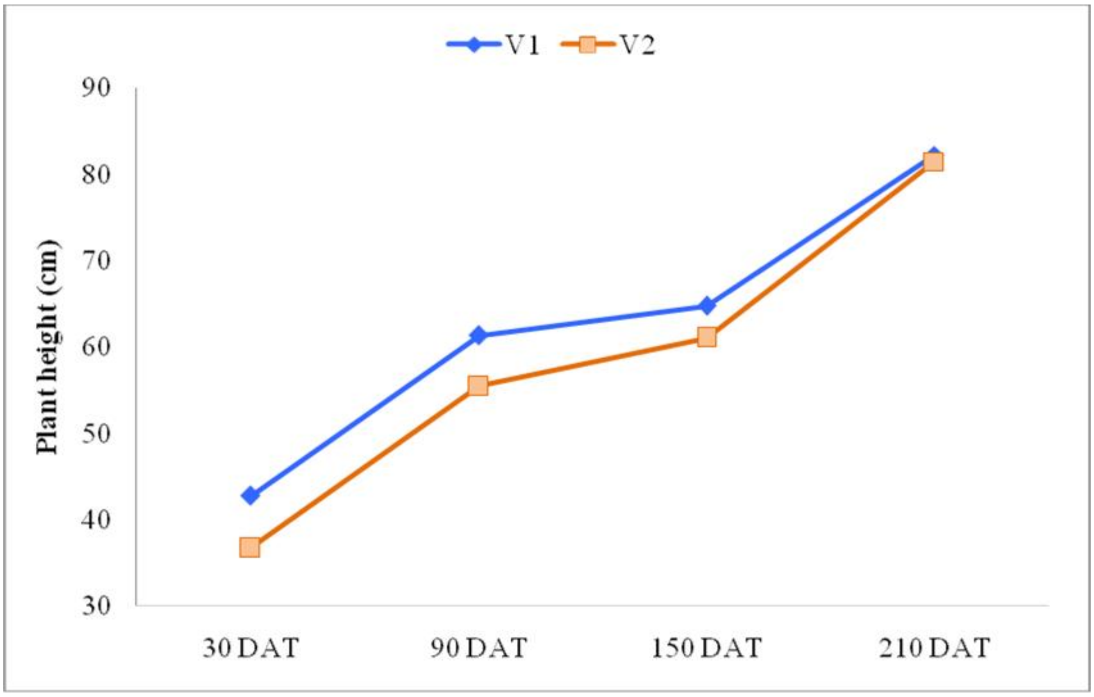

Fig. 2. Effect of species on plant height (cm) of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.1.2 Effect of organic manure on plant height (cm)

Plant heights were measured at 30, 90, 150, 210 DAT. Results revealed that organic manures had significant influence on plant height at all growth stages

(Fig. 2). From the figure it is observed that plant height increased with the advancement of time upto 210 DAT. The highest plant height at all the growth stages was recorded in F_2 (neem cake) followed by F_3 (vermicompost). In contrast, the lowest plant height was recorded in F_0 (control). The vegetative growth parameters were increased with neem cake application which was also supported by the results of Kamal And Yousuf (2012) who reported that the better performance of plants with neem cake was probably because it acted as natural fertilizer with pesticidal properties which protects plant roots from nematodes, soil grubs & white ants and performs as a nitrification inhibitor and prolongs the availability of nitrogen to short duration as well as long duration crops. Beside these, it improves the soil condition considerably and protects the soil during the droughts.

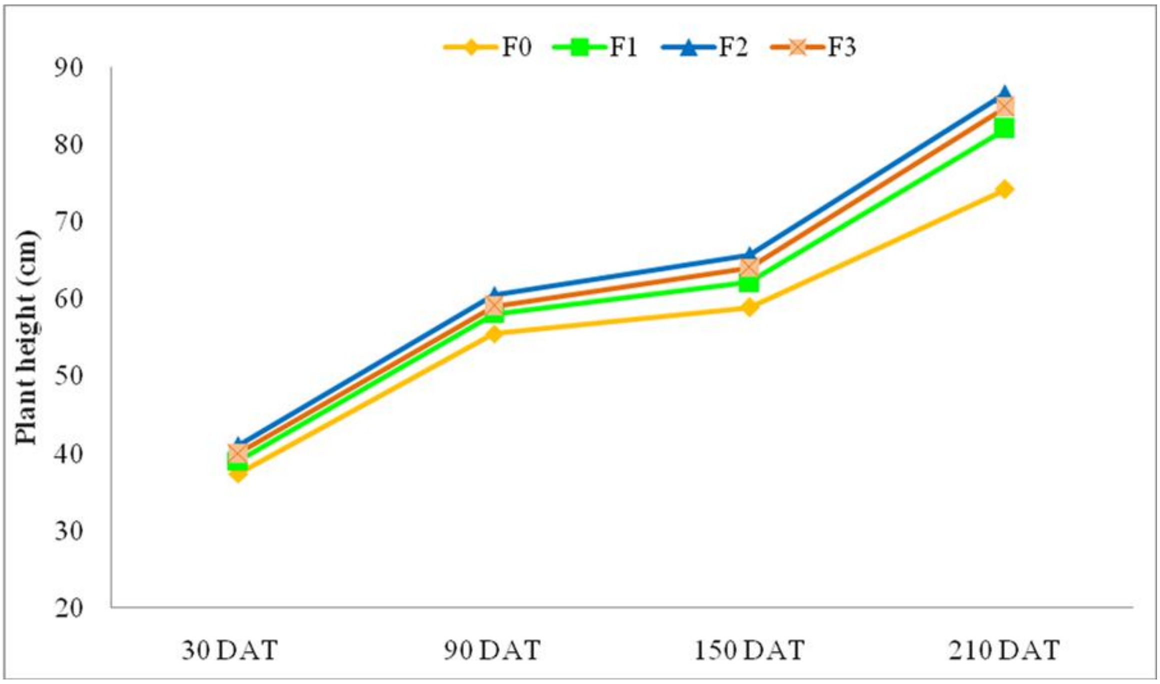

Fig. 3. Effect of organic manure on plant height (cm) of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.1.3 Interaction effect of species and organic manure on the plant height (cm)

Variation was observed in respect of plant height in relation with interaction effect of species and organic fertilizer (Table 1). The highest plant height at all growth stages was recorded from treatment combination V_1F_2 (white basil with neem cake) followed by V_1F_3 (white basil with vermicompost) at all growth stages. In contrast the lowest plant height was recorded from treatment combination V_1F_0 (white basil with no manure).

Table1. Interaction effect of species and organic manure on the plant height of basil different DAT

Treatment combinations	Plant height (cm) at			
	30 DAT	**90 DAT**	**150 DAT**	**210 DAT**
V_1F_0	34.27 d	50.53 d	55.20 c	70.43 g
V_1F_1	37.27 cd	57.20 bc	62.00 b	80.63 e
V_1F_2	44.87 a	62.47 a	68.33 a	89.83 a
V_1F_3	43.07 ab	62.27 a	65.67 ab	88.37 b
V_2F_0	37.07 cd	55.80 c	61.60 b	77.83 f
V_2F_1	38.40 c	58.40 bc	62.53 b	82.40 d
V_2F_2	42.73 ab	60.47 ab	65.53 ab	83.23 c
V_2F_3	40.47 bc	60.20 ab	62.67 b	82.63 d
$LSD_{(0.05)}$	3.572	3.828	4.553	0.3675
CV%	8.24%	6.43%	8.44%	6.45%

Here, V_1 = White basil, V_2 = Black basil and

F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.2 Plant base diameter (cm)

4.2.1 Effect of species on plant base diameter (cm)

Plant base diameter did not varied significantly by different species at the growth stages (Fig. 3). From the figure it is observed that base diameter was increased progressively with the advancement of time and growth stages till 210 DAT. Highest plant base diameter (1.8 cm) plant^{-1} was produced by V_1 (white basil) at 210 DAT. In contrast, the lowest plant base diameter (1.6 cm) plant^{-1} was recorded in V_2 (black basil) at the same DAT.

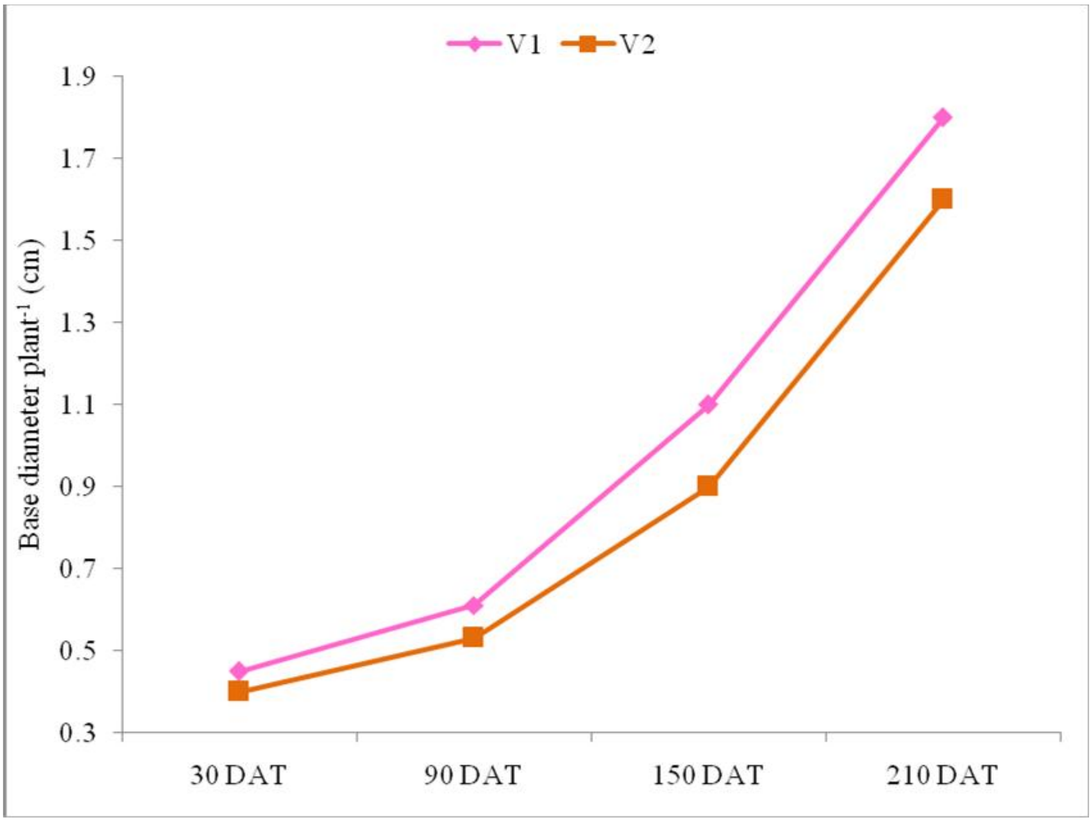

Fig. 4. Effect of species on plant base diameter (cm) of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.2.2 Effect of organic manure on plant base diameter (cm)

Plant base diameter did not varied significantly by different organic manure at the growth stages (Fig. 4). From the figure it is observed that base diameter was increased progressively with the advancement of time and growth stages until 210 DAT. The highest base diameter (1.8 cm) plant^{-1} was produced by F_2 (neem cake) followed by F_3 (vermicompost) at 210 DAT. In contrast, the lowest base diameter (1.5 cm) plant^{-1} was recorded in F_0 (control) at the same DAT.

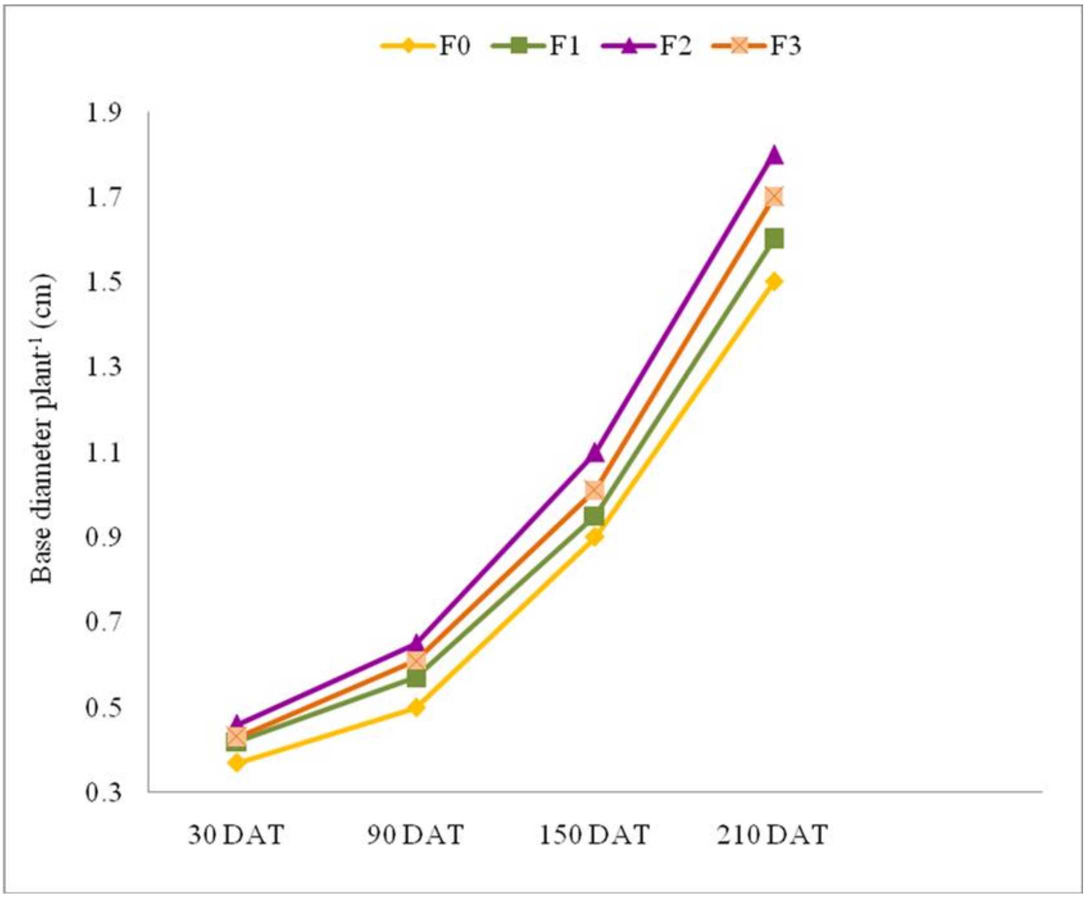

Fig. 5. Effect of organic manure on plant base diameter (cm) of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.2.3 Interaction effect of species and organic manure on plant base diameter (cm) plant^{-1}

Plant base diameter (cm) did not varied significantly due to interaction effect of species and organic fertilizer (Table 2) but the highest base diameter (1.98 cm) plant^{-1} was recorded from treatment combination V_1F_2 (white basil with neem cake) followed by V_1F_3 (white basil with vermicompost) at 210 DAT. In contrast the lowest base diameter (1.51 cm) plant^{-1} was recorded from the treatment combination V_2F_0 (black basil with no manure) followed by V_1F_0 (white basil with no manure) at the same DAT.

Table 2. Interaction effect of species and organic manure on base diameter (cm) plant^{-1}

Treatment combinations	Base diameter (cm) plant^{-1} at			
	30 DAT	90 DAT	150 DAT	210 DAT
V_1F_0	0.3933 a	0.5267 a	0.8933 a	1.517 a
V_1F_1	0.4333 a	0.5933 a	0.9800 a	1.610 a
V_1F_2	0.4667 a	0.6567 a	1.1930 a	1.977 a
V_1F_3	0.4567 a	0.6433 a	1.1000 a	1.870 a
V_2F_0	0.3800 a	0.4933 a	0.8833 a	1.510 a
V_2F_1	0.4067 a	0.5467 a	0.9267 a	1.570 a
V_2F_2	0.4467 a	0.6400 a	1.0070 a	1.770 a
V_2F_3	0.4367 a	0.5967 a	1.0130 a	1.663 a
$LSD_{(0.05)}$	0.3675	0.5197	0.5810	0.8217
CV%	7.02%	7.41%	8.16%	6.52%

Here, V_1 = White basil, V_2 = Black basil and

F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.3 Number of branch plant^{-1}

4.3.1 Effect of species on number of branch plant^{-1}

Number of branch plant^{-1} of basil were measured at 30, 90, 150, 210 DAT. It is observed from the result that species had significant influence only on number of branch plant^{-1} at 210 DAT (Fig. 5). From the figure it is observed that number of branch plant^{-1} increased with the advancement of time upto 210 DAT. The highest number of branch plant^{-1} (80) at all the growth stages was recorded in V_1 (white basil) at 210 DAT. In contrast, the lowest number of branch plant^{-1} (69.2) was recorded inV_2 (black basil) at the same DAT.

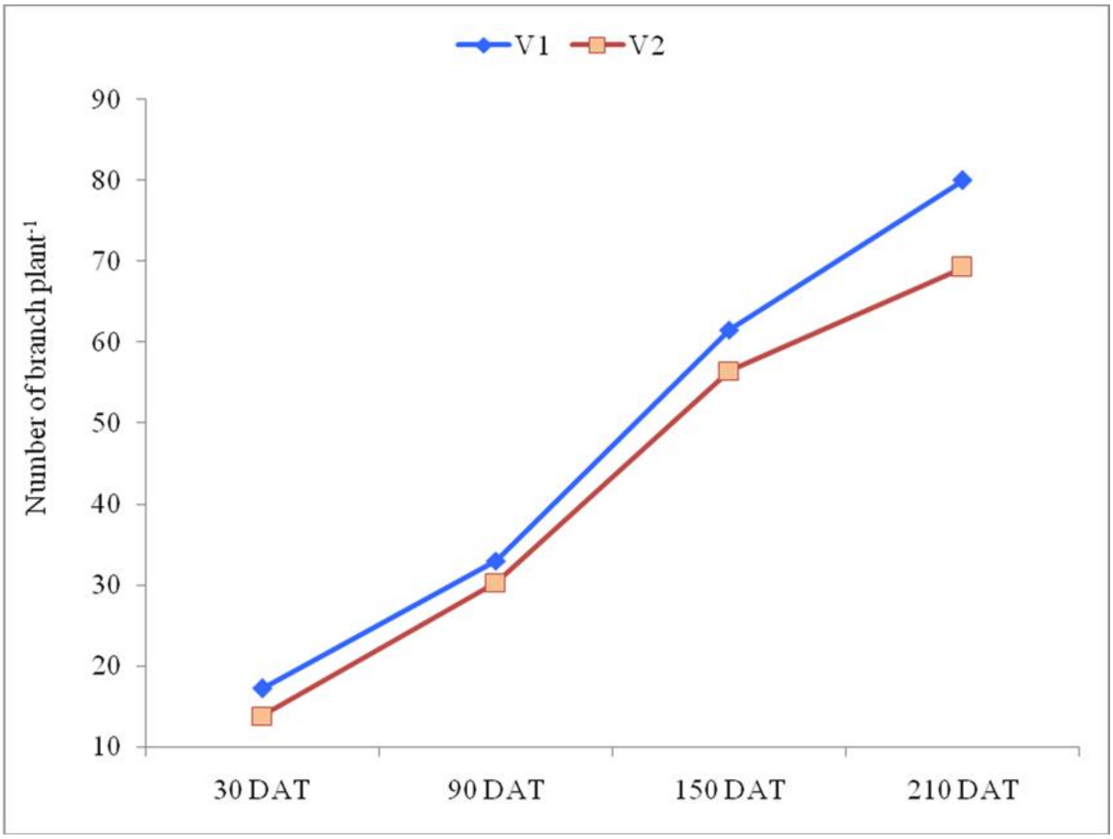

Fig. 6. Effect of species on number of branch plant^{-1} of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.3.2 Effect of organic manure on number of branch plant^{-1}

Number of branch plant^{-1} was significantly influenced by different organic manure at all growth stages (Fig. 6). From the figure it is observed that number of branch plant^{-1} increased progressively with the advancement of time and growth stages until 210 DAT. Maximum number of branch plant^{-1} (83) was produced by F_2 (neem cake) followed by F_3 (vermicompost) at 210 DAT. In contrast, the lowest number of branch plant^{-1} (63.4) was recorded in F_0 (control) at the same DAT.

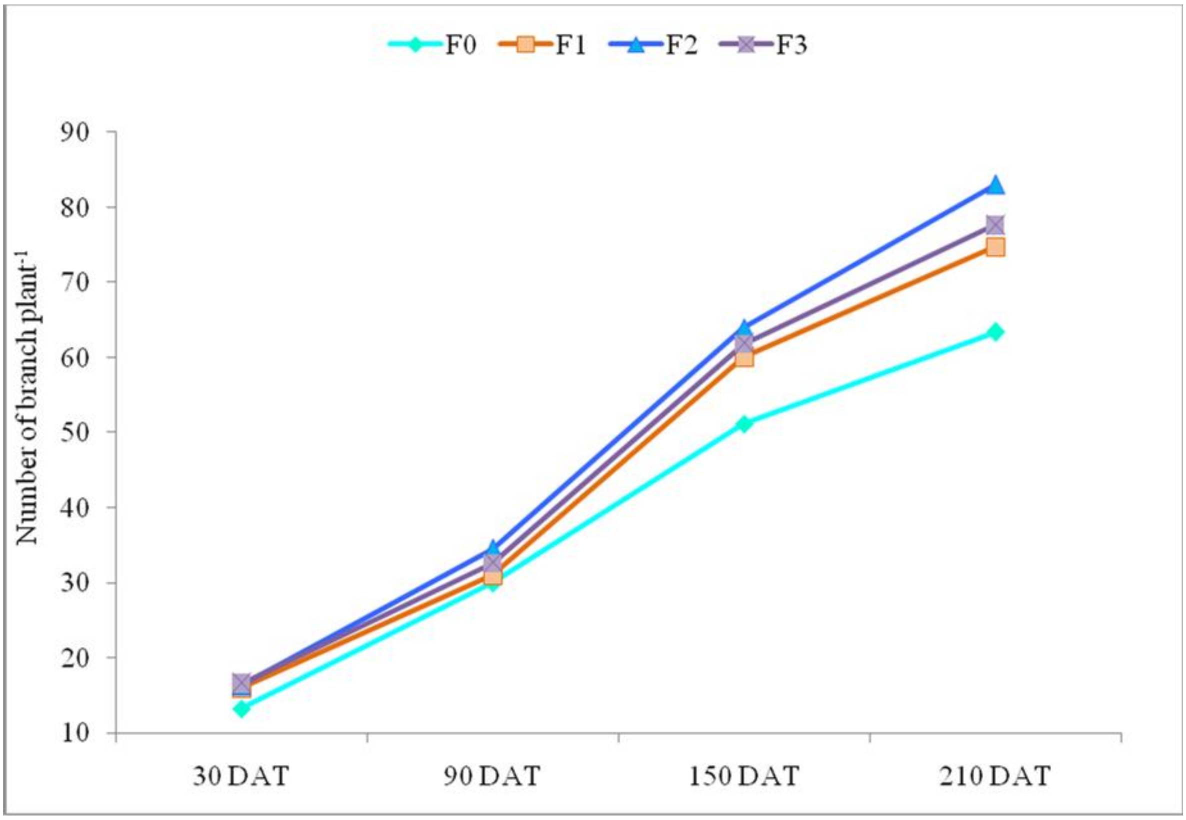

Fig. 7. Effect of organic manure on number of branch plant^{-1} of basil of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.3.3 Interaction effect of species and organic manure on number of branch plant^{-1}

Number of branch plant^{-1} was significantly varied due to interaction effect of species and organic manure (Table 3). At all growth stages the highest number branch plant^{-1} (91.53) was recorded from treatment combination V_1F_2 (white basil with neem cake) followed by V_1F_3 (white basil with vermicompost) at 210 DAT. In contrast the lowest number of branch plant^{-1} (57) was being recorded from the treatment combination V_2F_0 (black basil with no manure) at the same DAT.

Table 3. Interaction effect of species and organic manure on number of branch plant^{-1} of basil at different DAT

Treatment combinations	Number of branch plant^{-1} at			
	30 DAT	90 DAT	150 DAT	210 DAT
V_1F_0	13.60 cd	30.13 b	54.47 c	68.90 d
V_1F_1	14.93 bcd	30.87 b	58.80 bc	73.80 cd
V_1F_2	18.93 a	36.47 a	66.23 a	91.53 a
V_1F_3	17.93 ab	35.60 a	64.00 a	80.50 b
V_2F_0	11.53 d	29.03 b	47.93 d	57.00 e
V_2F_1	14.93 bcd	30.53 b	55.97 c	69.77 d
V_2F_2	17.07 ab	32.33 ab	63.20 ab	78.07 bc
V_2F_3	15.27 bc	31.13 b	61.33 ab	77.13 bc
$LSD_{(0.05)}$	3.398	4.410	5.143	6.330
CV%	9.06%	5.59%	7.50%	6.78%

Here, V_1 = White basil, V_2 = Black basil and

F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.4 Marketable leaf fresh weight plant^{-1}

4.4.1 Effect of species on marketable leaf fresh weight (g) plant^{-1}

Marketable fresh leaf weight (g) plant^{-1} did not differed significantly among the species (Fig. 7). From the figure it is observed that the highest marketable fresh leaf weight plant^{-1} was achieved at 120 DAT. Thereafter fresh leaf weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable fresh leaf yield (108.8 g plant^{-1}, 1.63 kg plot^{-1} and 4.35 t ha^{-1}) was recorded from V_1 (white basil) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable fresh leaf yield (102.5 g plant^{-1}, 1.54 kg plot^{-1} and 4.1 t ha^{-1}) was recorded from V_2 (black basil).

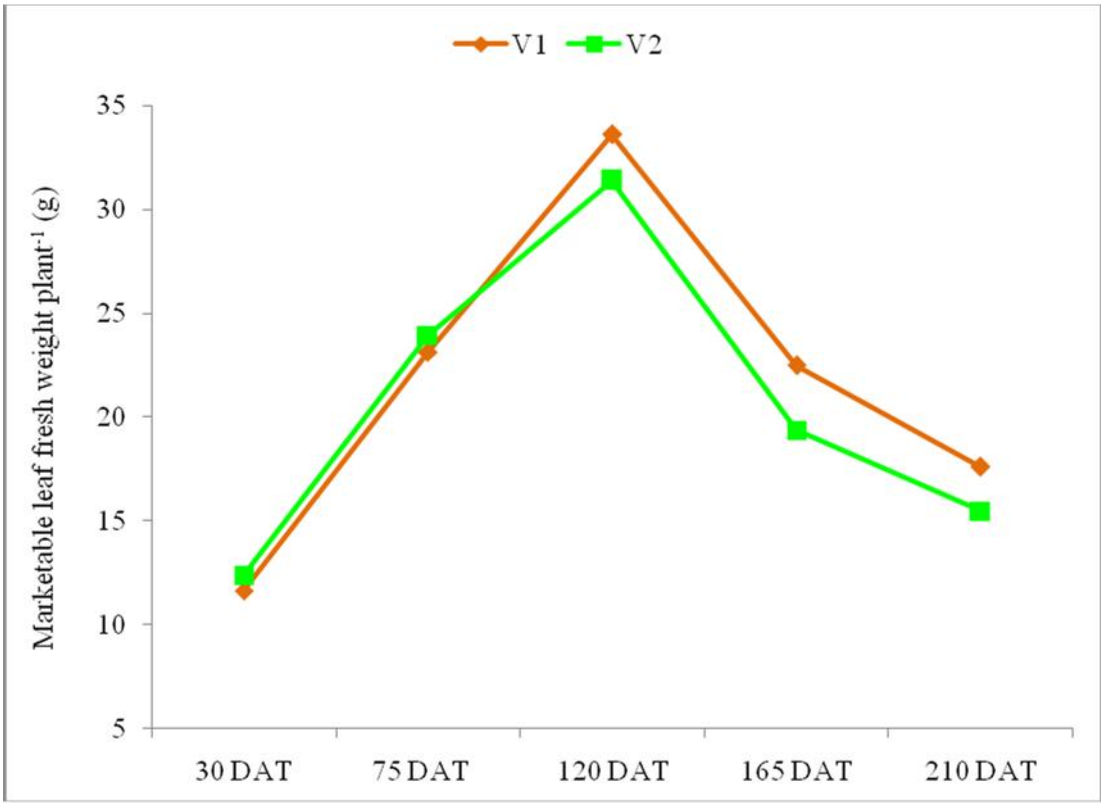

Fig. 8. Effect of species on leaf fresh weight (g) plant^{-1} of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.4.2 Effect of organic manure on marketable leaf fresh weight (g) plant^{-1}

Marketable leaf fresh weight (g) plant^{-1} significantly differed among the organic manures (Fig. 8). From the figure it is observed that the highest marketable fresh leaf weight plant^{-1} was achieved at 120 DAT. Thereafter fresh leaf weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable fresh leaf yield (140.3 g plant^{-1}, 2.1 kg plot^{-1} and 5.61 t ha^{-1}) was recorded from F_2 (neem cake) followed by F_3 (vermicompost) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable fresh leaf yield (90.55 g plant^{-1}, 1.36 kg plot^{-1} and 3.62 t ha^{-1}) was recorded from F_0 (control). The yield and yield attributes were increased with neem cake application which was also supported by the results of Elnasikh *et al.* (2011) who reported that neem seed cake enhances the population of nitrifying fungi and bacteria and reduces the population denitrifying microorganisms in soil hence the yield of basil increased to this manure than other types of manures.

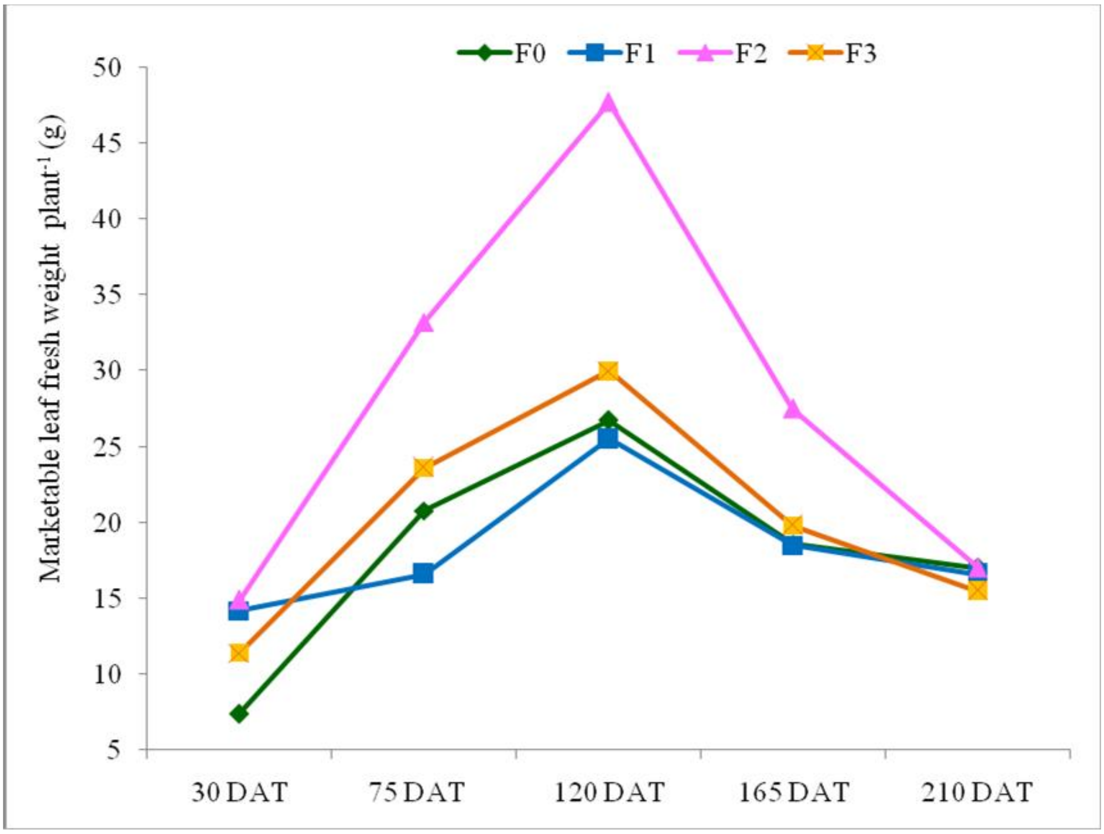

Fig. 9. Effect of organic manure on leaf fresh weight (g) plant^{-1} of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.4.3 Interaction effect of species and organic manure on marketable leaf fresh weight (g) plant^{-1}

Marketable leaf fresh weight (g) plant^{-1} was significantly varied due to interaction effect of species and organic manures (Table 4). From the result it is revealed that the highest marketable fresh leaf weight plant^{-1} was achieved at 120 DAT. Thereafter fresh leaf weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable fresh leaf yield (157 g plant^{-1}, 2.36 kg plot^{-1} and 6.28 t ha^{-1}) was recorded from V_1F_2 (white basil with neem cake) followed by V_2F_2 (black basil with neem cake) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable fresh leaf yield (80.2 g plant^{-1}, 1.2 kg plot^{-1} and 3.21 t ha^{-1}) was recorded from V_2F_0 (black basil with no manure).

4.5 Marketable leaf dry weight plant^{-1}

4.5.1 Effect of species on marketable leaf dry weight (g) plant^{-1}

Marketable dry leaf weight (g) plant^{-1} did not differed significantly among the species (Fig. 9). From the figure it is observed that the highest marketable dry leaf weight plant^{-1} was achieved at 120 DAT. Thereafter dry leaf weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable dry leaf yield (27.86 g plant^{-1}, 0.42 kg plot^{-1} and 1.11 t ha^{-1}) was recorded from V_1 (white basil). In contrast, the lowest total marketable dry leaf yield (26.26 g plant^{-1}, 0.39 kg plot^{-1} and 1.05 t ha^{-1}) was recorded from V_2 (black basil).

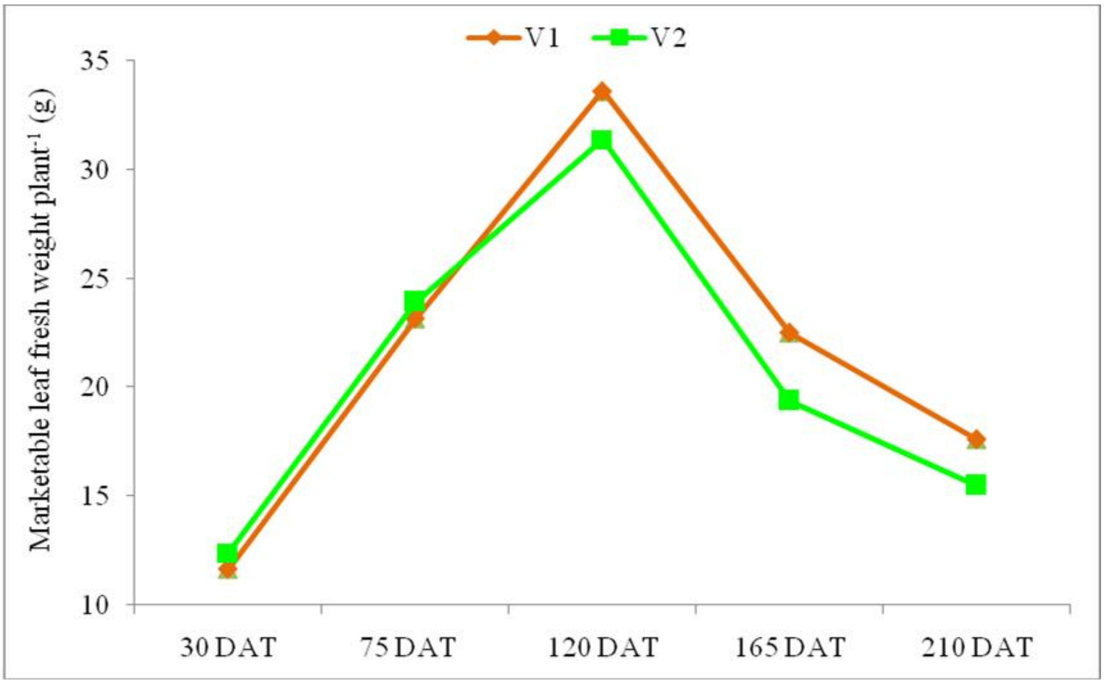

Fig. 10. Effect of species on leaf dry weight (g) plant^{-1} of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.5.2 Effect of organic manure on marketable leaf dry weight (g) plant^{-1}

Marketable leaf dry weight (g) plant^{-1} significantly differed among the organic manures (Fig. 10). From the figure it is observed that the highest marketable dry leaf weight plant^{-1} was achieved at 120 DAT. Thereafter dry leaf weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable dry leaf yield (36.31 g plant^{-1}, 0.54 kg plot^{-1} and

1.45 t ha^{-1}) was recorded from F_2 (neem cake) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable dry leaf yield (22.89 g plant^{-1}, 0.34 kg plot^{-1} and 0.92 t ha^{-1}) was recorded from F_0 (control).

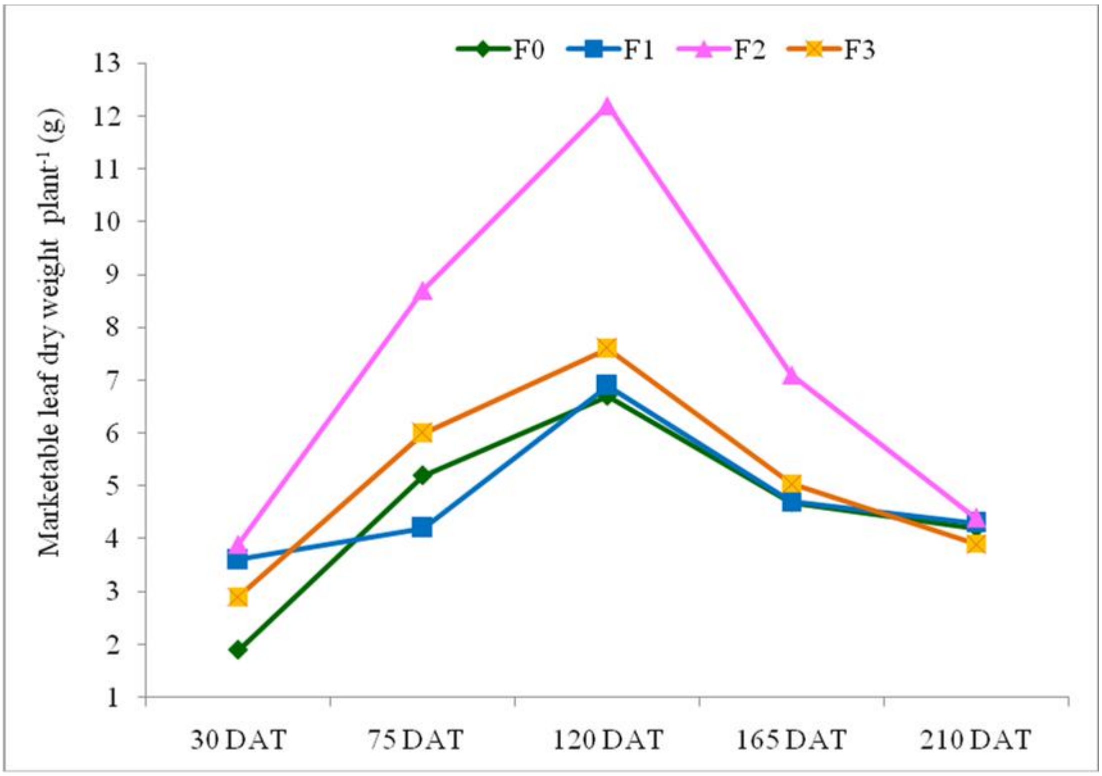

Fig. 11. Effect of organic manure on leaf dry weight (g) plant^{-1} of basil at different days after transplanting.
Here, F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.5.3 Interaction effect of species and organic manure on marketable leaf dry weight (g) plant^{-1}

Marketable leaf dry weight (g) plant^{-1} was significantly varied due to interaction effect of species and organic manure (Table 4). From the result it is revealed that the highest marketable dry leaf weight plant^{-1} was achieved at 120 DAT. Thereafter dry leaf weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable dry leaf yield (36.67 g plant^{-1}, 0.6 kg plot^{-1} and 1.6 t ha^{-1}) was recorded from V_1F_2 (white basil with neem cake) followed by V_2F_2 (black basil with neem cake) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable dry leaf yield (20.29 g plant^{-1}, 0.3 kg plot^{-1} and 0.81 t ha^{-1}) was recorded from V_2F_0 (black basil with no manure).

4.6 Whole fresh weight plant^{-1} (g)

4.6.1 Effect of species on whole fresh weight plant^{-1} (g)

Whole fresh weight plant^{-1} (g) of basil significantly differed among the species (Fig. 11). From result it is observed that the highest whole fresh weight plant^{-1} (350.8 g) was recorded from V_1 (white basil) at 210 DAT. In contrast, the lowest whole fresh weight plant^{-1} (221.1 g) was recorded from V_2 (black basil) at the same DAT.

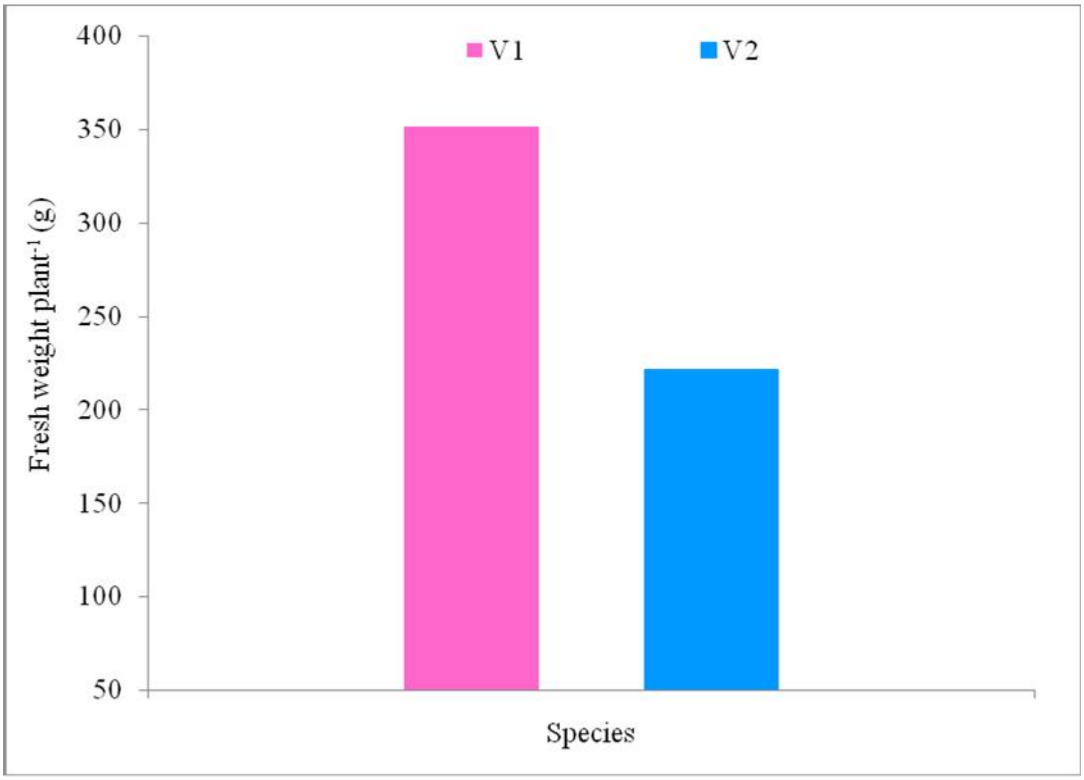

Fig. 12. Effect of species on Fresh weight plant^{-1} (g) of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.6.2 Effect of organic manure on whole fresh weight plant^{-1} (g)

Whole fresh weight plant^{-1} (g) of basil significantly differed among the organic manures (Fig. 12). From result it is observed that the highest whole fresh weight plant^{-1} (367.7 g) was recorded from F_2 (neem cake) followed by F_3 (vermicompost) at 210 DAT. In contrast, the lowest whole fresh weight plant^{-1} (228.6 g) was recorded from F_0 (control) at the same DAT.

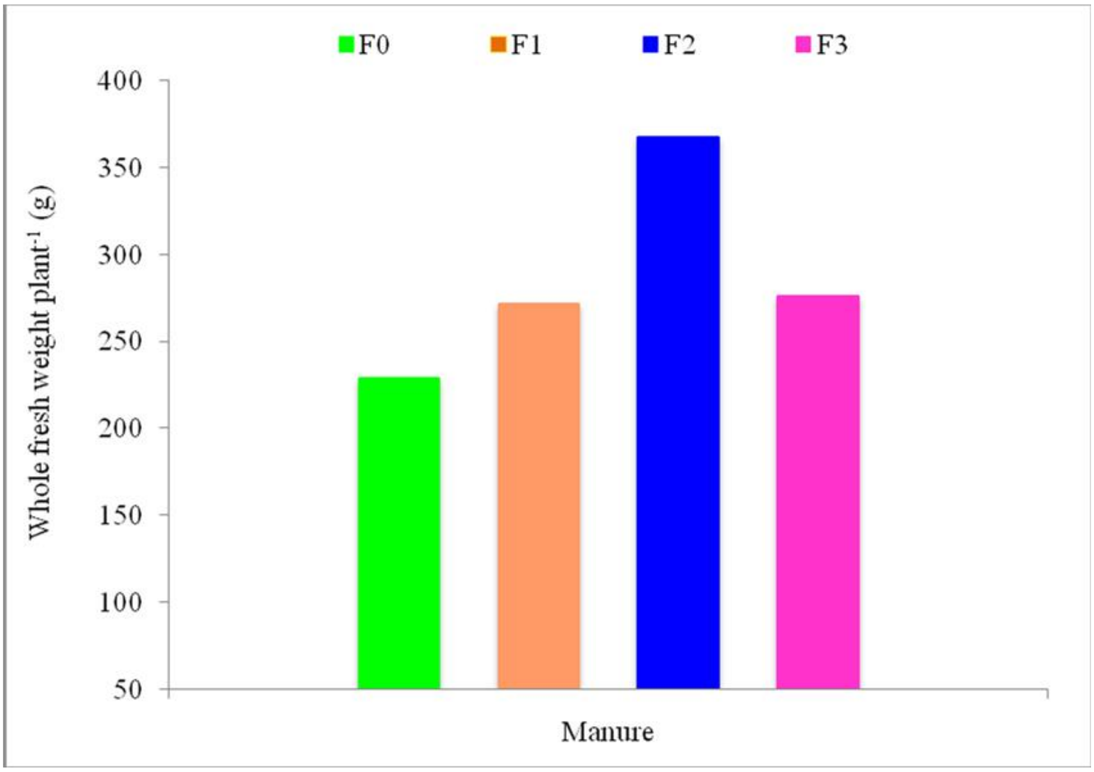

Fig. 13. Effect of organic manure on Fresh weight plant^{-1} (g) of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

4.6.3 Interaction effect of species and organic manure on whole fresh weight plant^{-1} (g)

Whole fresh weight plant^{-1} (g) was significantly varied due to interaction effect of species and organic manure (Table 5). The highest whole fresh weight plant^{-1} (458.8 g) was recorded from treatment combination V_1F_2 (white basil with neem cake) at 210 DAT. In contrast the lowest whole fresh weight plant^{-1} (189 g) was recorded from the treatment combination V_2F_0 (black basil with no manure) at the same DAT.

4.7 Fresh stem weight plant^{-1} (g)

4.7.1 Effect of species on stem fresh weight plant^{-1} (g)

Fresh stem weight plant^{-1} (g) of basil significantly differed among the species (Fig. 13). From result it is observed that the highest fresh stem weight plant^{-1} (283.7 g) was recorded from V_1 (white basil) at 210 DAT. In contrast, the lowest fresh stem weight plant^{-1} (167.4 g) was recorded from V_2 (black basil) at the same DAT.

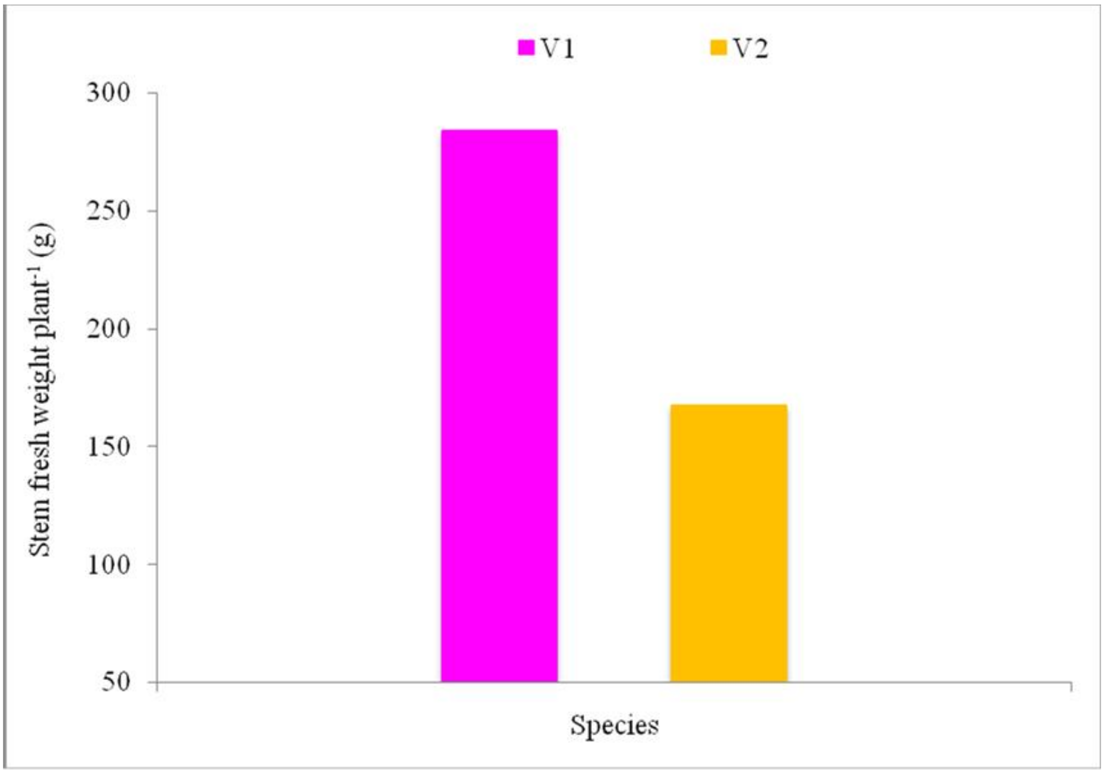

Fig. 14. Effect of species on fresh stem weight plant^{-1} (g) of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.7.2 Effect of organic manure on stem fresh weight plant^{-1} (g)

Fresh stem weight plant^{-1} (g) of basil significantly differed among the organic manures (Fig. 14). From result it is observed that the highest fresh stem weight plant^{-1} (302.9 g) was recorded from F_2 (neem cake) followed by F_3 (vermicompost) at 210 DAT. In contrast, the lowest fresh stem weight plant^{-1} (173 g) was recorded from F_0 (control) at the same DAT.

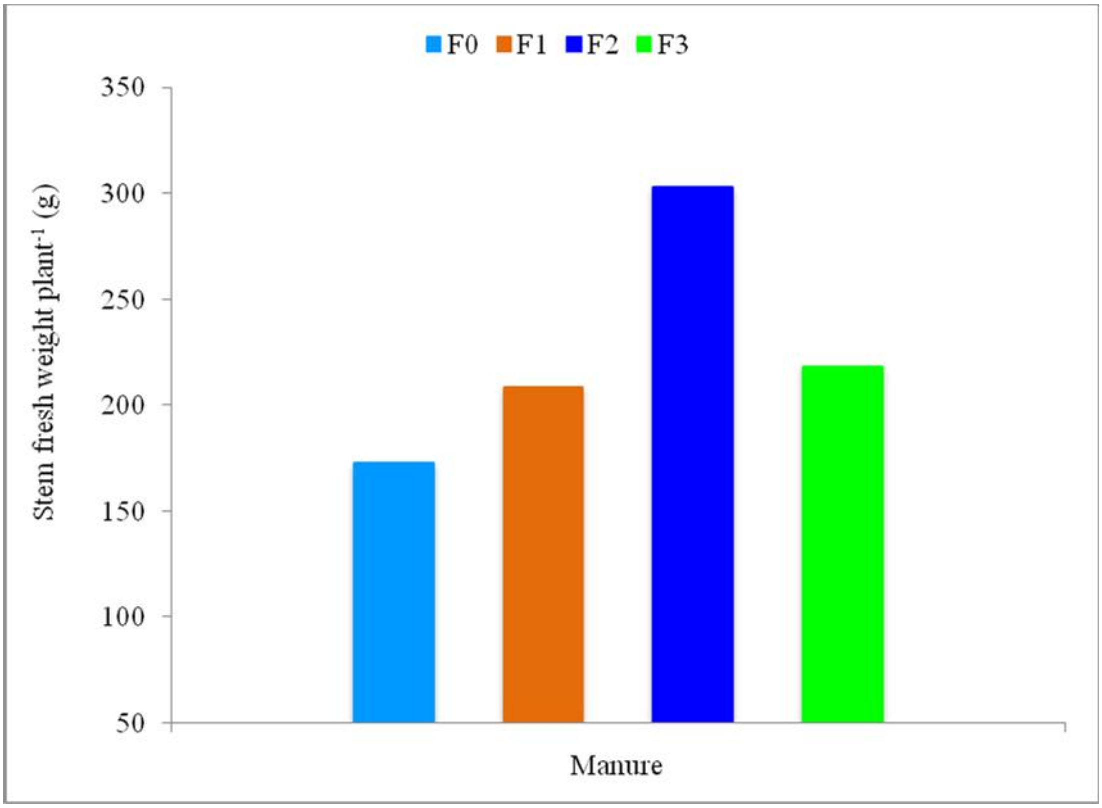

Fig. 15. Effect of organic manure on fresh stem weight plant^{-1} (g) of basil at different days after transplanting.
Here, F_0= Control, F_1= Cow dung, F_2= Neem cake, F_3= Vermicompost)

4.7.3 Interaction effect of species and organic manure on stem fresh weight plant^{-1} (g)

Fresh stem weight plant^{-1} (g) was significantly varied due to interaction effect of species and organic manures (Table 5). The highest fresh stem weight plant^{-1} (386.9 g) is recorded from treatment combination V_1F_2 (white basil with neem cake) followed by V_2F_2 (black basil with neem cake) at 210 DAT. In contrast the lowest fresh stem weight plant^{-1} (139.9 g) was recorded from the treatment combination V_2F_0 (black basil with no manure) at the same DAT.

4.8 Root fresh weight plant^{-1} (g)

4.8.1 Effect of species on root fresh weight plant^{-1} (g)

Fresh root weight plant^{-1} (g) of basil significantly differed among the species (Fig. 15). From result it is observed that the highest fresh root weight plant^{-1} (67.1 g) is recorded from V_1 (white basil) at 210 DAT. In contrast, the lowest fresh root weight plant^{-1} (53.7 g) was recorded from V_2 (black basil) at the same DAT.

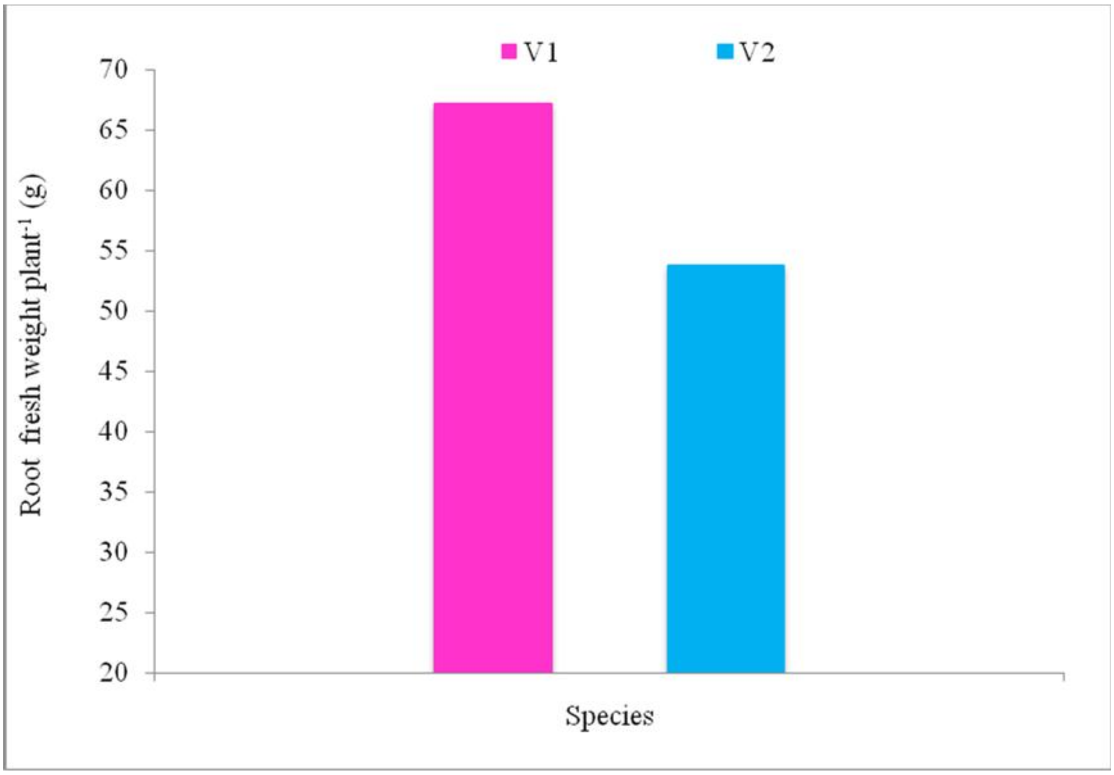

Fig. 16. Effect of species on fresh root weight plant^{-1} (g) of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.8.2 Effect of organic manure on fresh root weight (g) plant^{-1}

Fresh root weight plant^{-1} (g) of basil significantly differed among the organic manure (Fig. 16). From result it is observed that the highest fresh root weight plant^{-1} (64.9 g) is recorded from F_2 (neem cake) followed by F_3 (vermicompost) at 210 DAT. In contrast, the lowest fresh root weight plant^{-1} (55.6 g) is recorded from F_0 (control) at the same DAT.

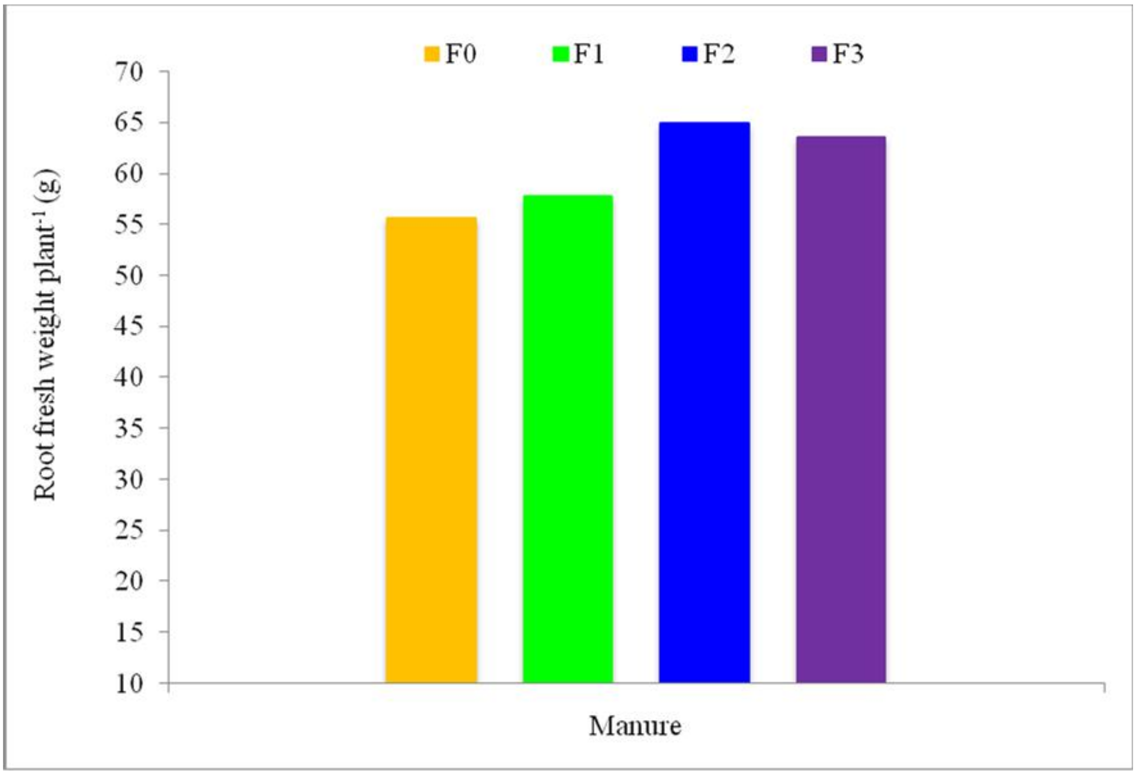

Fig. 17. Effect of organic manure on fresh root weight plant^{-1} (g) of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2 = Neem cake, F_3 = Vermicompost

4.8.3 Interaction effect of species and organic manure on fresh root weight plant^{-1} (g)

Fresh root weight plant^{-1} (g) was significantly varied due to interaction effect of species and organic manures (Table 5). The highest fresh root weight plant^{-1} (71.87 g) was recorded from treatment combination V_1F_2 (white basil with neem cake) at 210 DAT. In contrast the lowest fresh root weight plant^{-1} (49.07 g) was recorded from the treatment combination V_2F_0 (black basil with no manure) at the same DAT.

4.9 Root length plant^{-1} (cm)

4.9.1 Effect of species on fresh root length plant^{-1} (cm)

Root length plant^{-1} (cm) of basil did not differed significantly among the species (Fig. 17). But it is observed from the result that the highest root length plant^{-1} (24.72 cm) was recorded from V_1 (white basil) at 210 DAT. In contrast, the lowest root length plant^{-1} (20.78 cm) was recorded from V_2 (black basil) at the same DAT.

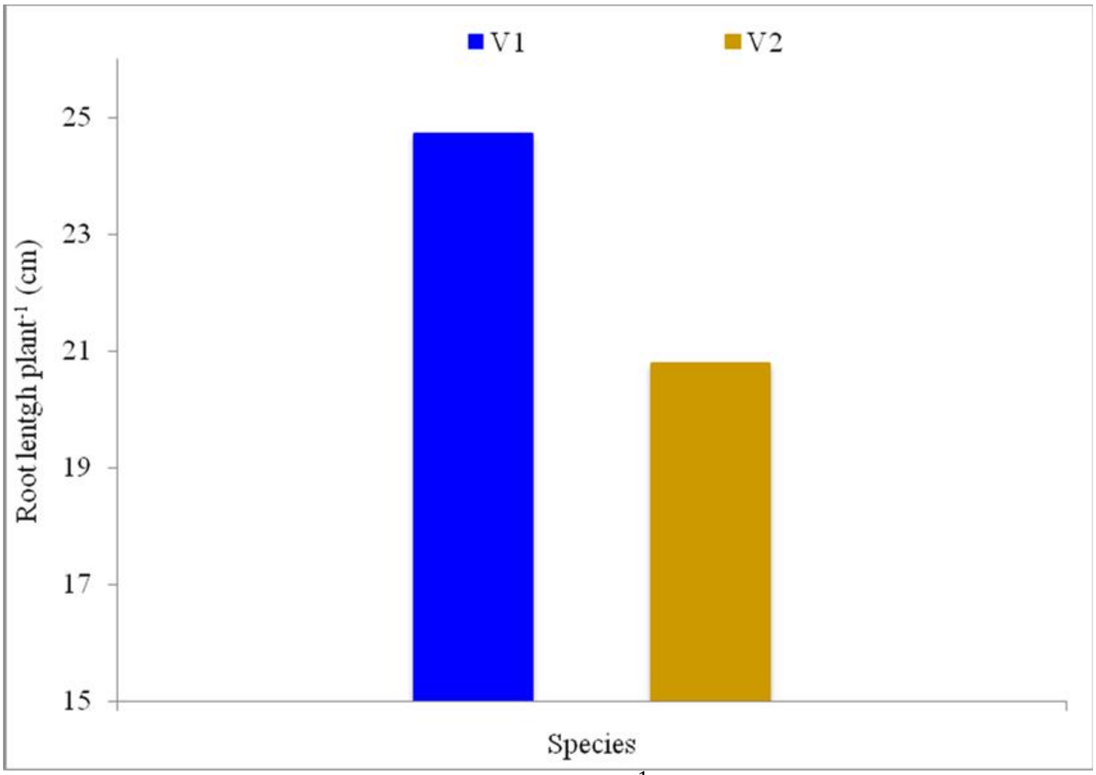

Fig. 18. Effect of species on root length plant^{-1} (cm) of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.9.2 Effect of organic manure on Root length plant^{-1} (cm)

Root length plant^{-1} (cm) of basil did not differed significantly among the organic manures (Fig. 18). But it is observed from the result that the highest root length plant^{-1} (23.50 cm) was recorded from F_2 (neem cake) followed by F_3

(vermicompost) at 210 DAT. In contrast, the lowest fresh root length plant^{-1} (21.93 cm) was recorded from F_0 (control) at the same DAT.

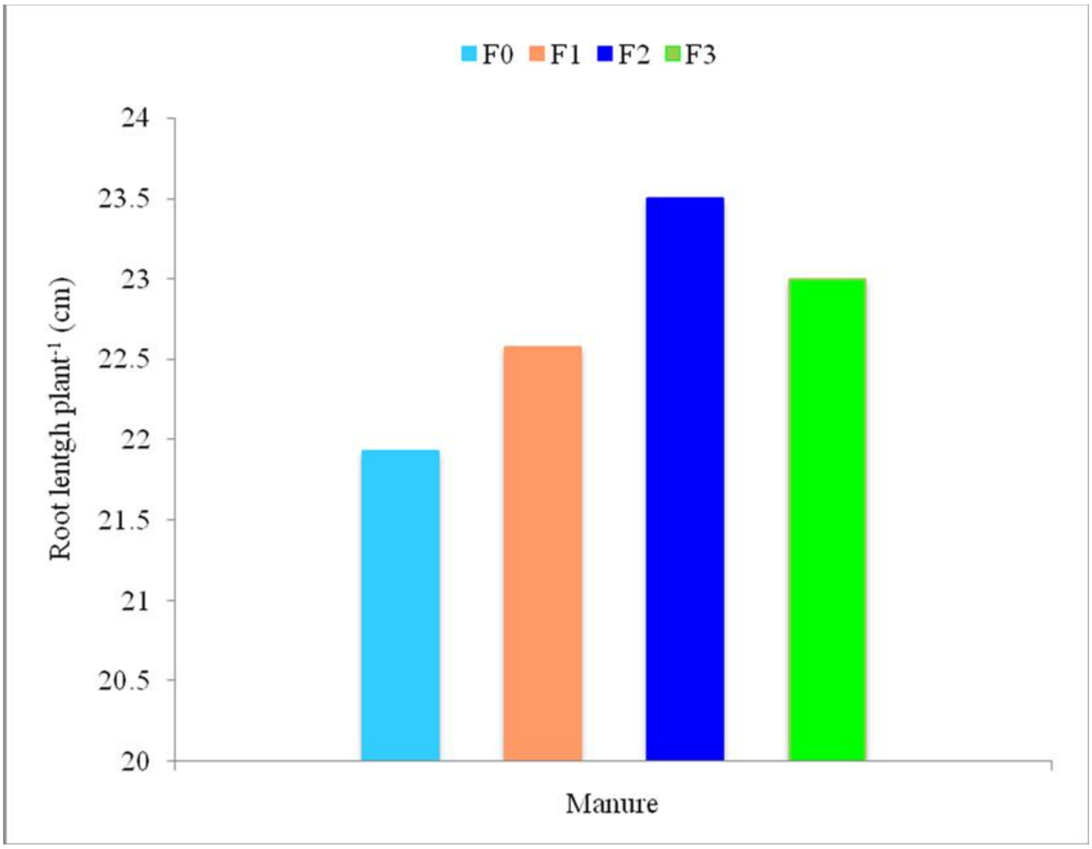

Fig. 19. Effect of organic manure on fresh root length plant^{-1} (g) of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2 = Neem cake, F_3 = Vermicompost

4.9.3 Interaction effect of species and organic manure on root length plant^{-1} (cm)

Root length plant^{-1} (cm) was significantly varied due to interaction effect of species and organic manure (Table 5). The highest root length plant^{-1} (25.33 cm) was recorded from treatment combination V_1F_2 (white basil with neem cake) followed by V_2F_2 (black basil with neem cake) at 210 DAT. In contrast the lowest root length (cm) plant^{-1} (18.87 cm) was recorded from the treatment combination V_1F_0 (white basil with no manure) at the same DAT.

4.10 Fresh seed weight plant^{-1}

4.10.1 Effect of species on fresh seed weight (g) plant^{-1}

Fresh seed weight (g) plant^{-1} did not differed significantly among the species (Fig. 19). From the figure it is observed that the highest fresh seed weight plant^{-1} was achieved at 120 DAT. Thereafter fresh seed weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total fresh seed yield (15.28 g plant^{-1}, 229.2 g plot^{-1} and 611.20 kg ha^{-1}) was recorded from V_1 (white basil) due to increased number of branch plant^{-1}. In contrast, the lowest total fresh seed yield (13.6 g plant^{-1}, 204 g plot^{-1} and 544 kg ha^{-1}) was recorded from V_2 (black basil).

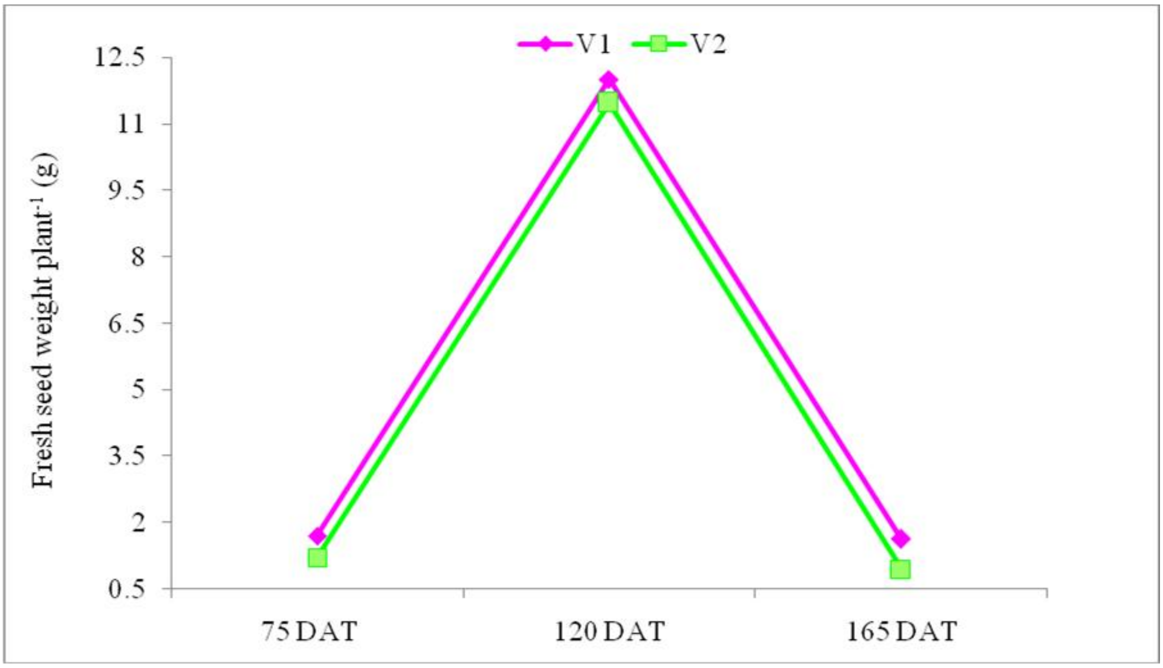

Fig. 20. Effect of species on seed fresh weight (g) plant^{-1} of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.10.2 Effect of organic manure on seed fresh weight (g) plant^{-1}

Fresh seed weight (g) plant^{-1} differed among the organic manures (Fig. 20). From the figure it is observed that the highest marketable fresh seed weight plant^{-1} was achieved at 120 DAT. Thereafter fresh seed weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable fresh seed yield (21.22 g plant^{-1}, 318.3 g plot^{-1} and 848.8 kg ha^{-1}) was recorded from F_2 (neem cake) followed by F_3 (vermicompost) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable fresh seed yield (9.64 g plant^{-1}, 144.6 g plot^{-1} and 385.6 kg ha^{-1}) was recorded from F_0 (control).

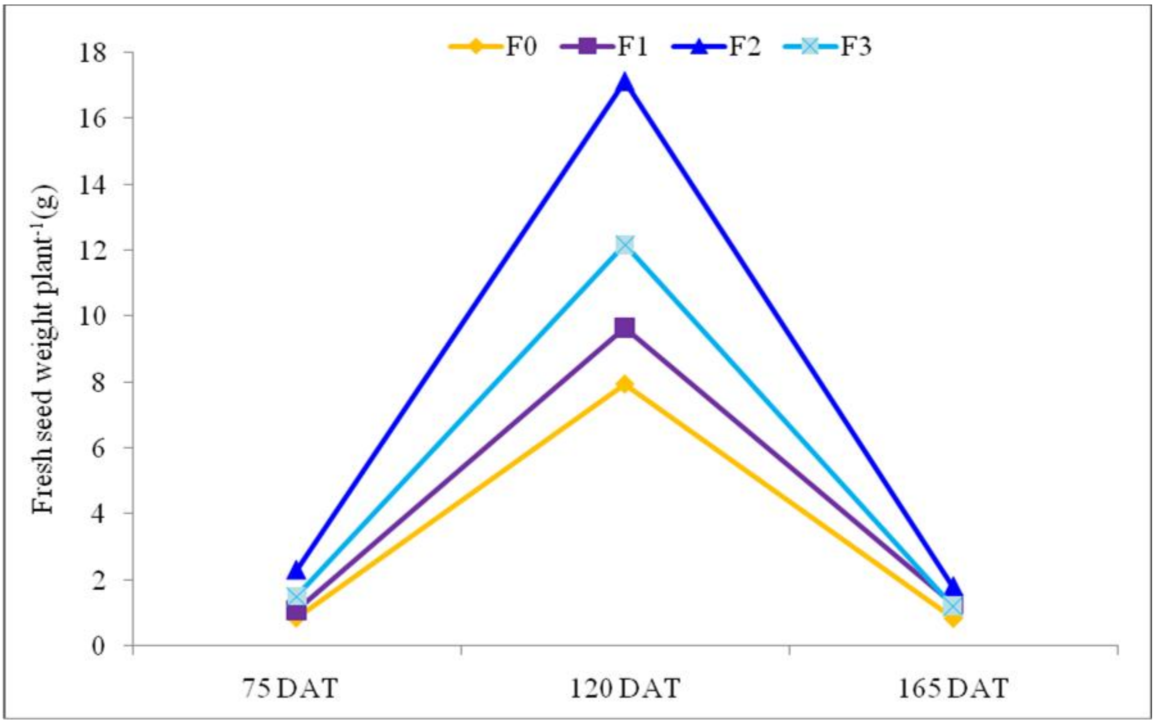

Fig. 21. Effect of organic manure on seed fresh weight (g) plant^{-1} of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2 = Neem cake, F_3= Vermicompost

4.10.3 Interaction effect of species and organic manure on seed fresh weight (g) plant^{-1}

Fresh seed weight (g) plant^{-1} was varied significantly due to interaction effect of species and organic manures (Table 6). From the result it is revealed that the highest fresh seed weight plant^{-1} was achieved at 120 DAT. Thereafter fresh seed weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total fresh seed yield (23.57 g plant^{-1}, 353.55 g plot^{-1} and 942.8 kg ha^{-1}) was recorded from V_1F_2 (white basil with neem cake) followed by V_2F_2 (black basil with neem cake) due to increased number of branch plant^{-1}. In contrast, the lowest total fresh seed yield (8.72 g plant^{-1}, 130.8 g plot^{-1} and 348.8 kg ha^{-1}) was recorded from V_1F_0 (white basil with no manure).

4.11 Marketable dry seed weight plant^{-1}

4.11.1 Effect of species on marketable dry seed weight (g) plant^{-1}

Marketable dry seed weight (g) plant^{-1} did not varied significantly among the species (Fig. 21). From the figure it is observed that the highest marketable dry seed weight plant^{-1} was achieved at 120 DAT. Thereafter dry seed weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable dry seed yield (1.85 g plant^{-1}, 27.75 g plot^{-1} and 74 kg ha^{-1}) was recorded from V_1 (white basil) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable dry seed yield (1.66 g plant^{-1}, 24.9 g plot^{-1} and 66.4 kg ha^{-1}) was recorded from V_2 (black basil).

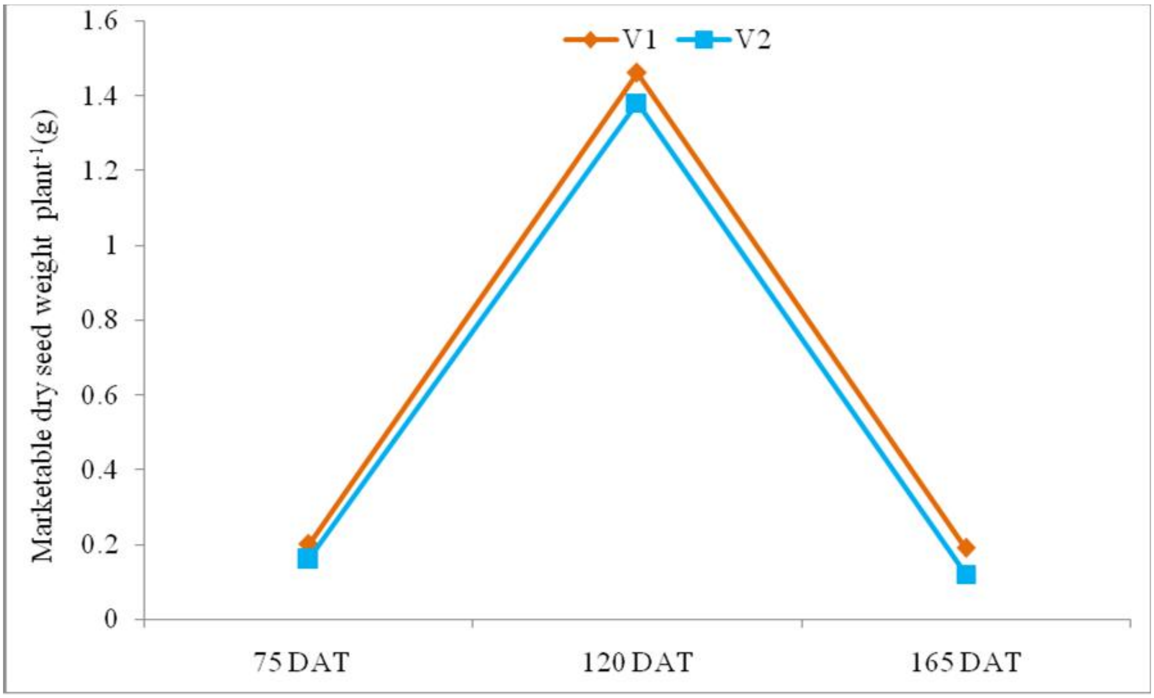

Fig. 22. Effect of species on dry seed weight (g) plant^{-1} of basil at different days after transplanting. (Here, V_1 = White basil, V_2 = Black basil)

4.11.2 Effect of organic manure on marketable dry seed weight (g) plant^{-1}

Marketable dry seed weight (g) plant^{-1} significantly differed among the organic manures (Fig. 22). From the figure it is observed that the highest marketable dry seed weight plant^{-1} was achieved at 120 DAT. Thereafter dry seed weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable dry seed yield (2.61 g plant^{-1}, 39.15 g plot^{-1} and 104.4 kg ha^{-1}) was recorded from F_2 (neem cake) followed by F_3 (vermicompost) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable dry seed yield (1.16 g plant^{-1}, 17.4 g plot^{-1} and 46.4 kg ha^{-1}) was recorded from F_0 (control).

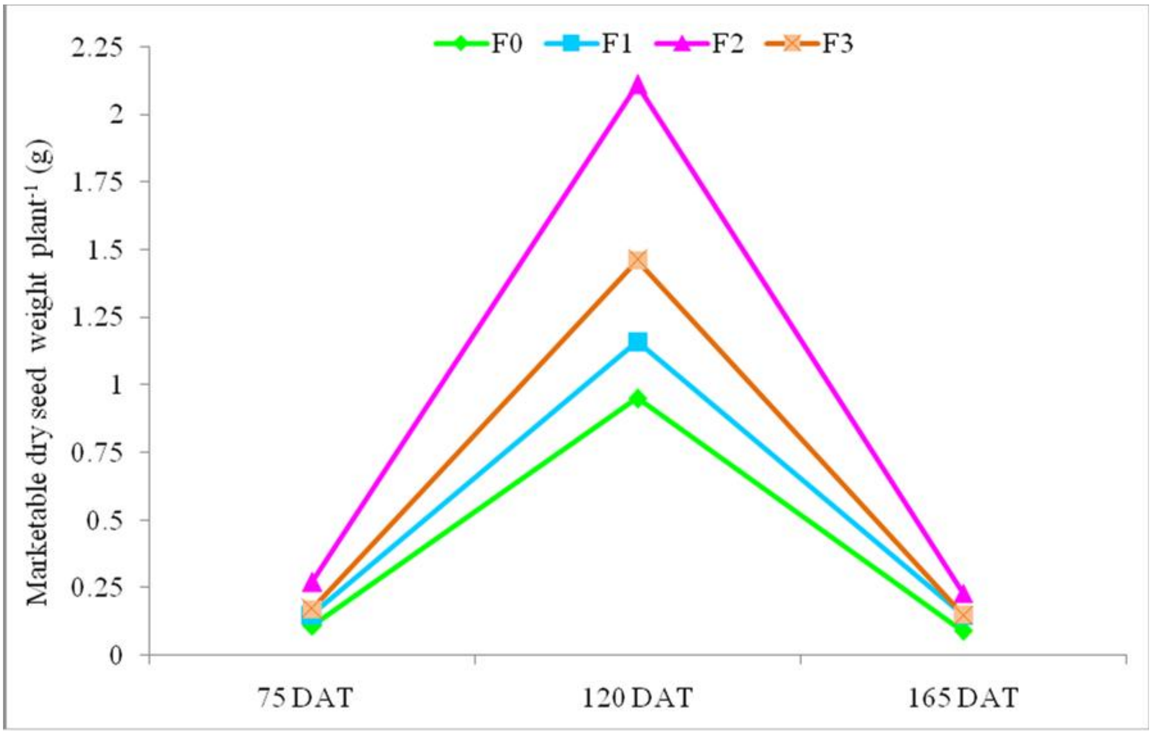

Fig. 22. Effect of organic manure on dry seed weight plant^{-1} (g) of basil at different days after transplanting.

Here, F_0= Control, F_1 = Cow dung, F_2 = Neem cake, F_3= Vermicompost

4.11.3 Interaction effect of species and organic manure on marketable dry seed weight (g) plant^{-1}

Marketable dry seed weight (g) plant^{-1} varied significantly due to interaction effect of species and organic manure (Table 6). From the result it is revealed that the highest marketable fresh leaf weight plant^{-1} was achieved at 120 DAT. Thereafter fresh leaf weight (g) plant^{-1} decreased. It may be for less vegetative growth due to lack of nutrient. The highest total marketable dry seed yield (2.91 g plant^{-1}, 43.65 g plot^{-1} and 116.4 kg ha^{-1}) was recorded from V_1F_2 (white basil with neem cake) followed by V_2F_2 (black basil with neem cake) due to increased number of branch plant^{-1}. In contrast, the lowest total marketable dry seed yield (1.03 g plant^{-1}, 15.45 g plot^{-1} and 41.2 kg ha^{-1}) was recorded from V_1F_0 (white basil with no manure).

Table 4. Interaction effect of species and organic manure on marketable fresh leaf weight (g) plant^{-1} and marketable dry leaf weight (g) plant^{-1} at different DAT

Treatment combinati-ons	Marketable fresh leaf weight (g) of plant^{-1} at						Marketable dry		
	30 DAT	**75 DAT**	**120 DAT**	**165 DAT**	**210 DAT**	**Total**	**30 DAT**	**75 DAT**	**120 D**
V_1F_0	13.43 ab	19.43 bc	24.93 b	17.10 b	13.27 b	88.17 c	3.373 ab	4.957 bc	6.323 b
V_1F_1	15.10 ab	13.77 c	26.13 b	19.90 b	20.00 a	94.90 bc	3.843 ab	3.517 c	7.463 b
V_1F_2	13.63 ab	35.73 a	56.20 a	32.36 a	19.07 a	157.0 a	3.547 ab	9.533 a	14.39 a
V_1F_3	10.50 ab	25.90 abc	30.53 b	21.37 b	14.87 ab	103.2 bc	2.663 ab	6.573 abc	7.683 b
V_2F_0	7.30 b	17.11 bc	21.59 b	17.73 b	16.47 ab	80.20 c	1.867 b	4.327 bc	5.463 b
V_2F_1	12.30 ab	21.24 bc	29.45 b	18.27 b	16.07 ab	97.34 bc	3.117 ab	5.427 bc	7.423 b
V_2F_2	16.17 a	30.58 ab	39.26 ab	22.66 b	15.00 ab	123.7 ab	4.250 a	7.890 ab	10.06 a
V_2F_3	7.57 ab	24.43 abc	31.93 b	19.43 b	17.54 ab	100.9 bc	1.927 b	6.210 abc	8.060 b
$LSD_{(0.05)}$	8.64	14.1	18.87	7.29	5.71	35.18	2.18	3.58	4.81
CV%	9.12%	8.22%	8.15%	9.72%	9.73%	9.08%	8.59%	7.77%	7.89%

Here, V_1 = White basil, V_2 = Black basil and F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

Table 5. Interaction effect of species and organic manure on whole fresh weight plant^{-1} (g), stem fresh weight plant^{-1} (g), root fresh weight plant^{-1} (g) and root length plant^{-1} (cm)

Treatment combinations	Whole fresh weight plant^{-1} (g)	Stem fresh weight plant^{-1} (g)	Root fresh weight plant^{-1} (g)
V_1F_0	259.4 d	147.3 fg	50.47 de
V_1F_1	197.7 f	198.7 e	57.87 c
V_1F_2	458.8 a	386.9 a	71.87 a
V_1F_3	322.6 c	253.0 c	66.33 ab

V_2F_0	189.0 f	139.9 g	49.07 e
V_2F_1	220.9 e	163.5 f	57.40 cd
V_2F_2	362.4 b	296.0 b	69.60 a
V_2F_3	276.7 d	218.8 d	60.67 bc
$LSD_{(0.05)}$	19.07	18.47	6.984
CV%	5.64%	5.81%	5.72%

Here, V_1 = White basil, V_2 = Black basil and F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

Table 6. Interaction effect of species and organic manure on seed fresh weight (g) plant^{-1} and marketable seed dry weight (g) plant^{-1}

Treatment combinations	Seed fresh weight plant^{-1} at				Marketable seed	
	75 DAT	**120 DAT**	**165 DAT**	**Total**	**75 DAT**	**120 DAT**
V_1F_0	0.78 d	7.00 d	0.94 b	8.72 e	0.09 d	0.84 d
V_1F_1	1.19 cd	10.34 cd	1.74 ab	13.27 cde	0.14 cd	1.25 cd
V_1F_2	2.76 a	18.34 a	2.47 a	23.57 a	0.33 a	2.28 a
V_1F_3	1.89 b	12.34 bc	1.34 ab	15.57 bc	0.22 b	1.48 bc
V_2F_0	0.93 d	8.89 cd	0.74 b	10.56 de	0.15 cd	1.06 cd
V_2F_1	0.99 d	9.00 cd	0.80 b	10.79 de	0.16 bcd	1.08 cd
V_2F_2	1.79 bc	15.95 ab	1.14 ab	18.88 b	0.22 bc	1.94 ab
V_2F_3	1.10 d	12.00 bc	1.07 b	14.17 cd	0.13 d	1.44 c
$LSD_{(0.05)}$	0.6737	3.975	1.349	4.592	0.07832	0.4796
CV%	6.97%	4.35%	10.00%	6.16%	5.61%	4.30%

Here, V_1 = White basil, V_2 = Black basil and F_0= Control, F_1 = Cow dung, F_2= Neem cake, F_3 = Vermicompost

CHAPTER V

SUMMARY AND CONCLUSION

Summary

The field experiment was conducted at the horticulture farm of Sher-e-Bangla Agricultural University (SAU), Dhaka from November, 2012 to June 2013, with a view to find out the performance of black and white basil (*Ocimum sp.* L.) as influenced by different organic manures. The experiment consisted of two levels of treatments viz. A: Two species of Basil, white basil (V_1) and black basil (V_2), B: Four levels of organic manures, control (F_0), cowdung (F_1), neem cake (F_2) and vermicompost (F_3). The experiment was laid out in two factor randomized complete block design with three replications. There were 8 treatments combinations. The total numbers of unit plots were 24. The unit plot size was 2.5 m × 1.5 m. All intercultural operations were practiced as and when required.

Data on crop growth characters like plant height, plant base diameter, number of branch plant^{-1}, were recorded at 30, 90, 150 and 210 DAT. Whole fresh weight plant^{-1}, stem fresh weight plant^{-1}, root fresh weight plant^{-1}, root length plant^{-1} were recorded at final harvesting (at the end of experiment i.e. at 210 DAT). Marketable fresh and dry leaf yield was recorded after each leaf harvest (at 30, 75, 120 and 165 DAT). Fresh and marketable dry seed yield was recorded after each seed harvest (at 75, 120 and 165 DAT). Finally yields plant^{-1} was converted to yields plot^{-1} and yields plot^{-1} was converted to t ha^{-1} (for leaf yield) and kg ha^{-1} (for seed yield) and analyzed the data with the help of computer package MSTATC. The mean differences among the treatments were adjusted by least significant difference (LSD) test at 5% level of significance.

Results of the experiment showed that species had significant differences for some of the growth characters. White basil gave maximum plant height, base

diameter plant^{-1}, number of branch plant^{-1}, marketable leaf fresh yield and dry yield, whole fresh weight plant^{-1}, stem fresh weight plant^{-1}, root fresh weight plant^{-1}, root length plant^{-1}, seed fresh yield, marketable seed dry yield and the lowest was found in black basil.

Organic manure exerted significant influence for most of the growth and yield contributing characters. Neem cake gave maximum plant height, base diameter plant^{-1}, number of branch plant^{-1}, marketable leaf fresh yield and dry yield, whole fresh weight plant^{-1}, stem fresh weight plant^{-1}, root fresh weight plant^{-1}, root length plant^{-1}, seed fresh yield, marketable seed dry yield and lowest was found in control. Interaction between neem cake and species significantly affected all the growth characters. V_1F_2 showed significantly higher yield contributing character in all cases.

In case of marketable fresh leaf weight, V_1 produced the highest total marketable fresh leaf yield (1.63 kg plot^{-1} and 4.35 t ha^{-1}) while V_2 produced the lowest total marketable fresh leaf weight (1.54 kg plot^{-1} and 4.1 t ha^{-1}). Among different organic manures, F_2 produced the highest total marketable fresh leaf weight (2.1 kg plot^{-1} and 5.61 t ha^{-1}) while F_0 produced the lowest total marketable fresh leaf weight (1.36 kg plot^{-1} and 3.62 t ha^{-1}). Interaction between species and organic manure, V_1F_2 produced the highest total marketable fresh leaf weight (2.36 kg plot^{-1} and 6.28 t ha^{-1}) and V_2F_0 produced the lowest total marketable fresh leaf weight (1.2 kg plot^{-1} and 3.21 t ha^{-1}).

Among the species, V_1 produced the highest total marketable dry leaf weight (0.42 kg plot^{-1} and 1.11 t ha^{-1}) while V_2 produced the lowest total marketable dry leaf weight (0.39 kg plot^{-1} and 1.05 t ha^{-1}). Among different organic manures, F_2 produced the highest total marketable dry leaf weight (0.54 kg plot^{-1} and 1.45 t ha^{-1}) and F_0 produced the lowest total marketable dry leaf weight (0.34 kg plot^{-1} and 0.92 t ha^{-1}). Interaction between species and organic manure, V_1F_2 produced the highest total marketable dry leaf weight (0.6 kg plot^{-1} and 1.6 t ha^{-1}) and V_2F_0 produced the lowest total marketable dry leaf weight (0.3 kg plot^{-1} and 0.81 t ha^{-1}).

In case of marketable dry seed weight, V_1 produced the highest total dry seed weight (27.75 g plot^{-1} and 74 kg ha^{-1}) while V_2 produced the lowest total marketable dry seed weight (24.9 g plot^{-1} and 66.4 kg ha^{-1}). Among different organic manures, F_2 produced the highest total marketable dry seed weight (39.15 g plot^{-1} and 104.4 kg ha^{-1}) and F_0 produced the lowest total marketable dry seed weight (17.4 g plot^{-1} and 46.4 kg ha^{-1}). Interaction between species and organic manure, V_1F_2 produced the highest total marketable dry seed weight (43.65 g plot^{-1} and 116.4 kg ha^{-1}) and V_1F_0 produced lowest total marketable dry seed weight (15.45 g plot^{-1} and 41.2 kg ha^{-1}).

Conclusions:

Based on the result of the present study, the conclusion may be drawn as:

- In case of species, white basil gave better performance in case of growth and yield contributing character than black basil.
- Among different organic manure, neem cake gave better performance in case of growth and yield contributing character than vermicompost, cowdung and control.
- For treatment combination, white basil with neem cake gave significantly higher yield contributing character in all cases.

Considering the findings of the present experiment, further studies in the following areas may be suggested

1. More research should be done through organic manure and other species of basil before the large scale organic farming in the crop field.
2. Chemical analysis of leaves may be given higher result which is suggested for further experiment.
3. This type of study may be carried out in other agro-ecological zones of Bangladesh before final recommendation.

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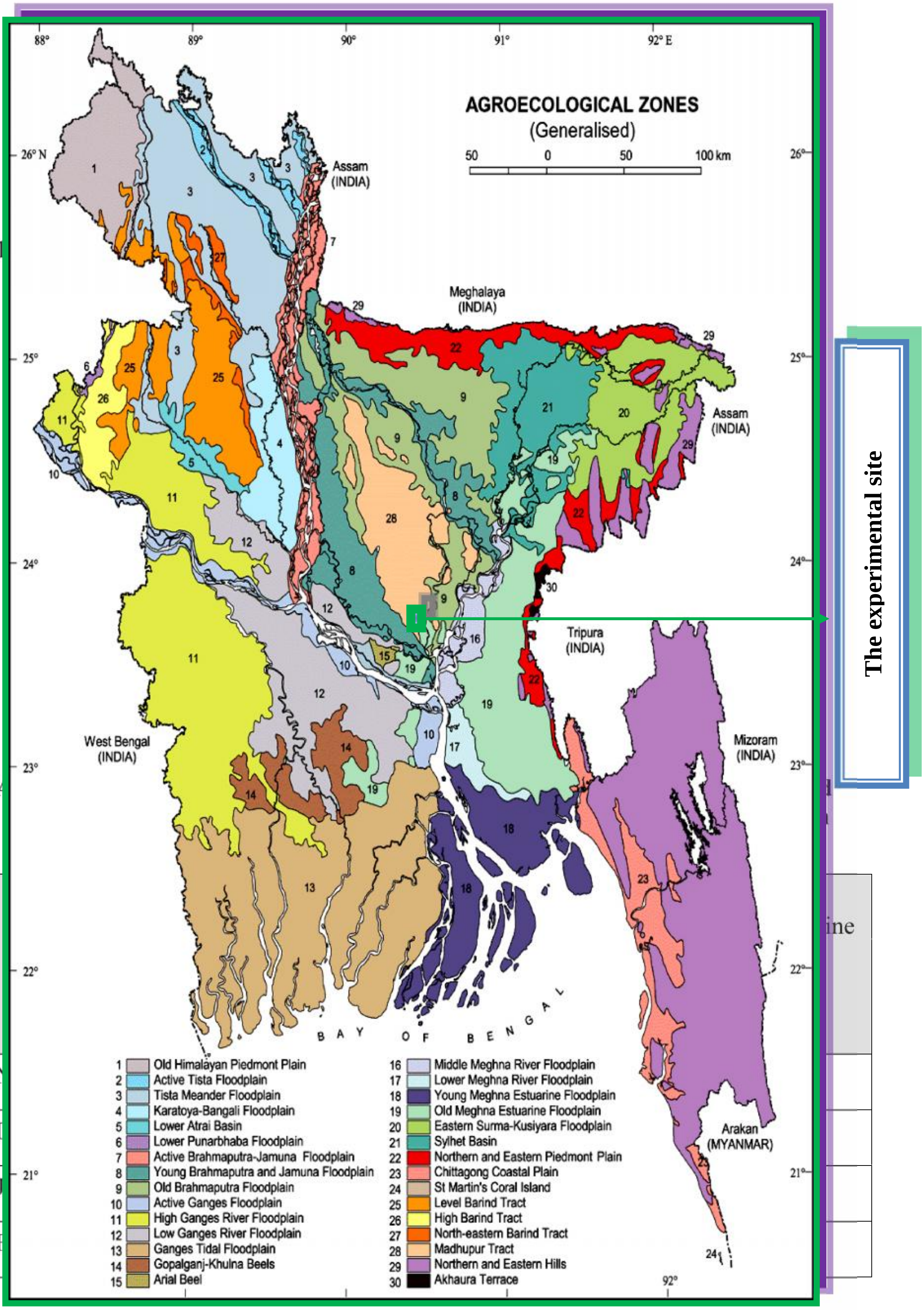
APPENDICES

Appendix I. Map showing the experimental sites under study



March, 2013	33.4	22.1	49.0	64.00	4.9
April 2013	32.2	24.4	30.0	69.50	4.7
May, 2013	31.7	24.8	390.0	70.00	4.7
June , 2013	33.7	27.2	318.0	81.70	4.8

* Monthly average in Dhaka

Source: Bangladesh Bureau of Statistics, Agargoan, Dhaka.

Appendix III. Characteristics of Farm soil as analyzed by Soil Resource Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level

Drainage	Well drained

Appendix IV: Physical and chemical properties of the soil before starting the experiment

Characters	Value
Particle Size Analysis	
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty clay
Chemical Analysis	
$_p$H	6.5
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/ 100g soil)	0.10

Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix V: Chemical Properties of Vermicompost, Cowdung and Neem Cake

Name of Element	Vermicompost*	Cowdung*	Neem cake**
Organic matter	28.32 %	27.2 %	-
Nitrogen	1.57 %	0.52 %	5.2 %
Phsporous	1.26 %	0.29 %	1.0 %
Potasium	2.60 %	0.75 %	1.4 %
Calsium	2.00 %	0.65 %	0.99 %
Magnesium	0.66 %	0.82 %	0.75 %
Sulfar	0.74 %	0.16 %	-
Ferrous	975 ppm	312 ppm	-
Manganse	712 ppm	254 ppm	-
Boron	0.06 %	-	-
Zinc	400 ppm	68 ppm	-
Cupper	20 ppm	13 ppm	-

Source:

Species	30 DAT	90 DAT	150 DAT	210 DAT
V_1	42.78 a	61.35 a	64.80 a	82.32 a
V_2	36.75 b	55.48 b	61.08 a	81.50 b
$LSD_{(0.05)}$	5.730	5.416	5.659	0.5187
CV%	8.24%	6.43%	8.44%	6.45%

* Soil Resource Development Institute (SRDI)

** Central Institute of Medicinal and Aromatic plants, Allasandra, Bangalore, India

Appendix VI: **Effect of species on plant height (cm) plant^{-1}**

Appendix VII: **Effect of organic manure on plant height (cm) plant^{-1}**

Manure	30 DAT	90 DAT	150 DAT	210 DAT
F_0	37.37 b	55.50 b	58.87 c	74.13 c
F_1	39.00 a	58.03 a	62.13 b	81.93 b
F_2	41.00 a	60.43 a	65.60 a	86.50 a
F_3	40.00 a	59.03 a	64.00 a	84.80 a
$LSD_{(0.05)}$	2.127	2.273	2.707	2.700
CV%	8.24%	6.43%	8.44%	6.45%

Appendix VIII: **Effect of species on base diameter (cm) plant^{-1}**

Species	30 DAT	90 DAT	150 DAT	210 DAT
V_1	0.4500 a	0.6100 a	1.100 a	1.800 a
V_2	0.4000 a	0.5300 a	0.900 a	1.600 a
LSD $_{(0.05)}$	0.7336	0.5187	0.7336	1.160
CV%	7.02 %	7.41 %	8.16 %	6.52 %

Appendix IX: Effect of organic manure on base diameter (cm) plant^{-1}

Manure	30 DAT	90 DAT	150 DAT	210 DAT
F_0	0.3700 a	0.5000 a	0.9000 a	1.500 a
F_1	0.4200 a	0.5700 a	0.9500 a	1.600 a
F_2	0.4567 a	0.6500 a	1.100 a	1.800 a
F_3	0.4300 a	0.6100 a	1.010 a	1.700 a
$LSD_{(0.05)}$	0.1837	0.2598	0.3182	0.4861
CV%	7.02%	7.41%	8.16%	6.52%

Appendix X: Effect of species on number of branch plant^{-1} (cm)

Species	30 DAT	90 DAT	150 DAT	210 DAT
V_1	17.22 a	33.00 a	61.51 a	80.00 a
V_2	13.83 a	31.00 a	56.47 a	69.20 b
$LSD_{(0.05)}$	4.782	6.225	7.260	8.937
CV%	9.06%	5.59%	7.50%	6.78%

Appendix XI: Effect of organic manure on number of branch plant^{-1} (cm)

Manure	30 DAT	90 DAT	150 DAT	210 DAT
F_0	13.23 b	30.08 b	51.20 c	63.38 c
F_1	16.00 a	31.00 ab	60.07 b	74.70 b
F_2	16.30 a	34.50 a	64.00 a	83.00 a
F_3	16.60 a	32.87 a	61.10 ab	77.60 b
$LSD_{(0.05)}$	2.021	2.624	3.058	3.764
CV%	9.06%	5.59%	7.50%	6.78%

Appendix XII : Effect of species on marketable leaf fresh weight (g) plant^{-1}

Species	30 DAT	75 DAT	120 DAT	165 DAT	210 DAT	Total
V_1	11.63 a	23.13 a	33.61 a	22.84 a	17.60 a	108.8 a
V_2	12.37 a	23.92 a	31.39 a	19.36 a	15.47 a	102.5 a
$LSD_{(0.05)}$	4.321	7.049	9.434	3.645	2.857	17.66
CV%	9.12%	8.22%	8.15%	9.72%	9.73%	9.08%

Appendix XIII: Effect of organic manure on marketable leaf fresh weight (g) plant^{-1}

Manure	30 DAT	75 DAT	120 DAT	165 DAT	210 DAT	Total
F_0	7.43 b	20.77 b	26.76 b	18.58 b	17.00 a	90.55 b
F_1	14.27 a	16.60 c	25.53 b	18.50 b	16.64 a	91.54 b
F_2	14.90 a	33.15 a	47.73 a	27.51 a	17.04 a	140.3 a
F_3	11.40 ab	23.57 b	29.99 b	19.82 b	15.47 a	100.3 b
$LSD_{(0.05)}$	6.110	9.968	13.34	5.154	4.04	24.97
CV%	9.12%	8.22%	8.15%	9.72%	9.73%	9.08%

Appendix XIV: Effect of species on marketable leaf dry weight (g) plant^{-1}

Species	30 DAT	75 DAT	120 DAT	165 DAT	210 DAT	Total
V_1	2.980 a	5.988 a	8.751 a	5.677 a	4.466 a	27.86 a
V_2	3.167 a	6.121 a	7.967 a	5.090 a	3.916 a	26.26 a
$LSD_{(0.05)}$	1.092	1.790	2.407	1.081	0.7289	4.673
CV%	8.59%	7.77%	7.89%	6.93%	9.87%	9.07%

Appendix XV: Effect of organic manure on marketable leaf dry weight (g) plant^{-1}

Manure	30 DAT	75 DAT	120 DAT	165 DAT	210 DAT	Total
F_0	1.90 b	5.27 b	6.76 b	4.68 b	4.29 a	22.89 b
F_1	3.61 a	4.24 b	6.89 b	4.70 b	4.22 a	23.66 b
F_2	3.90 a	8.71 a	12.23 a	7.12 a	4.36 a	36.31 a
F_3	2.89 ab	6.00 b	7.55 b	5.04 b	3.90 a	25.38 b
$LSD_{(0.05)}$	1.55	2.53	3.40	1.53	1.03	6.61
CV%	8.59%	7.77%	7.89%	6.93%	9.87%	9.07%

Appendix XVI: Effect of species on fresh weight plant^{-1} (g), fresh stem weight plant^{-1} (g), fresh root weight plant^{-1} (g) and root length plant^{-1} (cm)

Species	Fresh weight plant^{-1} (g)	Fresh stem weight plant^{-1} (g)	Fresh root weight plant^{-1} (g)	Root length plant^{-1} (cm)
V_1	350.8 a	283.7 a	67.12 a	24.72 a
V_2	221.1 b	167.4 b	53.70 b	20.78 a
$LSD_{(0.05)}$	26.92	26.07	9.856	6.311
CV%	5.64%	5.81%	5.72%	7.66%

Appendix XVII: Effect of organic manure on fresh weight plant^{-1} (g), fresh stem weight plant^{-1} (g), fresh root weight plant^{-1} (g) and root length plant^{-1} (cm)

Manure	Fresh weight plant^{-1} (g)	Fresh stem weight plant^{-1} (g)	Fresh root weight plant^{-1} (g)	Root length plant^{-1} (cm)
F_0	228.6 c	173.0 c	55.57 b	21.93 a
F_1	271.7 b	208.2 b	57.70 b	22.57 a
F_2	367.7 a	302.9 a	64.87 a	23.50 a
F_3	275.7 b	218.0 b	63.50 a	23.00 a
$LSD_{(0.05)}$	11.34	10.98	4.153	2.665
CV%	5.64%	5.81%	5.72%	7.66%

Appendix XVIII: Effect of species on fresh seed wt (g) plant^{-1}

Species	75 DAT	120 DAT	165 DAT	Total
V_1	1.66 a	12.00 a	1.62 a	15.28 a
V_2	1.20 b	11.46 a	0.94 b	13.60 a
$LSD_{(0.05)}$	0.3369	1.988	0.6743	2.296
CV%	6.97%	4.35%	10.00%	6.16%

Appendix XIX: Effect of organic manure on fresh weight (g) of seed plant^{-1}

Manure	75 DAT	120 DAT	165 DAT	Total
F_0	0.85 c	7.95 c	0.84 b	9.64 c
F_1	1.09 bc	9.67 bc	1.27 ab	12.03 bc
F_2	2.28 a	17.14 a	1.80 a	21.22 a
F_3	1.50 b	12.17 b	1.20 ab	14.87 b
$LSD_{(0.05)}$	0.4764	2.811	0.9536	3.247
CV%	6.97%	4.35%	10.00%	6.16%

Appendix XX: Effect of species on marketable seed dry weight (g) plant^{-1}

Species	75 DAT	120 DAT	165 DAT	Total
V_1	0.20 a	1.46 a	0.19 a	1.85 a
V_2	0.16 a	1.38 a	0.12 a	1.66 a
$LSD_{(0.05)}$	0.03916	0.2398	0.08307	0.2851
CV%	5.61%	4.30%	9.76%	6.54%

Appendix XXI: Effect of organic manure on marketable seed dry weight (g) plant^{-1}

Fertilizer	75 DAT	120 DAT	165 DAT	Total
F_0	0.11 c	0.95 c	0.09 b	1.16 c
F_1	0.15 bc	1.16 bc	0.15 ab	1.46 bc
F_2	0.27 a	2.11 a	0.23 a	2.61 a
F_3	0.17 b	1.46 b	0.15 ab	1.78 b
$LSD_{(0.05)}$	0.05538	0.3391	0.1175	0.4032
CV%	5.61%	4.30%	9.76%	6.54%