# EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON *Lolium perenne* L.

**A**

*Thesis*

by

**PRERNA VERMA**

***Submitted in partial fulfilment of the requirements for the degree of***

**DOCTOR OF PHILOSOPHY**

**in**

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**COLLEGE OF HORTICULTURE**
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# CERTIFICATE-I

This is to certify that the thesis entitled, **"Effect of Integrated Nutrient Management on *Lolium perenne* L.",** submitted in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY** in **HORTICULTURE (FLORICULTURE AND LANDSCAPING)** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) is a record of bonafide research work carried out by **Ms Prerna Verma (H-2007-12-D)** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigations have been fully acknowledged.

**Place: Nauni, Solan**
**Dated: 21st February , 2011**

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This is to certify that the thesis entitled, **"Effect of Integrated Nutrient Management on *Lolium perenne* L.",** submitted by **Ms Prerna Verma (H-2007-12-D)** to Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.), in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY** in **HORTICULTURE (FLORICULTURE AND LANDSCAPING)** has been approved by the Student's Advisory Committee after an oral examination of the same in collaboration with the external examiner.

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This is to certify that all the mistakes and errors pointed out by the external examiner have been incorporated in the thesis entitled, **"Effect of Integrated Nutrient Management on *Lolium perenne* L.",** submitted to Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) by **Ms Prerna Verma (H-2007-12-D)** in partial fulfillment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY** in **HORTICULTURE (FLORICULTURE AND LANDSCAPING).**

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# List of Abbreviations

| | | |
|---|---|---|
| Cv | = | Cultivar |
| M | = | Meters |
| amsl | = | Above mean sea level |
| N | = | North |
| E | = | East |
| $^{o}C$ | = | Degree Celsius |
| kg | = | Kilogram |
| G | = | Gram |
| mg | = | Milligram |
| et al | = | *et al* (and other) |
| $m^2$ | = | Square meter |
| % | = | Per cent |
| FYM | = | Farm Yard Manure |
| @ | = | At the rate |
| RBD | = | Randomized Block Design |
| $CaCO_3$ | = | Calcium carbonate |
| No. | = | Number |
| nm | = | Nanometer |
| ANOVA | = | Analysis of variance |
| / | = | Per |
| gp | = | group |
| UV | = | Ultra violet |
| R.H.S | = | The Royal Horticultural Society |
| am | = | Before mid day |
| ml | = | Milliliter |
| cm | = | Centimeter |
| mm | = | Millimeter |
| viz. | = | Namely |
| CD | = | Critical difference |
| i.e. | = | id. est (that is) |
| eg. | = | For example |
| $ | = | US Dollar |
| HCl | = | Hydrochloric acid |
| $K_2O$ | = | Muriate of potash |
| l | = | Liter |
| N aCl | = | Sodium chloride |
| $NH_4^+$-N | = | Ammonical nitrogen |
| $NO_3^-$-N | = | Nitrate nitrogen |
| N, P and K | = | Nitrogen, phosphorus and potassium |
| NS | = | Non-significant |

| | | |
|---|---|---|
| OC | = | Organic carbon |
| $P_2O_5$ | = | Superphosphate |
| PSB | = | Phosphorus Solubilizing Bacteria |
| VAM | = | Vesicular Arbuscular Mycorrhizae |
| v/v | = | Volume by volume |
| *N* | = | Normal |
| ha | = | Hectare |
| H.P. | = | Himachal Pradesh |
| RDF | = | Required dose of fertilizers |
| $m^3$ | = | Cubic meter |
| S | = | Sulphur |
| AM | = | Arbuscular Mycorrhiza |
| $N_2$ | = | Nitrogen |
| yr | = | Year |
| $y^{-1}$ | = | Per year |
| $ha^{-1}$ | = | Per hectare |
| $kg^{-1}$ | = | Per kilogram |
| df | = | Degree of freedom |
| $dSm^{-1}$ | = | Deci- Siemens per meter |
| EC | = | Emulsifiable concentrate |
| C:N | = | Carbon: Nitrogen |
| min. | = | Minimum |
| max. | = | Maximum |
| $cm^2$ | = | Square centimeter |
| USA | = | United States of America |
| w.e.f. | = | With effect from |
| U.H.F. | = | University of Horticulture and Forestry |
| CEC | = | Cation exchange capacity |
| pH | = | Puissance d' hydrogen |
| M/S | = | Messieurs |
| µm | = | Micrometer |
| µ | = | Micro |

*Chapter-1*

# INTRODUCTION

Floriculture and landscaping are related industries. In the past, landscaping was commonly regarded as a luxury for the wealthy or as a cosmetic for making mediocre and average architecture. In its purest and most modern sense, however, landscaping represents a major defence against monotonous building styles, scrolling, unplanned sub-urban neighbourhoods, inner city decay and destruction of land through misuse. The major tools of landscaping are the use of plant material like trees, shrubs, climbers, annuals, ground covers and lawn grasses. Over the past fifty years, landscape architects and designers have used the ornamental grasses to create a soft, dreamy, impressionistic effect in the garden. Today, growers offer hundred of selections for landscape designers who envisions their backyard canvases swept with glowing grasses.

Members of the family Poaceae, grasses number 600 genera and 9000 species (Rademacher, 2003), out of which 20-25 species are used for turf production (Vengris, 1973). Lawn grasses are usually categorized as cool- season grasses and warm-season grasses (Carpenter *et al*., 1975). Their utility is increasing with the emphasis on recreation, sports, outdoor living, urbanisation and beautification.

Lawn is an integral part of any landscape whose quality is determined by the management of the turf. In the European countries, the species have been defined and used as per the requirements i.e. for a turf, the species may differ from those used in golf courses, cricket grounds or used only for ornamental purposes.

The turf grass industry consists of many diverse groups including millions of homeowners, athletic field managers, lawn care operators, golf course superintendents, architects, developers and owners, landscape designers and contractors, seed and sod producers, parks and grounds superintendents, roadside and vegetation managers and cemetery managers. The sport turf market includes golf courses (public and private), athletic fields (football, baseball and soccer) and other turf areas used for less common sports including polo, lacrosse, field hockey and rugby. In addition, turf grasses provide safety and dust control along millions of miles of highways and thousands of airport runways. Turf grasses beautify our parks and landscapes. Finally, turf grasses provide environmental protection and enhancement by purifying and protecting our water, soil and air wherever they are grown.

The turf grass industry is expanding and has annual associated revenues in excess of $ 10 million each year. Currently in the USA, there are more than 50 million acres of maintained turf grass including lawns, parks, golf courses and highway right-of-ways. In addition, it is estimated by the Economic Research Service that the US turf grass industry, in all its forms, is a $ 40 billion industry (Anonymous[1], 2010).

In India, not much work has been done on any aspect of lawn grasses. Establishment and maintenance of turf depends on many factors like its planting time and methods, irrigation schedule, mowing, and most important being its fertilization. Since, turf formation is a continuous process, application of fertilizers should be simpler and less time consuming. Although the application of inorganic fertilizers give quick results but the texture and structure of the medium is not taken care of which makes the use of organic fertilizers an integral part of the fertilization schedule. Also, the applications of synthetic fertilizers are expensive and hamper the ecological balance of the soil.

The balanced application of organic manure, biofertilizers and inorganic fertilizers to get quality turf production is need of the hour. Apart from this, excessive and unbalanced use of synthetic fertilizers leads to degradation of physico-chemical properties and microbial status of soil. Therefore, an alternate source of nutrition is needed to sustain productivity of land. The integrated nutrient supply including the use of chemical fertilizers with organic manures like FYM, vermicompost, biofertilizers (Azotobacter, Vesicular Arbuscular Mycorrhiza (VAM), Phosphorus Solubilising Bacteria (PSB), etc.) helps not only in bridging the existing wide gap between the nutrient removal and supply but also in ensuring balanced nutrient proportion, by enhancing nutrient response efficiency and maximising turf quality. These biofertilizers are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes.

Based on the evaluation studies conducted on cool-season grasses by Verma (2007), *Festuca rubra* L. and *Lolium perenne* L. were graded as 'A' among the several lawn grass species, according to their performance under mid-hill conditions of H.P.

*Lolium perenne* L. commonly known as perennial rye grass or English rye-grass is a cool-season, bunch-type, quick germinating grass which may behave as an annual, short-lived perennial, or perennial depending upon environmental conditions. It is native to Europe, temperate Asia and North Africa and is widely distributed throughout the world, including North and South America, Europe, New Zealand, and Australia (Hannaway *et al.,* 1999). It provides a good bottom to the sward, is quick to recover from adverse conditions, is winter green, its rapid growth excludes weeds easily and it covers the ground quickly after being sown. Apart from its usage in lawns, it is widely used in playing fields and is very suitable for football, hockey, and rugby pitches, and also for cricket outfields. This species is also used as a nurse grass in cool-season turfgrass mixtures for intensively trafficked athletic turfs. Hence, an attempt was made to further carry on the nutritional studies with the objective:

❖ To study the effect of Integrated Nutrient Management i.e. the use of organic and inorganic fertilizers on two genotypes of *Lolium perenne* L.

# *Chapter-2*

# REVIEW OF LITERATURE

The use of inorganic, organic and biofertilizers in the turf grasses has been investigated by several workers. Inorganic fertilizers are known to show their impact in short durations but pose a threat to soil health. The current trend is to replace a significant portion of inorganic fertilizers by biofertilizers which, apart from improving the quality, improve the soil health too. In recent years, concept of integrated nutrient management involving combined use of organic and inorganic fertilizers has been developed.

## 2.1 INORGANIC FERTILIZERS

Chemical fertilization is the most common means of supplying turf grasses with their nutritional requirements as inorganic fertilizers are the sources of nutrients available instantly to the plants. Inorganic fertilizers have been used in various forms to improve the productivity of the growing soil. The commercial sources of N, P and K in the recent past were the straight fertilizers i.e. urea and calcium ammonium nitrate in various forms like $NO_3^-$ -N and $NH_4^+$-N, $P_2O_5$ through single super phosphate and $K_2O$ through muriate of potash. The contribution of workers who carried out the nutrition experiments using various forms have been reviewed below:

Synder and Burt (1976) performed nitrogen fertilization of bermudagrass turf through an irrigation system and observed that turf appearance and clipping yields were significantly better at the higher nitrogen rate.

Turgeon and Street (1979) studied the effects of mowing height and fertilization rate on the establishment of ‘A-20’ kentucky blue grass (*Poa pratensis* L.) sod from plugs and the results indicated that initial and first-season cover was attained faster due to high mowing heights and application of 25 kg

N/ha per growing followed by maximum cover and sod strength in subsequent years.

Welling (1988) studied the effects of NPK fertilization on lawn grasses viz., red fescue, perennial rye grass and kentucky blue grass and reported that over all, the best turf grass colour occurred where N fertilizer was applied and it was unaffected by P or K.

Carrow and Johnson (1989) compared the effect of slow- release nitrogen (N) sources viz., Escote 100, isobutylidene diurea (IBDU), sulphur-coated urea (SCU) and SCU + $NH_4$ $NO_3$ with a single application of water-soluble N on centipede grass performance and it was found that all slow-release N carrier treatments provided turf grass colour and quality (summer and late fall) equal to that provided by Ammonium nitrate and hence, all could be used effectively on centipede grass.

Fry *et al*. (1989) studied the creeping bent grass response to P and K on a sand medium where P (0, 5 and 11 kg/ha) and K (0, 4 and 8 kg/ha) treatments were applied monthly to creeping bent grass receiving uniform N (49 kg/ha per month) and a significant (quadratic) response of creeping bent grass quality to increasing P level was observed each year, whereas, K had no effect on visual quality of creeping bent grass.

Glinski *et al.* (1990) advocated that nitrogen influences the root growth of sodded creeping bent grass and further nitrate form of nitrogen helps in extensive root development.

Allam (1993) have reported that plant height increases as a result of increasing N fertilization rates in ryegrass lawns.

Razmjoo and Kaneko (1993) reported that increasing the application rates of nitrogen from 50 to 650 kg/ha increased the colour, density and growth of *Lolium perenne* L.

Soni *et al*. (1993) while working on *Zoysia matrella* reported that increase in nitrogen dose from 0 to 40 g $N/m^2$ increased the fresh weight of clippings and nitrogen content of tissue and higher dose of nitrogen (40g $N/m^2$) applied in four splits i.e. November, February, May and September improved the turf quality.

Tainton *et al*. (1999) while studying the response of *Lolium multiflorum* (Lam.) to applied phosphorus levels (ranging between 2 and 28.5 mg/l) and potassium levels (ranging between 109.5 and 480.5 mg/l) on a cricket pitch clay reported that the plant yield increased asymptotically with increasing soil P level, whereas the response to K was significantly quadratic, although relatively small. Phosphorus and potassium application had a much greater effect on nutrient levels in plant tissue i.e. not only the P and K levels but also the levels of other plant nutrients.

Paswan and Machahary (2000) studied the effect of nitrogen on Bahia grass and found that the increase of nitrogen levels from 0 to 40 $g/m^2$ increased the shoot length, chlorophyll content of leaf, fresh weight of clipping and percent nitrogen content of shoot tissue i.e. 12.89 cm, 1.775 mg/g, 329.94 $g/m^2$ and 2.015 %, respectively. They also reported that the maximum shoot length and fresh weight were observed in July, whereas, the highest chlorophyll content of leaf was observed in June under the Jorhat conditions.

Rodriguez *et al*. (2001) evaluated bermuda grass establishment on high sand content soils using N-P-K ratios and found that the 1 N - 0.4 P- 0.8 K fertilizer treatment resulted in the highest cover rates for all the 4 grasses (‘FloraDwarf’, ‘TifDwarf’ ‘TifEagle’ and ‘TifWay’) and highest shoot weights for 3 grasses (‘FloraDwarf’, ‘TifDwarf’ and ‘TifEagle’). Also, increased coverage rate with additional P was optimized at a ratio of 1 N – 0.4 P.

Trenholm *et al*. (2001) studied the wear tolerance, growth and quality of seashore paspalum in response to nitrogen and potassium. Fertility treatments were applied as annual N rates of 192 and 396 kg/ha and K rates of 92 and 392 kg/ha and it was found that the higher N rate increased wear tolerance, shoot growth, shoot density, visual quality and colour of the two ecotypes of seashore paspalum namely, AP 10 and AP 14. However, measured responses to K were minimal and no enhancement of wear tolerance in response to K treatment was noted.

Frank *et al*. (2002) studied the effects of nitrogen, phosphorus and potassium on seeded buffalo grass establishment and found that buffalo grass coverage was enhanced by N rates up to 147 kg/ha. Application of P also improved establishment while potassium application had no influence on establishment.

Kozowski *et al*. (2002) evaluated the colour of lawns of *Poa pratensis* (smooth meadow grass or kentucky blue grass) on the basis of the chlorophyll content where the lawns were treated with 200 kg N, 70 kg $P_2O_5$ and 120 kg $K_2O$/ha. It was reported that among the genotypes, the Trawan mixture had the highest chlorophyll content of leaf blades and, consequently, the highest saturation with dark-green colour in the first year of lawn utilization while in the second year of utilization, the values of these parameters were highest for Limmousine and it was also found that the chlorophyll content of leaf blades was affected by soil moisture content and fertilizer, especially N.

Senapati and Padhihari (2002) reported that the use of chemical fertilizers enhance the degradation of soil applied phorate in comparison to control soil. The rate of degradation was reported in order of phosphatic > potassic > nitrogenous fertilizers. When soil was treated with farmyard manure, the rate of degradation was more than that of all the fertilizer treatments.

Dong *et al*. (2004) studied the effects of 4 levels of nitrogen fertilizer, 0, 115, 230 and 345 kg/ha on soil and plant characteristics on 3 mixtures of 4 perennial grasses, *Bromus inermis* (BI) + *Elymus nutans* (EN), BI + *E. sibricus* (ES) + (*Agropyron cristatum* (AC) and BI + ES + EN+AC and it was reported that total soil N at 0-30 cm increased with N application rate and application year, whereas, soluble soil N at 0-30 cm increased with application rate but decreased with application year.

Kaminski *et al*. (2004) evaluated the influence of two general fertilizer and soil amendment programs for their effect on establishment and quality of creeping bent grass (*Agrostis stolonifera* L.) cultivars. Four treatments consisted of surface-applied synthetic fertilizer (SF); mostly water-soluble N and methylene urea thereafter; surface-applied hydrolyzed poultry meal (PM); pre-plant-incorporated granular humate (GH) with surface applied synthetic fertilizer and pre- plant -incorporated poultry meal with surface applied poultry meal. The study demonstrated the beneficial effects of readily available N from SF for rapid establishment and from GH for initial root development and it was reported that SF generally provided the best overall turf quality.

Marcolino *et al*. (2004) studied the effect of nitrogen and simulated traffic on some turf quality parameters in construction systems of soccer pitches where two nitrogen rates (200 and 400 kg $Nha^{-1}y^{-1}$), and two levels of simulated soccer traffic (traffic and no traffic) were used. Four parameters of turf quality: general appearance, density, texture and colour were estimated over 12 months using visual ratings. Results showed that the quality ratings of turf receiving 400 kg of N $ha^{-1}$ were higher than those receiving 200 kg of N $ha^{-1}$.

Miltner *et al*. (2004) studied the effect of four fertilizer N sources (ammonium sulphate, polymer coated sulphur, coated urea, polymer coated urea and isobutylidene diurea applied in four different months (November, December, January, February) to perennial ryegrass (*Lolium perenne* L.) and to kentucky bluegrass (*Poa pratensis* L.) and it was found that late fall fertilizer N in eastern Washington should be confined to November, using soluble or more quickly available slow release nitrogen fertilizers.

Two field studies (winter and summer) were conducted by Nikolopoulou *et al*. (2004) in order to evaluate the effect of three different fertilization programmes, viz., (a) quick release (QR) granular fertilizer, (b) slow release (SR) fertilizer, and (c) foliar fertilizer (F) and urea formaldehyde resin foam (UFRF) soil amendment, on sod establishment and anchorage. Sod establishment and growth were evaluated by the determination of the clippings dry weight, root dry weight, visual quality ratings and the vertical force required for sod detachment. Foliar fertilization promoted root growth and sod anchorage. SR fertilization provided moderate top growth and root growth, while QR application increased top growth and maintained high visual quality.

Bushoven and Hull (2005) found that nitrate plays an important role in modulating growth and partitioning of nitrate assimilation between roots and leaves of perennial ryegrass (*Lolium perenne* L.) and it was observed that increase in root growth enhance grass ability to acquire N and other mineral nutrients from the soil.

Miltner *et al.* (2005) studied the effects of mowing height (3.8, 5.0, or 6.3 cm), nitrogen (N) rate (9.8, 19.6, or 26.4 g N/m$^2$/year) and N fertilizer source (natural organic (ORG) or synthetic organic (SYN) on turf grass quality, weed encroachment and disease injury and it was found that the lowest N rate resulted in turf grass of unacceptable quality, due in part to weed encroachment whereas the lowest mowing height resulted in the highest quality, and quality decreased as height increased. However, it was found that increased mowing height also resulted in lower weed populations. The SYN N source resulted in the higher quality than the ORG source and the ORG source also resulted in higher weed populations and more severe foliar symptoms of leaf spot.

Nektarios *et al.* (2005) conducted two field studies (winter and summer) to evaluate the effect of three different fertilizer programs viz., a quick release (QR) granular fertilizer (12-12-17), a slow release (SR) fertilizer (27-5-7), and a foliar fertilizer (FL) (20-20-20) with the application rate of 50, 30, 0.35 g/m$^2$ for QR, SR and FL, respectively and a urea formaldehyde resin foam (UFRF) soil amendment on sod establishment and anchorage and the effects were evaluated through measurements of the dry weight of clippings and roots and the visual quality of the turf. It was reported that foliar fertilization enhanced sod establishment compared to QR and SR by accelerating sod anchorage and root growth and QR improved winter green up of the sod in late autumn, whereas, UFRF did not improve or accelerate sod establishment and it possessed a minimal capacity to improve soil properties of sandy loam soils.

Webster and Ebdon (2005) studied the effects of nitrogen and potassium fertilization on perennial ryegrass cold tolerance during acclimation in late winter and early spring where treatments included five rate levels of N (49, 147, 245, 343 and 441/kg/ha/yr) and three rate levels of K ( 49, 245, and 441 kg/ha/yr). They reported that maximum cold hardiness occurred when low to moderate N (49 to 147 kg/ha/yr) was applied with medium-high to high levels of K (245 to 441 kg/ha/yr), which corresponded to soil exchangeable K levels ranging from 200 to 260 mg $kg^{-1}$.

Hamel and Heckman (2006) predicted the need for phosphorus fertilizer by soil testing during seeding of cool season grasses and found that P fertilizer application has an important role in early establishment and soil coverage.

Walker *et al*. (2007) studied the aboveground plant responses of three cool-season lawn species: kentucky blue grass (*Poa pratensis* L.; KBG), perennial rye grass (*Lolium perenne* L.; PRG) and turf-type tall fescue (*Festuca arundinacea* Schreb; TTTF) to nitrogen rates that varied from 0 to 196 kg N $ha^{-1}$ $yr^{-1}$. It was observed that annual turf grass quality (TQ) was highest and most seasonally consistent for TTTF, followed by KBG & PRG and kentucky blue grass generally possessed the greenest canopy when averaged across all N programmes, followed by TTTF and PRG.

Stiglbauer *et al*. (2009) observed the factors affecting establishment speed for 'Diamond' zoysia grass with two sprigging rates (91 and 183 $m^3$ $ha^{-1}$), three nitrogen (N) sources (urea, ammonium nitrate and ammonium sulphate) and two nitrogen rates (1.7 and 3.4 g/$m^2$/week) . Turf colour and cover results showed that high rates of fertility associated with high rates of sprigs produced 100 % turf cover.

Teuton *et al.* (2009) conducted an experiment on establishment and maintenance of hybrid blue grass (*Poa arachnifera* Torr. x *Poa pratensis* L.) with different cultivars (Thermal blue and Dura), seeding rates (50, 100, 150, 200 and

250 kg $ha^{-1}$), fertilization rates: ammonium nitrate (100, 200 and 300 kg N/ha/year), urea formaldehyde (200 and 300 kg N/ha/year) and mowing heights (2-, 3.5- and 5- cm) and it was found that higher fertility regimes increased quality evaluations in April but decreased quality evaluations in October. Also, increasing the mowing height improved turf quality and decreased biomass production for both grasses and hence, it can be concluded that a proposed optimum method for establishment included seeding 'Thermal Blue' in April at 150 kg $ha^{-1}$ and fertilizing with 300 kg $ha^{-1}$ of nitrogen and then mowing at 5 cm height.

## 2.2 ORGANIC MANURES

The organic manures, from agriculture/animal/humanwaste contain essential plant nutrients and other plant growing agents like enzymes and hormones while chemical fertilizer may cause some undesirable effects on plants but their complete deletion from manurial schedule is indispensable. Rosati (2002) reported application of large amount of organic manure may be beneficial in improving soil parameters but in the presence of soil pathogens it is likely to cause them to proliferate.

FYM is a decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. FYM contains 0.5% N, 0.2% $P_2O_5$ and 0.5% $K_2O$. One tonne of cattle dung can supply only 2.95 kg N, 1.59 kg $P_2O_5$ and 2.95 kg of potash (Arun, 2004).

The use of composted manure improves soil quality and reduces the energy consumption associated with the use of commercial fertilizers (De Luca and De Luca, 1997).

Barley and Jennings (1959), Atlavinyte and Vanagas (1982) and Zhao and Fun-Zhen (1992) have all shown that vermicompost increases the nutrient uptake. The availability of P in vermicompost is often significantly greater than in bulk soil. This can be attributed to the quantities of phosphorus ingested by earthworms in the organic matter they consume, this passes through the intestine and is excreted in their castes. Some authors believe that the greater release of P from casts is due to enhanced microbial activity (Lee, 1985; Scheu, 1987). However, others suggest it is due to increased phosphatase activity (Lavelle and Martin, 1992). High K concentrations were found in the earth worm humus ; a consequence of the high content of the original substrates. Other authors have reported similar results too. (Basker *et al*.,1992).

Sharma (2002) reported that some of the secretions of worms and the associated microbes act as growth promoters along with other nutrients. It also improved physical, chemical and biological properties of the soil in long run on repeated applications. He also stated that vermicompost releases the nutrients slowly and steadily into the soil which enhances the capability of plants to absorb these nutrients. The soil enriched with vermicompost provides additional substances that are not found in the chemical fertilizers.

Karpagam and Nalini (2005) reported that incorporation of organic matter, influenced soil colour, binds soil particles (sand, silt and clay) into the structural unit, enhance rate of infiltration/percolation, drainage and water holding capacity but reduced plasticity, cohesion and stickiness etc. Organic matter also affects the densities of the soil especially bulk density which in turn influence the soil porosity favourably.

Mangel and Kirkby (1987) reported an increase in leaf phosphorus following the use of organic matter which accelerated the microbial growth in soil profile. These microbes are known to produce acids and chelating agents, and also play an important role in solubilization of unavailable phosphates.

Jackson and Looney (1999) reported that addition of organic manures tend to reduce pH, a feature that can be advantageous to some situations.

Loschinkohl and Boehm (2001) studied the establishment of turf grass on compost amended and non-amended sub-soil and found that turf grass establishment estimated from visual assessments of percentage cover were enhanced by the incorporation of the composted biosolids. These results were found in Kentucky bluegrass cover, perennial ryegrass cover and Kentucky bluegrass/perennial ryegrass mix cover.

Worm manure is rich in microbial activity, plant growth regulators and is fortified with pest repellance attributes as well. In short, earth worms, through a type of biological achemy, are capable of transforming garbage into 'gold' (VermiCo, 2001)

Kumari and Kumari (2002) reported about $10^6$ bacteria, $10^5$ fungi and $10^5$ actinomycetes counts under vermicompost applications. Phosphate solubilising bacteria, N-fixing free- living organisms and entomophagous fungi were also observed in the range of $10^5$ to $10^6$ while earthworm (*Eudrillus eugenie*) casts was found rich in rock phosphate solublising microbes and had high rock phosphate solubilising capacity.

Prakash *et al*. (2002) conducted experiment on comparative efficacy of organic manures on the changes in soil properties and nutrient availability in an alfisol and reported the availability of all the major nutrients except P and micronutrients were higher in treatments with organic nutrient sources compared to chemical fertilizers and untreated control. The value of nitrogen, phosphorus and potassium availability due to farmyard manure treatment were although higher, over all other commercial manures.

Singh *et al*. (2002) reported that available N, P and K were higher in soil that had received green manuring, FYM or Azotobacter along with 30 kg N/ha than those treatments which received only chemical fertilizers.

Sen (2003) reported that inclusion of organic manures, i.e. farmyard manure or farm residues alone or in combination with inorganic fertilizers, at variable rates, increased organic carbon and available nitrogen, phosphorus, potassium and zinc contents in the soil thereby improving the soil fertility status and justified the need of balanced fertilization in vertisols.

Misra (2004) reported that the continuous use of FYM at the rate of 45 kg N/ha changed the soil pH from 4.8 to 5.5, OC 3.6 to 5.2 g/kg, CEC 3.0 to 5.7 c mol ($p^+$) $kg^{-1}$ and bulk density 1.53 to 1.31 Mg $m^3$ in laterite soil.

Ntoulas *et al.* (2004) studied the effects of olive mill compost soil amendment (OMC) on tall fescue (*Festuca arundinacea* 'Plantation') and bermuda (C*ynodon dactylon* 'Princess') grass establishment and growth and it was reported that OMC amendment improved visual quality of tall fescue during establishment while bermuda grass did not exhibit any significant differences among the treatments.

The benefit of CCB (Coal Combustion By-product) and organic waste/product mixtures as supplemental soil /growth media for production of hybrid bermuda grass [*Cynodon dactylon* (L.) Pers. *X C. transvaalensis* Burtt – Davy] sod was observed by Schlossberg and Miller (2004) and it was reported that mixtures of CCB and biosolids increased yield of biomass and nutrient content of tissue which were found to be greater than the control media.

Sharma *et al*. (2004) conducted trial on the effect of vermicompost, prepared from lantana and congress grass weeds, on soil fertility status. They reported that vermicompost increased the nutrient contents of soil, except potassium, considerably over the substrate used. The increase in nitrogen content from 2.52% to 2.94% in lantana and 2.04 to 2.38% in congress grass can be attributed due to enhanced microbial activity, because carbon is utilized by micro organisms for their energy requirements and cause the transformation of soluble nitrogen into microbial protein, thereby, preventing the nitrogen loss. The nutrients composition of vermicompost, made from lantana and congress grass, was higher than those of farm yard manure. All the macro and micro nutrients, except calcium and magnesium were much higher in vermicompost than in FYM, while C: N ratio was approximately half of the C:N ratio of FYM.

Castillo *et al*. (2005) studied the influence of earthworms on organic waste composting where the selected waste mixtures were- pine saw dust + poultry litter ($M_1$), cotton industry waste + poultry litter ($M_2$), shredded paper +

horse manure ($M_3$) , and cotton industry waste + horse manure ($M_4$) which were composted for 85, 64, 60 and 60 days respectively in plastic boxes and at the end of this process 95, 80, 75 and 95 g of *Eisenia andrei* were added to each treatment respectively to initiate vermicomposting . It was observed that $M_3$ was the best medium for earthworm activity and that $M_4$ had the best chemical and physical properties as an organic manure. However, $M_1$ was the best mixture in a test involving the growth of ryegrass (*Lolium perenne* cv. Weterwald) ascompared to controls.

Wright *et al.* (2005) studied the influence of compost sources and application rates on concentrations of soil dissolved organic carbon (DOC), $No_3$ – N, and extractable P over 29 months after a one-time application of compost to bermudagrass (*Cynodon dactylon* (L.) Pers.] turf. It was revealed that dissolved organic carbon continued to increase from 3 to 29 months after application, suggesting that compost mineralization and growth of bermudagrass contributed to DOC dynamics in soil. However, soil $No_3$-N was generally unaffected by compost application rate, as $No_3$-N decreased for unamended soil and all compost treatments while soil extractable P initially increased after compost application, but increasing the application rate generally did not increase P from 3 to 29 months.

## 2.3 BIOFERTILIZERS

Soil contains variety of fungi and other microorganisms. Some of these are pathogens and harmful to plant growth, whereas, others are beneficial to the plants. Such group of beneficial microorganisms includes Azotobacter, phosphate solubilizer, and VAM fungi. These are used for nitrogen fixation, or phosphorus solubilization or both either through seed or roots. In the recent past, attention has also been shifted from plant-microbe interaction to plant-microbe-microbe interaction.

Sukhda (1999) suggested that biofertilizers are microorganisms that are capable of mobilizing nutritive elements from non available form to usable form through biological process. They are cost effective and inexpensive source of plant nutrients and do not require non-renewable source of energy during their production. They improve crop growth and quality of the product by producing plant hormones and help in sustainable crop production through maintenance of soil productivity. They are useful as biological agents, since they control many plant pathogens and harmful microorganism. The similar findings regarding biofertilizers were also expressed by other workers (Gaur, 1990, and Sardan, 1997).

Biofertilizers are safe for the environment and they reduce the need for chemical fertilization, thus reducing the cost of fertilizers and labour. In addition to their main function of fixing molecular nitrogen, the enhancing effect of biofertilizers on some plant growth characters was explained by Subba Rao (1984). He attributed this effect to other factors such as (a) the ability of biofertilizers and secrete indole acetic acid, cytokinins, gibberellins and cytokinin- or gibberellin-like substances, (b) increasing amino acids content and (c) producing anti-fungal antibiotics which inhibit a variety of soil fungi.

Nitrogen fixation by free-living root-associated bacterias has been well documented. The taxonomic range of plants involved in such associations is wide, and includes various forage grasses (Neyra and Dobereiner, 1977). A variety of $N_{2-}$ fixing bacteria have been isolated from the roots and rhizospheres of various forage grasses, most commonly these isolates have been members of the genera *Azospirillum*, *Azotobacter*, *Erwinia, Klebsiella* and *Bacillus* (Rennie, 1980).

A greater number of studies have investigated microorganisms and promising results were obtained from biofertilization studies (Cakmakci *et al.*, 2006). The bacteria used as phosphorus biofertilizers could contribute to increasing the availability of phosphates immobilized in soil and could enhance plant growth by increasing the efficiency of other nutrients (Kucey *et al.*, 1989).

Azotobacter is a free living (non-symbiotic), aerobic, nitrogen fixing organism and this gram negative bacteria, belongs to family Azotobacteriaceae. There are seven known species of Azotobacter viz., *A. beijerinckii, A. agillis, A.*

*insignis, A. chroococcum*, *A. vinelandii, A. paspali* and *A. macrolgytogenes*. *A. chroococcum* appeared more in acid soils and arable soils while *A. beijarinckii* in neutral and alkali soils. Soil organic matter is important factor that decides the growth of these bacteria. Poor organic matter contents in Indian soil are a limiting factor that affect the proliferation of Azotobacter in soil and also limits the N-fixing capacity too (Sharma, 2002). When Azotobacter inoculants applied to the crop either as seed treatment or seedling crop root dip or as soil treatment, large number of Azotobacter cells sticks to the seeds or roots, multiply rapidly in the soil along with the developing roots and form a thick sheath of bacterial population around roots. Azotobacter prefers to thrive mainly in soil close to roots for their multiplication and the food is derived either from dead organic matter present in the soil or from root exudates excreted by the developing roots. In this routine course of activity they fix atmospheric nitrogen. Initially it fixes for their own build-up, but very soon population stabilizes and fixed nitrogen is released to the close vicinity of roots. Thus, released nitrogen is quickly absorbed by the plants. Subba Rao (1993) reported that Azotobacter cells are not usually present on the rhizoplane (root surface) but are in abundance in the rhizosphere (the soil immediately surrounding roots).

Phosphate solubilizers containing mainly *Pseudomonas, Bacillus* and *Aspergillus* etc. have ability to solubilize insoluble phosphorus to the soluble form by production of organic acids and then make it available to the plants (Gaur, 1990). Whereas, mycorrhizal fungi form symbiotic relationship with the roots of the host plant, in which host plant provides carbohydrates for the fungus and fungus in turn supplies nutrients to the host.

Okon (1984) mentioned that biofertilizers promote the synthesis of some vitamins, including $B_{12}$. Among the large number of bacteria which have been tested for their nitrogen fixation ability, *Azotobacter chroococcum* and *Bacillus polymyxa* have yielded very good results. *A. chroococcum* bacteria are strictly aerobic, whereas *B. polymyxa* bacteria are facultative anaerobes. The favourable effect of *Azotobacter* bacteria was attributed to an increase in the water and mineral uptake from the soil, which might be ascribed to increase in root surface area, root hairs and root elongation. On the other hand, the beneficial effect of *Bacillus polymyxa* may be attributed, not only to its N-fixation ability, but also to its solubilization of organic phosphate compounds, suppression of pathogenic organisms in the rhizosphere and the bacterial production of indoleacetic acid and caused an increase in aggregated soil particles by 57% which led to a more porous structure within the rhizosphere soil and consequently, enhanced water retention and nutrient transfer in the rhizosphere.

Bolan *et al.* (1987) reported that the improvement of P nutrition of plants has been the most recognized beneficial effect of mycorrhizas. AM- fungi have been reported to improve nutrition of the other macronutrients like N (Hodge, 2003). It is also reported that the AM-fungi also increases the uptake of K and concentration of K has been found more in mycorrhizal than non-mycorrhizal plants (Bressan *et al.*, 2001). Mycorrhiza resulted in better uptake of water by plants as well as induced drought tolerance (Sheraz Mahdi and Bhat, 2010).

Rennie (1981 a, b) has shown that three species of wheat grass, pubescent (*Agropyron trichophorum*), tall (*A. elongatum*) and northern (*A. dasystachyum*), support populations of *Azospirillum, Azotobacter* or *Eriwinia* in their rhizospheres.

*Festuca pratensis* showed an increase in the N content as a result of inoculation with *Klebsiella, Enterobacter* (Haahtela, 1986) or *Azospirillum brasilense* (Yurko, 1997).

Holl *et al*. (1988) studied the effect of inoculation of crested wheat grass (*Agropyron cristatum* L.), perennial ryegrass (*Lolium perenne* L.), and white clover (*Trifolium repens* L.) with the soil diazotroph *Bacillus polymyxa* and it was found that the plant growth responses to inoculation varied from slightly negative (perennial ryegrass) to highly positive (white clover and crested wheat grass) when root, shoot and dry weights were measured.

Cerealin biofertilizers are a group of commercial products that contain different species of bacteria, depending on the crop.

Kotb (1998) mentioned that the maximum effect of cerealin (containing *Azospirillum lipoferum*, *Azotobacter chroococcum* and *B. polymyxa*) was achieved when it was combined with chemical N fertilization. Inoculating wheat or *Pennisetum clandestinum* (kikuyu grass), with cerealin followed by chemical N fertilization was sufficient to maintain high quality growth and chemical composition.

Peacock and Daniel (1992) compared "Rebel" tall fescue (*Festuca arundinacea*. Schreb.) and "TifWay" bermuda grass (*Cynodon dactylon* (L.) Pers. X C. *transvaalensis* Burtt.Davy) growth response to a natural organic fertilizer (Turf Restore) amended or not amended (with a soil-derived microbiological inoculum) with soluble urea using sterilized and non-sterilized soil and it was found that urea fertilizer increased tall fescue growth rates by 68 % in the non - sterilized soil and 126 % in the sterilized soil compared to rates for turf grown with Inoculated Turf Restore in tall fescue. Bermuda grass response was similar to that of tall fescue where growth rate was 67 % and N uptake 51 % higher with urea than with Turf Restore regardless of inoculant addition.

Subba Rao (1993) reported that the number of *A. chroococcum* in Indian soils rarely exceed $10^4$ to $10^5$/g soil and he also noticed that lack of organic matter in soil is a limiting factor in the proliferation of Azotobacter.

Quarles (1996) concluded that application of biofertilization treatments to golf courses (using *Azospirillum brasilense*) reduced the need for fertilizer applications.

Hashem and Wassif (1997) observed the effect of the interaction between elemental sulphur and biofertilizer applications on forage production of calcareous soils and it was found that the application of combined treatment of biofertilizer with 0.5 ton S/fed was the best for increasing clover production under calcareous soil conditions.

Hussein and Mansour (2003) reported that inoculation of *Pennisetum clandestinum* (kikuyu grass) with cerealin reduced the need for chemical N fertilization by 25-33 % and they also recorded that raising the rate of chemical nitrogenous fertilization (with or without cerealin) caused a steady increase in fresh and dry weights of underground parts/$m^2$ in *Pennisetum clandestinum* turf grass. They also reported that plant height increased as a result of increasing N fertilization rates.

Kavanova *et al*. (2006) studied the phosphorus nutrition and mycorrhiza effects on grass leaf growth and found that P status affected leaf growth directly only through effects on relative tissue expansion rates and it was observed that symbiosis with arbuscular mycorrhizal fungus did not modify these relationships.

Al Karaki *et al*. (2007) determined the effect of Arbuscular Mycorrhizal (AM) fungi inoculation on water use efficiency and establishment of a lawn mixture of kentucky blue grass and perennial rye grass grown on a sandy soil with low P fertilizer level (50 % of commonly recommended rate) and it was reported that inoculated plots with AM fungi had improved turf coverage, shoot and root growth, clipping yield and water use efficiency in comparison with uninoculated plots. The results revealed that turf grass inoculated with AM fungi established more quickly and had more biomass than uninoculated turf which indicate the potential of mycorrhiza in improving utilization of fertilizer and irrigation water to hasten and improve the establishment of grass lawn.

Hussein and Arafa (2009) studied the response of seashore paspalum (*Paspalum vaginatum*, Swartz cv. Salam) to two N sources: ammonium nitrate (33.5%N) at the rates of 3, 4 or 5 g N/$m^2$/ month, only or cerealin (a commercial product containing *Bacillus polymyxa* and *Azotobacter chroococcum* bacteria) with or without ammonium nitrate at the same rates and it was reported that all treatments increased plant height, turf density, fresh and dry weights of clippings/ $m^2$ and underground parts/$m^2$ , as well as the leaf contents of pigments (total chlorophylls and carotenoids), total carbohydrates, N , P and K, compared with the control . It was also found that combining cerealin with chemical N fertilization reduced the need for chemical N fertilization by approximately 20-25 % and hence, it can be concluded that inoculation of *Paspalum vaginatum*, Swartz cv. Salam plugs with cerealin, followed by chemical N fertilization of the turf at the rate of 4 g $N/m^2$/month was sufficient to maintain high quality for the above-ground turf and relatively good characteristics for the underground parts.

Erkovan *et al*. (2010) studied the effects of phosphorus fertilizer and phosphorus solubilizing bacteria applications on the dry matter production and botanical composition of a natural meadow. Phosphorus fertilizer (0, 11, 22, 33, 44 kg P $ha^{-1}$) and phosphorus solubilizing bacteria (*Bacillus megaterium* var *phosphaticum*) were added and it was found that phosphorus fertilization significantly affected dry matter yield while phosphorus solubilizing bacteria did not show any affect on dry matter yield and hence, it can be concluded that phosphorus fertilization did not affect the botanical composition of grasses.

# *Chapter-3*

# MATERIALS AND METHODS

The present investigations entitled, "Effect of Integrated Nutrient Management on *Lolium perenne* L." were carried out at the experimental farm of Department of Floriculture and Landscaping, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan during March, 2009 to June, 2010.

The experimental farm is located at 1276 m amsl at a latitude of $30^{o}52'$ $02''$ N and at a longitude of $77^{o}11'30''$ E. The climate of this area is typically sub-temperate. The meteorological data were recorded throughout the investigation period and mean maximum temperature ranged between 19.20 to 39.3$^{o}$C and mean minimum temperature varied from 1.50 to 20.5 $^{o}$C with 0 to 408 mm mean annual rainfall (Appendix – I).

## 3.1 PLANT MATERIAL

The seeds of two genotypes of *Lolium perenne* L. (perennial rye grass) viz. Amenity Type and Agricultural type were procured from M/S Emorsgate seeds, United Kingdom. A brief description of species is given below:

### 3.1.1 *Lolium perenne* L. (perennial rye grass)

It is distinguished by its smooth leaf margins, narrow, longer, not hairy auricles. It has fine texture and the leaves are folded in the bud shoot. Blades are 2-6 mm wide, bright green, with the upper surface prominently ridged and the lower surface is glossy. Sheath is flattened to almost round, closed or split, reddish at base. Ligule is 1-2 mm long and is obtuse. Auricles are narrow, 1-3 mm or longer. Collar is distinct and broad, inflorescence has long, narrow flat spikes with awn spikelets (Vengris,1973 and Decker & Decker, 1988) (Figure 1).

The two genotypes of *Lolium perenne* L. used in the present studies were:

(a) *Lolium perenne* L. (Amenity Type)

(b) *Lolium perenne* L. (Agricultural Type)

Though the Amenity type of *Lolium perenne* L. has been recommended as a lawn grass (Hannaway *et al*., 1999) but Agricultural type may also be used for landscape purposes (Anonymous[2], 1995). The two *Lolium perenne* L. genotypes are non-creeping bunch type which germinate fast and establish quickly but Amenity type rye grasses are more fine leaved and have dark green leaf blade colour than Agricultural type grasses and also, grows more slowly than forage ryegrasses (Creemers-Molennar and Beerepoot, 1992).

## 3.2 BIOFERTILIZERS

Three biofertilizers namely Azotobacter, Phosphate Solubilizing Bacteria (PSB) and Vesicular Arbuscular Mycorrhizae (VAM) (which is now a days also called as Arbuscular Mycorrhizal Fungi (AMF)) were used in these investigations.

### 3.2.1 Azotobacter

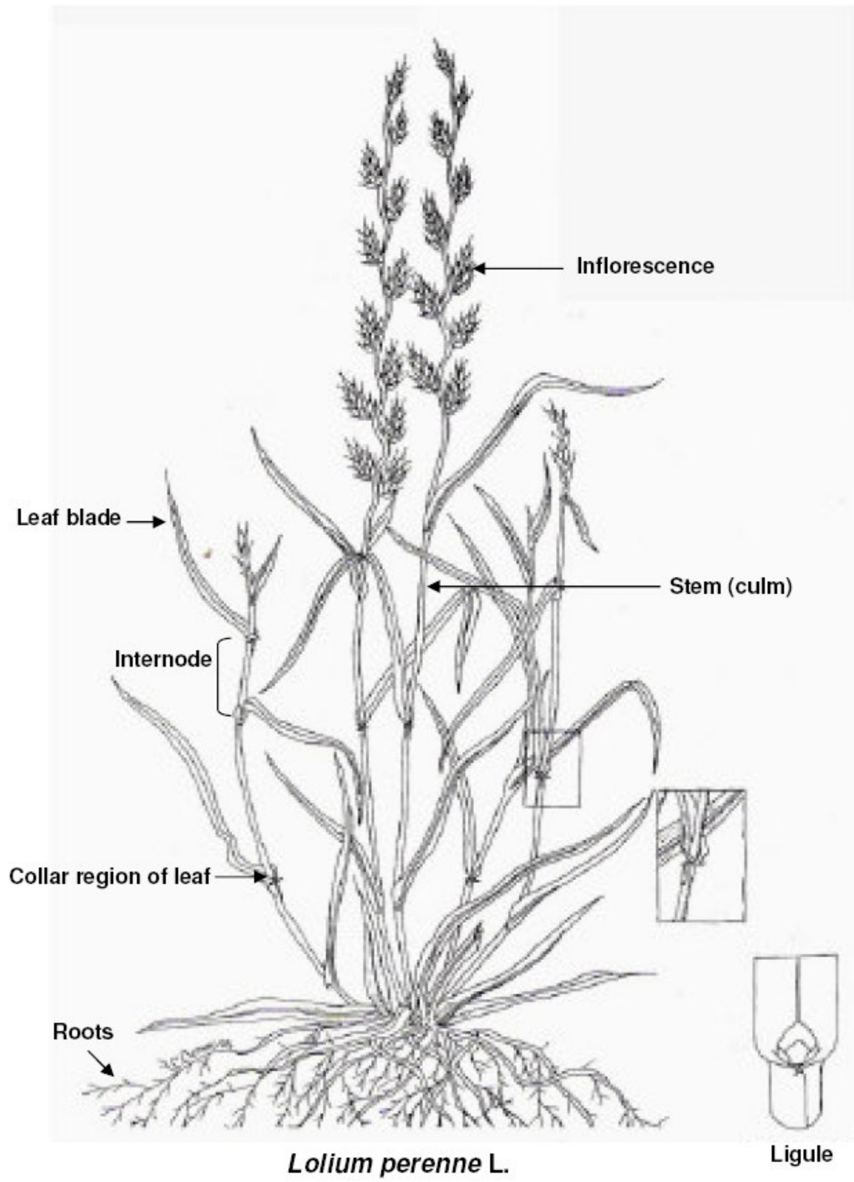
Azotobacter is an aerobic, gram negative and non-symbiotic $N_2$ fixing bacteria. Its cells are polymorphic, varying from 2.0-7.0 x 1.0-2.5 µm and are having peritrichous flagella (Subba Rao, 1977). Apart from nitrogen, this organism is capable of producing antibacterial and antifungal compounds, hormones and siderophores (Sharma, 2002).

### 3.2.2 Phosphorus Solubilizing Bacteria (PSB)

These are group of heterotrophic microorganisms and they have the ability to solubilize inorganic P from insoluble sources. Several soil bacteria, particularly those belonging to the genera *Pseudomonas* and *Bacillus* and fungi belonging to the genera *Penicillium* and *Aspergillus* possess the ability to bring insoluble phosphates in soil into soluble forms by secreting organic acids such as fumic, acetic, propionic, lactic, glycolic, fumaric and succinic acid (Subba Rao, 1977). These microorganisms are the carrier based inoculants.

### 3.2.3 Vesicular Arbuscular Mycorrhizae (VAM)

VAM fungi are obligate endosymbionts and have not been cultured and the only means of identifying them is to collect resting spores from soil. VAM fungi possess special structures known as vesicles and arbuscules (Subba Rao,




*Lolium perenne* L.

**Fig.1. Morphological features of *Lolium perenne* L.**

1977). Vesicles are normally oval, occasionally round and sometimes irregularly lobed. They serve as storage organs. Arbuscules are like haustoria of parasitic fungi and are believed to transfer nutrients especially phosphate. VAM fungi are classified on the basis of size, shape and colour of spores (Gerdemann and Nicolson, 1963), e.g., 50 μ diameter spore is classified as *Glomus microcarpus* whereas, 100 μ to 200 μ spore may belong to *G. mosseae*, *Gigaspora cladospora* and *Glomus caledonius* (Plate 1).

### 3.3 FARM YARD MANURE (FYM)

It was a decomposed mixture of cow dung and urine along with litter and left over material from roughages or fodder fed to the cattle. Farm yard manure is being used from ancient time as a supplement of nutrition and improves soil physical conditions too. Farm yard manure contains lots of living micro and macro organisms like bacteria, fungi and insects, etc. These organisms are involved in several oxidation-reduction reactions, which release several useful nutrients and stimulate the production of hormones and enzymes required by the plants for their optimum growth and development. FYM has been the source of various soil borne pathogens and weed infestation hence influences cost of cultivation. To overcome these drawbacks vermicompost is being recommended as an alternative supplement of soil in the recent years.

### 3.4 VERMICOMPOST

Vermicompost is stable fine granular organic matter, when added to clay soils loosens the soil and provides the passage for the fast entry of air and water. Vermicomposting is a simple biotechnological process of composting, in which certain species of earth worms like *Eisenia foetida*, *Eudrilus eugeiae*, *Bimastos parvus*, *Lampito mauritti*, *Metaphire anomala*, etc. are used to enhance the process of waste conversion to produce a better end product. The mucus associated with the earthworm cast being hygroscopic in nature, absorbs water, prevents water logging and improves water- holding capacity too. It is a good source of macro and micronutrients. There is abundant evidence that concentration of exchangeable calcium, sodium, magnesium, potassium and available phosphorus and molybdenum are higher in earthworrn casts than in surrounding soil. It is also free from almost all harmful insect pests, which are prevalent in farmyard manure. Application of vermicompost also found help in checking nematode population in the soil. Several valuable compounds are also produced through the earthworm micro flora interaction which include vitamins (such as $B_{12}$) and plant growth hormones such as gibberellins.

## 3.5 INORGANIC FERTILIZERS

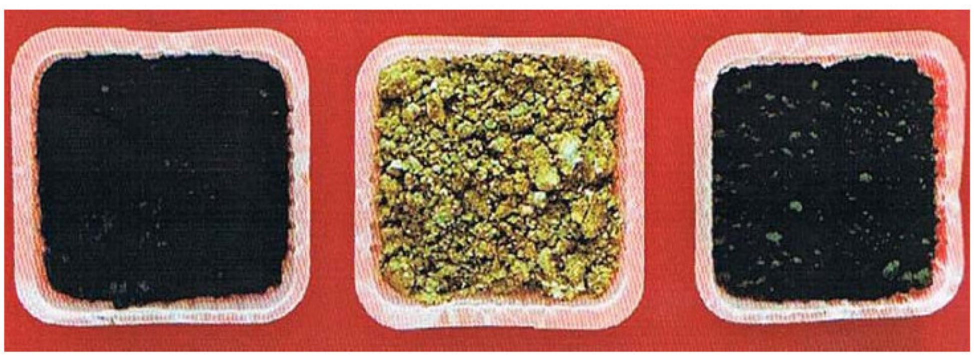
Inorganic fertilizers (N, P and K) were supplied through Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) which have 46% nitrogen, 16% phosphorus and 60% potassium, respectively. Foliar application of N was given through urea. The required dose of fertilizers (RDF) was applied as per the requirement of species (Vengris, 1973 and Charles, 2010).

## 3.6 EXPERIMENTAL DETAILS

| | | |
|---|---|---|
| Design | : | Randomized Block Design (Factorial) |
| Number of genotypes | : | 2 |
| Total treatment combinations | : | 12 |
| Number of replications | : | 3 |
| Plot size | : | 1 $m^2$ |
| Spacing | : | 10 x 10 cm |

Treatment combinations

| | | |
|---|---|---|
| $T_1$ | : | Control (no application) |
| $T_2$ | : | 100 % RDF* + FYM |
| $T_3$ | : | FYM + Biofertilizers (Azotobacter + Phosphobacteria + VAM) |
| $T_4$ | : | Vermicompost + Biofertilizers (Azotobacter + Phosphobacteria + VAM) |
| $T_5$ | : | 100 % RDF + FYM + Biofertilizers (Azotobacter + Phosphobacteria + VAM) |
| $T_6$ | : | 100 % RDF + Vermicompost + Biofertilizers (Azotobacter + Phosphobacteria + VAM) |



AZOTOBACTER VESICULAR ARBUSCULAR MYCORRHIZA P-SOLUBILISING BACTERIA

Plate 1. Biofertilizers used

$T_7$ : 75 % RDF + FYM + Biofertilizers (Azotobacter + Phosphobacteria + VAM)

$T_8$ : 75 % RDF + Vermicompost + Biofertilizers (VAM + Azotobacter + Phosphobacteria)

$T_9$ : 50 % RDF + Vermicompost + Foliar application of N @ 0.5 %.

$T_{10}$ : 50 % RDF + FYM + Foliar application of N @ 0.5 %.

$T_{11}$ : FYM + Biofertilizers + Foliar application of N @ 0.5 %.

$T_{12}$ : Vermicompost + Biofertilizers + Foliar application of N @ 0.5 %.

*RDF : Required Dose of Fertilizers (N: P: K/ $m^2$**:** 15:5:10/$m^2$)

## 3.7 EXPERIMENTAL METHODOLOGY

### 3.7.1 Sources of manures, fertilizers and biofertilizers used:

Required quantity of manures, fertilizers and biofertilizers were procured from the following sources:

| | | | |
|---|---|---|---|
| a) | FarmYard Manure | : | Local (It contained 0.5% $N_2$, 0.2% $P_2O_5$ and 0.5% $K_2O$) |
| b) | Vermicompost | : | Local (It contained 9.5-13.5% organic carbon, 0.1-1.8%nitrogen, 0.1-1.05% phosphorus and 0.1-0.8% potassium) |
| c) | Azotobacter, Phosphobacteria and Vesicular Arbuscular Mycorrhizae (VAM) | : | Department of Microbiology IARI, New Delhi |
| d) | Inorganic fertilizers | : | From departmental store, in form of Urea, SSP and MOP. |

### 3.7.2. Calculation of fertilizer doses

100 % RDF required for 1 $m^2$ plot was calculated and applied as per the details below:

N = 32.6 g

$P_2O_5$ = 31.25 g

$K_2O$ = 16.66 g

For 75 % RDF required for 1m$^2$ plot:

N = 24.45 g

$P_2O_5$ = 23.43 g

$K_2O$ = 12.50 g

For 50% RDF required for 1m$^2$ plot:

N = 16.3 g

$P_2O_5$ = 5.62 g

$K_2O$ = 8.33 g

Foliar application of N @ 0.5% was applied by mixing 0.23 g of urea per litre of water.

Organic fertilizers (Biofertilizers) viz: Azotobacter, Phosphobacteria, VAM were applied @ 2 g each per meter square whereas vermicompost and FYM were applied @ 5 kg/m$^2$, respectively.

### 3.7.3 Nursery Raising

The seeds of *Lolium perenne* L. (Amenity Type) and *Lolium perenne* L. (Agricultural Type) were sown in trays filled with perlite:cocopeat: vermicompost (1:1:3) during March (Plate 2).

Before sowing of seeds, a layer of pebbles was spread in the germination trays below the media. The seeds were sown in lines about 1 cm deep and were covered with a thin layer of media prepared. These were then drenched with a solution containing Bavistin @ 0.1% and Dithane M-45 @ 0.2 %. The trays were covered with jute cloth and light irrigations were applied regularly to keep the media moist. The seeds germinated after 2 weeks of sowing (Plate 3).

### 3.7.4 Experimental planting

The experimental field was prepared by digging the soil thoroughly upto a depth of 12". Stubbles of previous crops, weeds and gravels were removed and


**Plate 2. Trays filled with sowing medium**

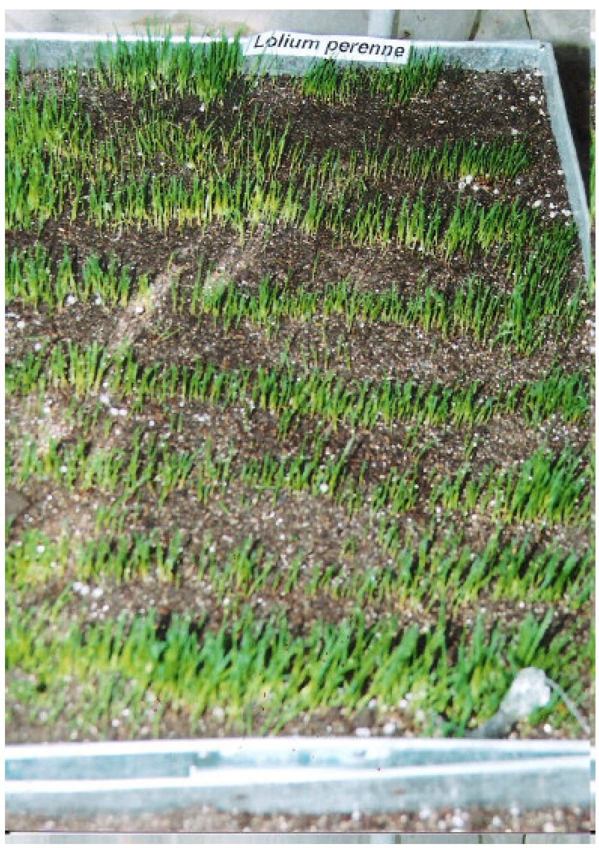



**Plate 3. Trays showing germination of seeds**

field was levelled well. Raised beds of $1m^2$ were prepared. Transplanting of the seedlings of *Lolium perenne* L. was done in the field on 15th April when they attained a height of about 5 cm. The seedlings were planted in clumps in such a way that each clump consisted of 8 seedlings. Treatments were applied after one month of transplanting i.e. on 15th May, 2009 (Plate 4).

### 3.7.5 Cultural practices

Standard cultural practices like irrigation, weeding and hoeing were followed as per the requirement of the crop. Drenching with a solution containing Bavistin @ 0.1% and Dithane M-45 @ 0.2 % was done periodically to prevent any disease incidence.

## 3.8 OBSERVATIONS RECORDED

### 3.8.1 Establishment rate (%)

Number of clumps that survived after 45 days of transplanting were counted and expressed as per cent.

$$\text{Establishment rate (\%)} = \frac{\text{No. of survived clumps after 45 days of transplanting}}{\text{Total number of clumps planted}} \times 100$$

After observing the establishment rate, the following observations were recorded on monthly basis starting from July, 2009 onwards.

### 3.8.2 Culm length (cm)

Culm length was measured monthly with the help of a scale from the crown portion to the tip of the shoot (culm). The increase in growth of the culm was recorded by maintaining a standard length of 5 cm and before mowing of the next month. Monthly increase in the culm length was expressed in cm.

### 3.8.3 Number of mowings required

Depending upon the monthly increase in growth of the culms after maintaining a standard of 5 cm length, the number of mowings were recorded as per the details below:

| Increase in culm length (cm) | Number of mowings |
|---|---|
| 0-2 | 1 |
| 2-4 | 2 |
| 4-6 | 3 |
| 6-8 | 4 |
| 8-10 | 5 |
| 10-12 | 6 |
| 12-14 and above | 7 |

### 3.8.4 Turf colour

Colour of the grass leaves (turf) was recorded with the help of colour charts of "The Royal Horticultural Society", London.

### 3.8.5 Leaf blade texture

Leaf texture was noted by "Hand feel" method given by Srivastava and Kumar (2002).

### 3.8.6 Weed population ($m^2$)

Number of weeds per square meter was counted.

### 3.8.7 Turf growth ($cm^2$)

Turf growth was measured as the distance between the leaf blades in the east to west x north to south directions of the clump. It was recorded after mowing till recording of the data for the next month.

### 3.8.8 Visual quality rating

Visual quality ratings of the grass was assessed on 1-5 scale (1=min. to 5=max.) depending on the characteristics like:

a. Aesthetic appearance of turf :

Visual assessment of uniformity and an estimate of even appearance of turf was observed to record this observation.

b. Turf colour :

Visual observations were recorded for turf colour which varied from green to yellow and grey.

Plate 4. View of the crop planted in open field

### 3.8.9 Rate of multiplication

Ten randomly selected clumps per treatment per replication were selected. Number of propagules/ clump were counted. This observation was recorded at the termination of the experiment.

### 3.8.10. Rooting behaviour

It was assessed on the basis of total length of roots, fresh and dry weight of the roots per clump. For this, the clump was uprooted carefully without damaging the root system and was cleaned and washed carefully. The length of roots was measured on Comair Root Length Scanner and was expressed in metres (Zutter *et al*., 1999). Fresh and dry root mass was measured with the help of electronic balance and expressed in grams. This observation was recorded at the termination of the experiment.

### 3.8.11 Presentability

Presentability of both the genotypes was assessed on the basis of number of mowings required, weed population/$m^2$, turf growth and visual quality rating (aesthetic appearance of turf and turf colour) during different months w.e.f. July, 2009 to June, 2010.

Based on the above parameters, scoring of genotypes was done by allotting a maximum of 20 points to each parameter making the total to be a maximum of 100 (Table 1).

### 3.8.12 Chlorophyll content (mg/100g)

The chlorophyll content in the leaves of both the genotypes was estimated as per the method described by Mahadevan and Sridhar (1986). This estimation was done for four seasons as described by Meteorology Centre, Deptt. of Environmental Science, U.H.F., Nauni which are given as :

1. Monsoon season (July to September),
2. Post- monsoon season (October to December),
3. Winter season (January to March) and
4. Summer season (April to June)

**Table 1. Scores allotted (out of hundred) to various parameters for evaluating the presentability of two genotypes of *Lolium perenne* L.**

| | Parameter | Description (as observed) | Points allotted |
|---|---|---|---|
| **1.** | **Number of mowings required** | 1 | 20 |
| | | 2 | 17 |
| | | 3 | 14 |
| | | 4 | 11 |
| | | 5 | 8 |
| | | 6 | 5 |
| | | 7 | 2 |
| **2.** | **Weed population/m$^2$** | 0-5 | 20 |
| | | 5-10 | 16 |
| | | 10-15 | 12 |
| | | 15-20 | 8 |
| | | 20-25 | 4 |
| | | 25 & above | 2 |
| **3.** | **Turf growth (cm$^2$)** | 7-8 | 20 |
| | | 6-7 | 17.5 |
| | | 5-6 | 15.0 |
| | | 4-5 | 12.5 |
| | | 3-4 | 10.0 |
| | | 2-3 | 7.5 |
| | | 1-2 | 5.0 |
| | | 0-1 | 2.5 |
| **4.** | **Visual quality rating** | | |
| **a)** | **Aesthetic appearance of** | 5 | 20 |
| | **turf** | 4-5 | 16.0 |
| | | 3-4 | 12.0 |
| | | 2-3 | 8.0 |
| | | 1-2 | 4.0 |
| **b)** | **Turf colour** | 5 | 20 |
| | | 4-5 | 16.0 |
| | | 3-4 | 12.0 |
| | | 2-3 | 8.0 |
| | | 1-2 | 4.0 |

### (a) Collection of samples

Representative leaves were detached from the plants of two genotypes at 9:30 a.m. and were immediately placed in an icebox and were brought to the laboratory. The samples were then kept in the refrigerator below $0^{o}C$ to avoid degradation of chlorophyll pigments.

**b) Extraction**

Leaf samples of each genotype were washed and chopped into fine pieces with the help of a sterilized blade. One gram of chopped material was ground in mortar and pestle using 80 per cent acetone for the extraction of chlorophyll. A small quantity of $CaCO_3$ and acid washed sand were used to prevent degradation of pigments and to enhance maceration. The extract was filtered through Buchner funnel fitted with filter paper (Whatman No. 1). The residue was washed with excess of acetone until it was colourless. All these operations were carried out in subdued light.

**c) Estimation**

The filtrate was made to 25 ml volume with 80 per cent acetone. The absorbance was recorded on UV-Spectrophotometer at 645 and 663 nm wavelengths against blank after the estimation of chlorophyll 'a' and chlorophyll 'b', respectively. The quantity of total chlorophyll was calculated by using the standard formula:

$$\text{Total chlorophyll (mg/g of fresh weight)} = \frac{20.20\ A_{645} + 8.02\ A_{663}}{A \times 1000 \times W} \times V$$

where, A = length of light path (1 cm)

V = volume of extract

W = fresh weight of sample

$A_{645}$ = absorbance at 645nm

$A_{663}$ = absorbance at 663 nm

The results were expressed in milligrams of total chlorophyll per gram of fresh weight.

### 3.8.13 Soil analysis

A composite soil sample from 0-15 cm layer and 15-30 cm was collected from four sites of each experimental plot with the help of screw type auger. The soil samples thus collected were dried in shade, grinded, sieved in 2 mm plastic sieve and stored in cloth bags. The samples were analyzed for soil pH, electrical conductivity, organic carbon and available macro nutrients (N, P, K). The analysis was determined as per the methods mentioned below:

**Table 2. Methods used for the analysis of soil**

| Particulars | Methods employed |
|---|---|
| pH | 1:2.5 Soil water suspension with digital pH meter (Jackson, 1967) |
| EC ($dSm^{-1}$) | 1:2.5 Soil water suspension (Jackson, 1967) |
| Organic Carbon (%) | Walkley and Black's rapid titration method (Piper, 1966) |
| Available N (Kg $ha^{-1}$) | Alkaline potassium permanganate method (Subbiah and Asija, 1956) |
| Available P (Kg $ha^{-1}$) | Olsen method using $NaHCO_3$ extractant (pH 8.5) and colour development with chlorostannous molybdophosphoric acid (Olsen *et al.*, 1954) |
| Available K (Kg $ha^{-1}$) | Extraction with neutral normal ammonium acetate and determination by flame photometer (Jackson, 1973). |

The initial status of soil has been presented in Table 3.

**Table 3. Initial physico-chemical properties and available nutrients in soil**

| | |
|---|---|
| pH (1:2) | 7.10 |
| EC ($dSm^{-1}$) | 0.28 |
| OC (%) | 1.5 |
| N (kg/ha) | 137.98 |
| P (kg/ha) | 201.6 |
| K (kg/ha) | 573.44 |

### 3.8.14 Plant nutrient analysis

#### 3.8.14.1 Collection and preparation of leaf samples

Leaf blade samples were collected and washed under tap water followed by 0.1 N HCl and distilled water. The samples were spread on filter paper sheets for surface drying and were subsequently put in paper bags which were kept in hot air oven at 68$^{o}$C for 48 hours (Chapman, 1964). The oven dried samples were crushed, ground and stored in air-tight containers for the estimation of various nutrient elements.

### 3.8.14.2 Digestion of plant material

One gram of well grounded leaf samples were used for estimation of leaf nitrogen. The samples were digested on digestion system unit using 4 g of digestion mixture in 15 ml of concentrated sulphuric acid. The digestion mixture was prepared by mixing 400 parts potassium sulphate, 20 parts of copper sulphate, 3 parts of mercuric oxide and 1 part of selenium powder as suggested by Jackson (1967). The samples were digested on electric hot plate. The digestion was continued till 2-3 ml of clear digested material was left in the conical flasks. After complete digestion the samples were diluted to 100 ml with the help of distilled water. The boiling was continued till appearance of light blue colour. The samples were cooled and diluted to 100 ml with distilled water.

One gram of well grounded leaf samples were used for the estimation of P and K and digestion was carried out in the 20 ml diacid mixture containing nitric acid and per chloric acid mixture in the ratio of 4: 1 (Jackson, 1967) which was transferred into 250 ml conical flasks. The samples were digested on electric hot plate. The digestion was continued till 2-3 ml of clear digested material was left in the conical flasks. After complete digestion the samples were diluted to 100 ml with the help of distilled water.

**Table 4. Methods used for the analysis of total leaf nutrient content**

| **Nutrients** | **Methods** |
|---|---|
| Nitrogen | Micro-Kjeldahl method (AOAC, 1980) |
| Phosphorus | Vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973) |
| Potassium | Digital flame photometer (Jackson, 1973) |

Data on N, P and K was expressed in per cent on dry weight basis.

### 3.8.15 Statistical analysis

The data recorded on different parameters were subjected to analysis of variance (ANOVA) using Randomized Block Design Factorial (Cochran and Cox, 1963).

# *Chapter-4*

# EXPERIMENTAL RESULTS

The results derived from the present studies are presented parameter wise in this chapter. The analysis of variance (ANOVA) for the parameters under study is presented in Appendix –II.

## 4.1 ESTABLISHMENT RATE (%)

The data presented in Table 5 reveals that amongst the genotypes, Amenity type had better establishment rate (96.17 %) as compared to Agricultural type (80.40 %). However, the treatments and the interaction, genotypes x treatments were found to be non-significant. (Appendix –II).

**Table 5. Effect of Integrated Nutrient Management treatments on establishment rate (%) of two genotypes of *Lolium perenne* L.**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|---|
| $T_1$ | Control (no application) | 93.55 | 77.25 | 85.40 |
| $T_2$ | 100 % RDF + FYM | 98.27 | 82.08 | 90.17 |
| $T_3$ | FYM + Biofertilizers | 95.83 | 80.56 | 88.20 |
| $T_4$ | Vermicompost + Biofertilizers | 96.18 | 81.57 | 88.88 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 97.22 | 79.63 | 88.43 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 95.84 | 80.77 | 88.30 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 97.57 | 80.93 | 89.25 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 96.53 | 81.10 | 88.82 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 95.14 | 77.59 | 86.37 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5% | 96.53 | 79.54 | 88.04 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 94.45 | 80.17 | 87.31 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 96.88 | 83.57 | 90.22 |
| | Mean | 96.17 | 80.40 | 88.89 |

$CD_{0.05}$ for:

| | |
|---|---|
| Genotypes | 1.22 |
| Treatments | NS |
| Genotypes x treatments | NS |

## 4.2 CULM LENGTH (cm)

Monthly increase in culm length (cm) has been presented in Table 6a, b, c and d. Perusal of data presented in Table 6a reveals that amongst the genotypes, Amenity type showed less increase in culm length (5.26 cm) as compared to Agricultural type (9.35 cm). Amongst the treatments, $T_3$ was effective in reducing the culm length (6.36 cm) and was at par with $T_6$ and $T_{11}$, whereas, $T_4$ increased the culm length significantly (8.43 cm) and was found to be at par with $T_{10}$. Interaction, genotypes x treatments reveals that minimum culm length (4.02 cm) was achieved when Amenity type was treated with $T_3$ and was found to be at par with $T_1$, $T_6$ and $T_{11}$ of Amenity type. Maximum culm length (11.47 cm) was recorded in Agricultural type when treated with $T_4$.

**Table 6a. Effect of Integrated Nutrient Management treatments on culm length (cm) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|---|
| $T_1$ | Control (no application) | 4.47 | 9.99 | 7.23 |
| $T_2$ | 100 % RDF + FYM | 6.40 | 8.68 | 7.54 |
| $T_3$ | FYM + Biofertilizers | 4.02 | 8.71 | 6.36 |
| $T_4$ | Vermicompost + Biofertilizers | 5.38 | 11.47 | 8.43 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 5.45 | 9.02 | 7.24 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 4.95 | 8.24 | 6.60 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 5.28 | 9.60 | 7.44 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 5.17 | 9.20 | 7.19 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 5.89 | 8.74 | 7.31 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 5.65 | 10.31 | 7.98 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 4.57 | 9.41 | 6.99 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 5.91 | 8.75 | 7.33 |
| | Mean | 5.26 | 9.35 | 7.30 |

$CD_{0.05}$ for:

| | |
|---|---|
| Genotypes | 0.27 |
| Treatments | 0.66 |
| Genotypes x Treatments | 0.94 |

An inquisition of data in Table 6b reveals that amongst the months, minimum increase in culm length (3.26 cm) was recorded during April, 2010 and was found to be at par with May, 2010, while maximum culm length (13.75 cm) was observed during August, 2009, and was at par with September, 2009. Interaction, genotypes x months reveals that minimum increase in culm length (1.07 cm) was recorded in plots where Amenity type was grown during May, 2010, which was statistically at par with Amenity type during April, 2010. Maximum increase in culm length (16.08 cm) was however, observed in plots where Agricultural type was grown during August, 2009 and was found to be statistically at par with Agricultural type during September, 2009.

Non-significant differences were obtained in interaction, treatments x months (Table 6c) and in interaction, genotypes x months x treatments (Table 6d) (Appendix-II).

**Table 6b. Effect of Integrated Nutrient Management treatments on culm length (cm) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Months | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|
| **July, 2009** | 9.74 | 13.00 | 11.37 |
| **August, 2009** | 11.42 | 16.08 | 13.75 |
| **September, 2009** | 10.55 | 15.47 | 13.01 |
| **October, 2009** | 6.92 | 12.04 | 9.48 |
| **November, 2009** | 5.90 | 8.92 | 7.41 |
| **December, 2009** | 4.61 | 7.49 | 6.05 |
| **January, 2010** | 3.95 | 6.83 | 5.39 |
| **February, 2010** | 3.08 | 6.63 | 4.85 |
| **March, 2010** | 2.44 | 7.55 | 5.00 |
| **April, 2010** | 1.31 | 5.23 | 3.26 |
| **May, 2010** | 1.07 | 5.94 | 3.50 |
| **June, 2010** | 2.16 | 6.97 | 4.57 |

$CD_{0.05}$ for:

| | |
|---|---|
| Months | 0.66 |
| Genotypes x Months | 0.94 |

**Table 6c. Effect of Integrated Nutrient Management treatments on culm length (cm) of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | 2010 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | Months | | | | | | | | | | | |
| | July | August | September | October | November | December | January | February | March | April | May | June |
| $T_1$ Control (no application) | 11.04 | 13.42 | 12.48 | 9.12 | 7.60 | 6.42 | 5.49 | 5.46 | 4.48 | 3.24 | 3.45 | 4.59 |
| $T_2$ 100 % RDF + FYM | 11.58 | 14.23 | 13.96 | 10.02 | 7.92 | 6.08 | 5.13 | 4.98 | 4.89 | 3.11 | 3.90 | 4.69 |
| $T_3$ FYM + Biofertilizers | 10.10 | 12.32 | 11.61 | 7.54 | 6.51 | 5.14 | 4.42 | 3.78 | 4.30 | 3.06 | 3.42 | 4.19 |
| $T_4$ Vermicompost + Biofertilizers | 11.55 | 13.73 | 13.40 | 11.43 | 8.93 | 7.69 | 6.80 | 5.58 | 5.27 | 4.46 | 5.14 | 7.18 |
| $T_5$ 100 % RDF + FYM + Biofertilizers | 11.69 | 14.75 | 13.82 | 8.93 | 6.02 | 4.94 | 5.83 | 4.29 | 5.24 | 3.04 | 3.81 | 4.51 |
| $T_6$ 100 % RDF + Vermicompost + Biofertilizers | 10.85 | 12.95 | 12.40 | 8.74 | 6.31 | 4.98 | 4.41 | 4.53 | 4.67 | 3.03 | 2.71 | 3.63 |
| $T_7$ 75 % RDF + FYM + Biofertilizers | 11.87 | 14.19 | 13.18 | 10.40 | 7.36 | 6.07 | 5.38 | 4.86 | 5.49 | 3.30 | 3.18 | 4.03 |
| $T_8$ 75 % RDF + Vermicompost + Biofertilizers | 11.21 | 13.52 | 13.35 | 9.41 | 7.72 | 6.20 | 5.32 | 5.55 | 4.74 | 2.82 | 2.75 | 3.66 |
| $T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 12.28 | 14.22 | 12.66 | 9.49 | 6.64 | 5.21 | 4.71 | 5.08 | 5.46 | 2.90 | 4.08 | 5.02 |
| $T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 % | 11.97 | 14.47 | 13.70 | 10.41 | 8.42 | 7.17 | 6.09 | 5.11 | 5.60 | 4.48 | 3.45 | 4.90 |
| $T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5% | 11.29 | 13.60 | 13.08 | 8.89 | 7.42 | 6.00 | 5.33 | 4.56 | 4.88 | 2.21 | 2.64 | 3.96 |
| $T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 11.01 | 13.55 | 12.52 | 9.34 | 8.09 | 6.73 | 5.74 | 4.48 | 4.96 | 3.57 | 3.53 | 4.48 |

$CD_{0.05}$ for:

Treatments x Months = NS

**Table 6d. Effect of Integrated Nutrient Management treatments on culm length (cm) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Months** | **July** | | **August** | | **September** | | **October** | | **November** | | **December** | | **January** | | **February** | | **March** | | **April** | | **May** | | **June** | |
| **Treatments** | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ |
| $T_1$ | 8.58 | 13.50 | 10.35 | 16.48 | 9.11 | 15.85 | 5.24 | 13.00 | 5.35 | 9.84 | 3.81 | 9.03 | 2.96 | 8.02 | 3.05 | 7.87 | 1.54 | 7.42 | 1.48 | 5.00 | 0.56 | 6.33 | 1.63 | 7.55 |
| $T_2$ | 12.03 | 11.13 | 13.41 | 15.05 | 12.46 | 15.46 | 8.70 | 11.33 | 8.02 | 7.83 | 6.67 | 5.48 | 5.87 | 4.39 | 2.55 | 7.40 | 2.59 | 7.19 | 1.27 | 4.94 | 1.19 | 6.61 | 2.05 | 7.33 |
| $T_3$ | 7.54 | 12.67 | 8.94 | 15.70 | 8.05 | 15.17 | 4.31 | 10.76 | 5.30 | 7.72 | 3.80 | 6.48 | 3.18 | 5.65 | 2.77 | 4.78 | 1.96 | 6.64 | 0.61 | 5.5 | 0.33 | 6.50 | 1.43 | 6.94 |
| $T_4$ | 10.13 | 12.96 | 11.76 | 15.71 | 11.07 | 15.72 | 8.54 | 14.31 | 5.59 | 12.26 | 4.41 | 10.96 | 3.68 | 9.91 | 2.73 | 8.43 | 1.71 | 8.83 | 1.54 | 7.37 | 1.19 | 9.08 | 2.21 | 12.14 |
| $T_5$ | 9.54 | 13.85 | 11.63 | 17.87 | 10.47 | 17.17 | 7.33 | 10.52 | 5.56 | 6.48 | 4.46 | 5.41 | 3.82 | 7.83 | 3.25 | 5.33 | 3.22 | 7.26 | 1.69 | 4.39 | 1.72 | 5.89 | 2.73 | 6.29 |
| $T_6$ | 8.26 | 13.44 | 10.08 | 15.81 | 9.26 | 15.53 | 8.23 | 9.26 | 5.76 | 6.85 | 4.52 | 5.45 | 3.91 | 4.91 | 2.78 | 6.27 | 2.53 | 6.80 | 1.17 | 4.90 | 0.92 | 4.50 | 2.04 | 5.21 |
| $T_7$ | 10.02 | 13.72 | 11.52 | 16.87 | 10.69 | 15.67 | 7.76 | 13.04 | 5.33 | 9.38 | 4.11 | 8.04 | 3.55 | 7.20 | 3.28 | 6.43 | 2.39 | 8.59 | 1.14 | 5.45 | 1.25 | 5.11 | 2.30 | 5.75 |
| $T_8$ | 9.37 | 13.05 | 11.17 | 15.87 | 10.96 | 15.74 | 5.91 | 12.90 | 6.09 | 9.35 | 4.78 | 7.61 | 3.98 | 6.65 | 3.07 | 8.03 | 2.37 | 7.11 | 1.08 | 4.56 | 1.11 | 4.39 | 2.17 | 5.15 |
| $T_9$ | 11.72 | 12.83 | 12.82 | 15.63 | 11.82 | 13.50 | 7.50 | 11.48 | 5.98 | 7.29 | 4.61 | 5.81 | 4.33 | 5.09 | 2.93 | 7.22 | 3.18 | 7.74 | 1.44 | 4.36 | 1.75 | 6.41 | 2.57 | 7.47 |
| $T_{10}$ | 10.45 | 13.48 | 12.41 | 16.54 | 11.87 | 15.54 | 6.94 | 13.88 | 5.97 | 10.87 | 4.63 | 9.71 | 3.78 | 8.41 | 3.50 | 6.72 | 2.77 | 8.43 | 2.20 | 6.75 | 1.06 | 5.83 | 2.23 | 7.56 |
| $T_{11}$ | 8.65 | 13.93 | 10.54 | 16.67 | 9.91 | 16.24 | 4.87 | 12.91 | 5.46 | 9.39 | 4.34 | 7.67 | 3.74 | 6.91 | 2.97 | 6.15 | 1.85 | 7.91 | 0.58 | 3.83 | 0.11 | 5.17 | 1.77 | 6.15 |
| $T_{12}$ | 10.57 | 11.44 | 12.39 | 14.72 | 10.96 | 14.07 | 7.65 | 11.04 | 6.44 | 9.74 | 5.19 | 8.26 | 4.54 | 6.94 | 4.05 | 4.92 | 3.17 | 6.74 | 1.49 | 5.65 | 1.64 | 5.42 | 2.83 | 6.12 |

$CD_{0.05}$ for:
Genotypes x Months x Treatments NS

$T_1$ Control (no application)
$T_2$ 100 % RDF + FYM
$T_3$ FYM + Biofertilizers
$T_4$ Vermicompost + Biofertilizers
$T_5$ 100 % RDF + FYM + Biofertilizers
$T_6$ 100 % RDF + Vermicompost + Biofertilizers
$T_7$ 75 % RDF + FYM + Biofertilizers
$T_8$ 75 % RDF + Vermicompost + Biofertilizers
$T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5%
$T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 %
$T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5%
$T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 %

**$G_1$ : Amenity type**
**$G_2$ : Agricultural type**

## 4.3 NUMBER OF MOWINGS REQUIRED

The data presented in Table 7 reveals that the number of required mowings depended upon the monthly increase in culm length.

During July, 2009, minimum number of mowings (four) were required in Amenity type when treated with $T_4$, while maximum number of mowings (seven) were required by Agricultural type when treated with $T_1$ to $T_{11}$.

During August, 2009, Amenity type required minimum number of mowings i.e. five when treated with $T_3$, however, Agricultural type required more number of mowings i.e. seven in all the treatments.

During September, 2009, minimum number of mowings required i.e. five were required by Amenity type when treated with $T_1$, $T_3$, $T_6$ and $T_{11}$, however, more number of mowings were required by Agricultural type (seven) with $T_1$ to $T_{12}$.

Minimum number of mowings were required by Amenity type (three) when treated with $T_1$, $T_3$ and $T_{11}$, however, Agricultural type required more number of mowings (seven) when treated with$T_1$, $T_4$, $T_7$, $T_8$, $T_{10}$ and $T_{11}$ during October, 2009.

During November, 2009, Amenity type required less number of mowings (three) when treated with all the treatments except $T_2$ and $T_{12}$, however, Agricultural type required more number of mowings (six) when treated with $T_{10}$.

During December, 2009, minimum number of mowings were required by Amenity type i.e. two when treated with $T_1$ and $T_3$ while Agricultural type required maximum number of mowings when treated with $T_4$ i.e. six.

Amenity type required less number of mowings i.e. two when treated with all the treatments except $T_2$, $T_9$ and $T_{12}$, however, Agricultural type required more number of mowings i.e. five when treated with $T_1$, $T_4$ and $T_{10}$ during January, 2010.

**Table 7. Effect of Integrated Nutrient Management treatments on monthly number of mowings required for two genotypes of *Lolium perenne* L. based on increase in culm length**

| **Year** | | **2009** | | | | | | | | | | | | **2010** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Months** | | **July** | | **Aug.** | | **Sept.** | | **Oct.** | | **Nov.** | | **Dec.** | | **Jan.** | | **Feb.** | | **Mar.** | | **Apr.** | | **May.** | | **June** | |
| **Treatments** | | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ |
| $T_1$ | Control (no application) | 5 | 7 | 6 | 7 | 5 | 7 | 3 | 7 | 3 | 5 | 2 | 5 | 2 | 5 | 2 | 4 | 1 | 4 | 1 | 3 | 1 | 4 | 1 | 4 |
| $T_2$ | 100 % RDF + FYM | 6 | 7 | 6 | 7 | 7 | 7 | 5 | 6 | 5 | 4 | 4 | 3 | 3 | 3 | 2 | 4 | 2 | 4 | 1 | 3 | 1 | 4 | 2 | 4 |
| $T_3$ | FYM + Biofertilizers | 4 | 7 | 5 | 7 | 5 | 7 | 3 | 6 | 3 | 4 | 2 | 4 | 2 | 3 | 2 | 3 | 1 | 4 | 1 | 3 | 1 | 4 | 1 | 4 |
| $T_4$ | Vermicompost + Biofertilizers | 6 | 7 | 6 | 7 | 6 | 7 | 4 | 7 | 3 | 7 | 3 | 6 | 2 | 5 | 2 | 5 | 1 | 5 | 1 | 4 | 1 | 5 | 2 | 7 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 5 | 7 | 6 | 7 | 6 | 7 | 4 | 6 | 3 | 4 | 3 | 3 | 2 | 4 | 2 | 3 | 2 | 4 | 1 | 3 | 1 | 3 | 2 | 4 |
| $T_6$ | 100 % RDF + Vermicopost + Biofertilizers | 5 | 6 | 6 | 7 | 5 | 7 | 5 | 5 | 3 | 4 | 3 | 3 | 2 | 3 | 2 | 4 | 2 | 4 | 1 | 3 | 1 | 3 | 2 | 3 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 6 | 7 | 6 | 7 | 6 | 7 | 4 | 7 | 3 | 5 | 3 | 5 | 2 | 4 | 2 | 4 | 2 | 5 | 1 | 3 | 1 | 3 | 2 | 3 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 5 | 7 | 6 | 7 | 6 | 7 | 3 | 7 | 4 | 5 | 3 | 4 | 2 | 4 | 2 | 5 | 2 | 4 | 1 | 3 | 1 | 3 | 2 | 3 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 6 | 7 | 6 | 7 | 6 | 7 | 4 | 6 | 3 | 4 | 3 | 3 | 3 | 3 | 2 | 4 | 2 | 4 | 1 | 3 | 1 | 4 | 2 | 4 |
| $T_{10}$ | Foliar application of N @ 0.5 % | 6 | 7 | 6 | 7 | 6 | 7 | 4 | 7 | 3 | 6 | 3 | 5 | 2 | 5 | 2 | 4 | 2 | 5 | 2 | 4 | 1 | 3 | 2 | 4 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 5 | 7 | 6 | 7 | 5 | 7 | 3 | 7 | 3 | 5 | 3 | 4 | 2 | 4 | 2 | 4 | 1 | 4 | 1 | 2 | 1 | 3 | 1 | 4 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 6 | 6 | 6 | 7 | 6 | 7 | 4 | 6 | 4 | 5 | 3 | 5 | 3 | 4 | 3 | 3 | 2 | 4 | 1 | 3 | 1 | 3 | 2 | 4 |

| **Increase in culm length (cm)** | **Number of mowings** |
|---|---|
| 0-2 | One mowings |
| 2-4 | Two mowings |
| 4-6 | Three mowings |
| 6-8 | Four mowings |
| 8-10 | Five mowings |
| 10-12 | Six mowings |
| 12 – 14 & > 14 | Seven mowings |

**$G_1$** = Amenity type
**$G_2$** = Agricultural Type

During February, 2010, Amenity type required less mowings i.e. two when treated with all the treatments except $T_{12}$, however, Agricultural type required more number of mowings i.e. five, when treated with $T_4$ and $T_{10}$.

During March, 2010, Amenity type required only one mowing when treated with $T_1$, $T_3$, $T_4$ and $T_5$, whereas , Agricultural type required five mowings with $T_4$, $T_7$ and $T_{10}$.

Minimum number of mowings were required by Amenity type (one), when treated with all the treatments except $T_{10}$, whereas, Agricultural type required four mowings when treated with $T_4$ and $T_{10}$ during April, 2010.

During May, 2010, Amenity type required minimum number of mowings i.e. one when treated with all the treatments, however, Agricultural type required four mowings when treated with $T_1$, $T_2$, $T_3$ and $T_9$.

During June, 2010, minimum number of mowings were required by Amenity type (one) when treated with $T_1$, $T_3$ and $T_{11}$, whereas, maximum number of mowings were required by Agricultural type i.e. seven when treated with $T_7$.

## 4.4 WEED POPULATION ($m^2$)

During the entire course of observations, the prominent weeds which were found growing in the experimental plots were *Cyperus rotundus, Capsella bursa-pastoris, Amaranthus viridis, Cynodon dactylon, Bidens pinosa, Trifolium repens, Chenopodium album, Digitaria sanguinalis, Euphorbia crusgalli, E. colonum, Gallinsoga parviflora, Solanum nigrum* etc.

Weed population has been presented in Table 8a,b,c and d. Perusal of data presented in Table 8a reveals that amongst the genotypes, less weed population was observed in plots where Agricultural type was grown (8.39 /$m^2$) while more weed population was recorded in plots where Amenity type was grown (10.30 /$m^2$). Amongst the treatments, minimum weed population (7.19 /$m^2$) was recorded when plots were treated with $T_6$, whereas, plots treated with $T_3$ resulted in maximum weed population (11.24 /$m^2$). Interaction, genotypes x treatments reveals that plots treated with $T_6$ in Agricultural type resulted in less weed population (6.94 /$m^2$) and was at par with $T_6$ in Amenity type, whereas, plots treated with $T_7$ in Amenity type resulted in more weed population (12.75/$m^2$).

**Table 8a. Effect of Integrated Nutrient Management treatments on weed population/$m^2$ of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|---|
| $T_1$ | Control (no application) | 8.47 | 8.64 | 8.56 |
| $T_2$ | 100 % RDF + FYM | 11.58 | 8.58 | 10.08 |
| $T_3$ | FYM + Biofertilizers | 12.00 | 10.47 | 11.24 |
| $T_4$ | Vermicompost + Biofertilizers | 10.64 | 8.25 | 9.44 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 10.83 | 7.67 | 9.25 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 7.44 | 6.94 | 7.19 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 12.75 | 7.83 | 10.29 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 9.00 | 7.83 | 8.42 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 10.61 | 8.53 | 9.57 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 10.06 | 8.08 | 9.07 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 10.00 | 8.86 | 9.43 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 10.17 | 8.94 | 9.56 |
| | Mean | 10.30 | 8.39 | 9.34 |

$CD_{0.05}$ for:

| | |
|---|---|
| Genotypes | 0.09 |
| Treatments | 0.21 |
| Genotypes x Treatments | 0.58 |

It is evident from Table 8b that minimum weed population (1.33 /$m^2$) was recorded during January, 2010, which was found to be statistically at par with December, 2009, whereas, maximum weed population (20.50 /$m^2$) was observed during August, 2009. Interaction, genotypes x months reveals that minimum weed population (1.08 /$m^2$) was recorded in Amenity type during November, 2009, which was statistically at par with December, 2009, January, 2010, February, 2010 and March, 2010, in Amenity type. Maximum weed population (33.58 /$m^2$) was observed in Amenity type during June, 2010.

**Table 8b. Effect of Integrated Nutrient Management treatments on weed population/$m^2$ of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Months | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|
| July, 2009 | 18.00 | 15.58 | 16.79 |
| August, 2009 | 21.78 | 19.22 | 20.50 |
| September, 2009 | 17.92 | 16.22 | 17.07 |
| October, 2009 | 9.89 | 8.56 | 9.22 |
| November, 2009 | 1.083 | 2.22 | 1.65 |
| December, 2009 | 1.11 | 1.75 | 1.43 |
| January, 2010 | 1.19 | 1.47 | 1.33 |
| February, 2010 | 1.33 | 3.11 | 2.22 |
| March, 2010 | 2.03 | 4.53 | 3.28 |
| April, 2010 | 3.39 | 2.78 | 3.08 |
| May, 2010 | 12.25 | 5.03 | 8.64 |
| June, 2010 | 33.58 | 20.17 | 26.88 |

$CD_{0.05}$ for:

| | |
|---|---|
| Months | 0.21 |
| Genotypes x Months | 0.29 |

Data presented in Table 8c reveals the interaction, treatments x months. Minimum weed population (1.00 /$m^2$) was recorded with $T_9$ during November, 2009, with $T_1$, $T_2$, $T_8$ $T_9$ and $T_{11}$ during December, 2009, and with $T_2$ and $T_{11}$ during January, 2010, which was found to be statistically at par with $T_2$, $T_6$, $T_7$, $T_{10}$, $T_{11}$ and $T_{12}$ during November, 2009, with $T_6$, $T_7$ and $T_{12}$ during December, 2009, with $T_1$, $T_5$, $T_6$, $T_8$, $T_9$, $T_{10}$ and $T_{12}$ during January, 2010, with $T_4$, $T_7$ and $T_8$ during February, 2010 and with $T_8$ during April, 2010. Maximum weed population (39.33 /$m^2$) was recorded when plots were treated with $T_7$ during June, 2010.

Table 8d presents the interaction, genotypes x months x treatments which reveals that minimum weed population (1.00 /$m^2$) was recorded in the plots treated with all the treatments except $T_4$ and $T_5$ in Amenity type and $T_9$ in Agricultural type during November, 2009, and with all the treatments except $T_3$, $T_4$, $T_5$ and $T_{10}$ in Amenity type and with $T_1$, $T_6$, $T_8$,

**Table 8c. Effect of Integrated Nutrient Management treatments on weed population/m$^2$ of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | 2010 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | Months | | | | | | | | | | | |
| | July | August | September | October | November | December | January | February | March | April | May | June |
| $T_1$ Control (no application) | 13.83 | 22.33 | 17.17 | 9.33 | 1.83 | 1.00 | 1.17 | 2.67 | 3.17 | 2.50 | 5.50 | 22.17 |
| $T_2$ 100 % RDF + FYM | 21.17 | 24.00 | 15.33 | 7.17 | 1.17 | 1.00 | 1.00 | 2.17 | 3.17 | 4.33 | 13.00 | 27.50 |
| $T_3$ FYM + Biofertilizers | 18.50 | 22.50 | 32.83 | 11.83 | 2.83 | 2.33 | 2.17 | 3.00 | 5.50 | 3.83 | 5.17 | 24.33 |
| $T_4$ Vermicompost + Biofertilizers | 15.83 | 19.50 | 16.50 | 7.33 | 2.50 | 2.00 | 2.00 | 1.67 | 2.00 | 2.50 | 9.33 | 32.17 |
| $T_5$ 100 % RDF + FYM + Biofertilizers | 17.33 | 20.83 | 15.00 | 9.83 | 2.00 | 1.83 | 1.67 | 2.00 | 3.17 | 3.50 | 11.83 | 22.00 |
| $T_6$ 100 % RDF + Vermicompost + Biofertilizers | 11.83 | 14.33 | 10.83 | 6.67 | 1.17 | 1.67 | 1.17 | 2.00 | 2.17 | 3.17 | 9.00 | 22.33 |
| $T_7$ 75 % RDF + FYM + Biofertilizers | 18.50 | 20.83 | 15.00 | 8.33 | 1.67 | 1.17 | 1.00 | 1.33 | 3.00 | 2.50 | 10.83 | 39.33 |
| $T_8$ 75 % RDF + Vermicompost + Biofertilizers | 18.00 | 20.50 | 14.00 | 9.17 | 1.83 | 1.00 | 1.17 | 1.67 | 2.67 | 1.33 | 4.83 | 24.83 |
| $T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 16.17 | 19.17 | 17.17 | 10.83 | 1.00 | 1.00 | 1.17 | 2.83 | 3.17 | 2.17 | 9.83 | 30.33 |
| $T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 % | 13.83 | 16.67 | 15.83 | 9.33 | 1.33 | 1.83 | 1.33 | 2.83 | 3.17 | 4.67 | 8.17 | 29.83 |
| $T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5% | 19.33 | 24.67 | 15.17 | 9.00 | 1.17 | 1.00 | 1.00 | 2.33 | 3.83 | 3.32 | 7.67 | 24.67 |
| $T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 17.17 | 20.67 | 20.00 | 11.83 | 1.33 | 1.33 | 1.17 | 2.17 | 4.33 | 3.17 | 8.50 | 23.00 |

$CD_{0.05}$ for:

Treatments x Months = 0.72

**Table 8d.** **Effect of Integrated Nutrient Management treatments on weed population/m$^2$ of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Months** | **July** | | **August** | | **September** | | **October** | | **November** | | **December** | | **January** | | **February** | | **March** | | **April** | | **May** | | **June** | |
| **Treatments** | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ |
| $T_1$ | 14.33 | 13.33 | 17.67 | 27.00 | 18.67 | 15.67 | 10.33 | 8.33 | 1.00 | 2.67 | 1.00 | 1.00 | 1.00 | 1.33 | 2.67 | 2.67 | 2.67 | 3.67 | 2.33 | 2.67 | 7.33 | 3.67 | 22.67 | 21.67 |
| $T_2$ | 24.00 | 18.33 | 26.33 | 21.67 | 13.00 | 17.67 | 6.67 | 7.67 | 1.00 | 1.33 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 3.33 | 1.00 | 5.33 | 5.67 | 3.00 | 21.33 | 4.67 | 37.00 | 18.00 |
| $T_3$ | 18.67 | 18.33 | 23.33 | 21.67 | 32.33 | 33.33 | 15.33 | 8.33 | 1.00 | 4.67 | 1.33 | 3.33 | 1.67 | 2.67 | 1.33 | 4.67 | 2.67 | 8.33 | 4.33 | 3.33 | 7.67 | 2.67 | 34.33 | 14.33 |
| $T_4$ | 15.33 | 16.33 | 20.33 | 18.67 | 21.67 | 11.33 | 9.00 | 5.67 | 1.67 | 3.33 | 1.33 | 2.67 | 1.67 | 2.33 | 1.67 | 1.67 | 1.33 | 2.67 | 2.67 | 2.33 | 13.33 | 5.33 | 37.67 | 26.67 |
| $T_5$ | 20.33 | 14.33 | 25.33 | 16.33 | 16.33 | 13.67 | 10.33 | 9.33 | 1.33 | 2.67 | 1.33 | 2.33 | 1.67 | 1.67 | 1.00 | 3.00 | 1.67 | 4.67 | 3.67 | 3.33 | 17.33 | 6.33 | 29.67 | 14.33 |
| $T_6$ | 9.33 | 14.33 | 11.00 | 17.67 | 9.67 | 12.00 | 6.67 | 6.67 | 1.00 | 1.33 | 1.00 | 2.33 | 1.00 | 1.33 | 1.00 | 3.00 | 1.00 | 3.33 | 3.67 | 2.67 | 13.67 | 4.33 | 30.33 | 14.33 |
| $T_7$ | 21.67 | 15.33 | 23.33 | 18.33 | 20.67 | 9.33 | 10.67 | 6.00 | 1.00 | 2.33 | 1.00 | 1.33 | 1.00 | 1.00 | 1.00 | 1.67 | 1.67 | 4.33 | 2.67 | 2.33 | 16.00 | 5.67 | 52.33 | 26.33 |
| $T_8$ | 17.33 | 18.67 | 20.67 | 20.33 | 16.33 | 11.67 | 8.00 | 10.33 | 1.00 | 2.67 | 1.00 | 1.00 | 1.00 | 1.33 | 1.33 | 2.00 | 1.67 | 3.67 | 1.33 | 1.33 | 6.33 | 3.33 | 32.00 | 17.67 |
| $T_9$ | 19.33 | 13.00 | 23.00 | 15.33 | 13.67 | 20.67 | 11.33 | 10.33 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.33 | 1.67 | 4.00 | 2.67 | 3.67 | 1.67 | 2.67 | 12.00 | 7.67 | 39.00 | 21.67 |
| $T_{10}$ | 18.33 | 9.33 | 21.67 | 11.67 | 16.33 | 15.33 | 10.33 | 8.33 | 1.00 | 1.67 | 1.33 | 2.33 | 1.33 | 1.33 | 1.33 | 4.33 | 3.33 | 3.00 | 4.00 | 5.33 | 10.33 | 6.00 | 31.33 | 28.33 |
| $T_{11}$ | 20.33 | 18.33 | 28.00 | 21.33 | 18.67 | 11.67 | 7.33 | 10.67 | 1.00 | 1.33 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 3.67 | 2.33 | 5.33 | 3.67 | 3.00 | 10.67 | 4.67 | 25.00 | 24.33 |
| $T_{12}$ | 17.00 | 17.33 | 20.67 | 20.67 | 17.67 | 22.33 | 12.67 | 11.00 | 1.00 | 1.67 | 1.00 | 1.67 | 1.00 | 1.33 | 1.00 | 3.33 | 2.33 | 6.33 | 5.00 | 1.33 | 11.00 | 6.00 | 31.67 | 14.33 |

$CD_{0.05}$ for:
Genotypes x Months x Treatments 1.02

| | | | |
|---|---|---|---|
| $T_1$ | Control (no application) | $T_7$ | 75 % RDF + FYM + Biofertilizers |
| $T_2$ | 100 % RDF + FYM | $T_8$ | 75 % RDF + Vermicompost + Biofertilizers |
| $T_3$ | FYM + Biofertilizers | $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% |
| $T_4$ | Vermicompost + Biofertilizers | $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % |

**$G_1$ : Amenity type**
**$G_2$ : Agricultural type**

$T_9$ and $T_{11}$ in Agricultural type during December, 2009 and with $T_1$, $T_2$, $T_6$, $T_7$, $T_8$, $T_9$, $T_{11}$ and $T_{12}$ in Amenity type and with $T_2$ and $T_{11}$ in Agricultural type during January, 2010 and with $T_2$, $T_5$, $T_6$, $T_7$, $T_{11}$ and $T_{12}$ in Amenity type during February, 2010, and with $T_2$ and $T_6$ in Amenity type during March, 2010. However, maximum weed population (52.33 /$m^2$) was recorded when plots were treated with $T_7$ in Amenity type during June, 2010.

## 4.5 TURF GROWTH ($cm^2$)

Turf growth has been presented in Table 9a,b,c and d. Perusal of data presented in Table 9a reveals that amongst the genotypes, more turf growth was recorded in plots where Amenity type was grown (3.75 $cm^2$) as compared to Agricultural type (3.31 $cm^2$). Amongst the treatments, $T_8$ was effective in producing maximum turf growth (4.03 $cm^2$), whereas, plots treated with $T_1$ resulted in minimum turf growth (2.66 $cm^2$). Interaction, genotypes x treatments

**Table 9a. Effect of Integrated Nutrient Management treatments on turf growth ($cm^2$) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|---|
| $T_1$ | Control (no application) | 2.96 | 2.37 | 2.66 |
| $T_2$ | 100 % RDF + FYM | 3.94 | 3.21 | 3.57 |
| $T_3$ | FYM + Biofertilizers | 3.43 | 3.21 | 3.32 |
| $T_4$ | Vermicompost + Biofertilizers | 3.41 | 3.07 | 3.24 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 4.17 | 3.68 | 3.92 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 4.07 | 3.80 | 3.93 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 4.10 | 3.62 | 3.86 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 4.52 | 3.54 | 4.03 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 3.50 | 3.05 | 3.27 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 3.85 | 3.48 | 3.67 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 3.45 | 3.30 | 3.38 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 3.64 | 3.34 | 3.49 |
| | Mean | 3.75 | 3.31 | 3.53 |

$CD_{0.05}$ for:

| | |
|---|---|
| Genotypes | 0.01 |
| Treatments | 0.03 |
| Genotypes x Treatments | 0.04 |

reveals that plots treated with $T_8$ in Amenity type resulted in more turf growth (4.52 $cm^2$), whereas, treatments with $T_1$ in Agricultural type resulted in minimum turf growth (2.37 $cm^2$).

Data pertaining to turf growth ($cm^2$) presented in Table 9b reveals that among the various months, maximum turf growth (5.17$cm^2$) was recorded during March, 2010, whereas, minimum turf growth (1.13 $cm^2$) was recorded during May, 2010. Interaction, genotypes x months reveals that maximum turf growth (5.56 $cm^2$) was recorded in the plots where Amenity type was grown during March, 2010, whereas, the plots in which Agricultural type was grown minimum turf growth (1.08 $cm^2$) was recorded during May, 2010.

**Table 9b. Effect of Integrated Nutrient Management on turf growth ($cm^2$) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Months | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|
| **July, 2009** | 2.50 | 2.31 | 2.40 |
| **August, 2009** | 4.40 | 3.06 | 3.73 |
| **September, 2009** | 3.71 | 3.21 | 3.46 |
| **October, 2009** | 3.13 | 3.44 | 3.28 |
| **November, 2009** | 2.82 | 3.45 | 3.14 |
| **December, 2009** | 3.03 | 2.87 | 2.95 |
| **January, 2010** | 3.30 | 2.66 | 2.98 |
| **February, 2010** | 5.21 | 4.42 | 4.81 |
| **March, 2010** | 5.56 | 4.78 | 5.17 |
| **April, 2010** | 4.85 | 3.82 | 4.33 |
| **May, 2010** | 1.17 | 1.08 | 1.13 |
| **June, 2010** | 5.36 | 4.58 | 4.97 |

$CD_{0.05}$ for:

| | |
|---|---|
| Months | 0.03 |
| Genotypes x Months | 0.04 |

Perusal of data presented in Table 9c reveals the interaction, treatments x months. Maximum turf growth (6.54 $cm^2$) was recorded when the plots were treated with $T_5$ during March, 2010, whereas, plots treated with $T_1$ resulted in minimum turf growth (0.46 $cm^2$) during May, 2010.

An inquisition of data in Table 9d shows the interaction, genotypes x months x treatments. Maximum turf growth (8.13 $cm^2$) was recorded in the plots where Amenity type was grown and treated with $T_5$ during March, 2010. Plots in

**Table 9c. Effect of Integrated Nutrient Management treatments on turf growth ($cm^2$) of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | 2010 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | Months | | | | | | | | | | | |
| | July | August | September | October | November | December | January | February | March | April | May | June |
| $T_1$ Control (no application) | 1.91 | 3.05 | 2.68 | 1.66 | 2.16 | 1.74 | 2.36 | 4.09 | 4.53 | 4.06 | 0.46 | 3.26 |
| $T_2$ 100 % RDF + FYM | 2.80 | 4.42 | 4.30 | 2.70 | 2.55 | 2.76 | 2.83 | 4.51 | 5.00 | 4.17 | 1.25 | 5.56 |
| $T_3$ FYM + Biofertilizers | 2.30 | 4.18 | 2.90 | 3.21 | 2.60 | 2.79 | 2.87 | 4.65 | 4.24 | 4.63 | 1.20 | 4.29 |
| $T_4$ Vermicompost + Biofertilizers | 2.25 | 3.39 | 3.85 | 2.40 | 2.26 | 3.56 | 2.85 | 4.45 | 4.68 | 4.17 | 0.99 | 4.04 |
| $T_5$ 100 % RDF + FYM + Biofertilizers | 2.85 | 3.40 | 3.67 | 5.09 | 3.68 | 2.35 | 3.05 | 5.26 | 6.54 | 4.69 | 0.97 | 5.53 |
| $T_6$ 100 % RDF + Vermicompost + Biofertilizers | 2.62 | 4.65 | 3.42 | 2.85 | 3.67 | 3.38 | 3.61 | 5.69 | 5.25 | 5.00 | 0.84 | 6.18 |
| $T_7$ 75 % RDF + FYM + Biofertilizers | 2.65 | 3.24 | 4.77 | 4.14 | 3.12 | 2.40 | 3.45 | 5.41 | 5.22 | 5.05 | 1.05 | 5.80 |
| $T_8$ 75 % RDF + Vermicompost + Biofertilizers | 2.70 | 3.94 | 4.27 | 3.51 | 4.43 | 4.07 | 3.64 | 5.12 | 4.57 | 4.85 | 1.56 | 5.73 |
| $T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 2.18 | 2.65 | 2.76 | 3.01 | 2.80 | 2.65 | 2.60 | 4.49 | 5.53 | 4.40 | 1.39 | 4.82 |
| $T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 % | 2.18 | 3.52 | 2.42 | 3.55 | 4.07 | 4.43 | 2.57 | 5.60 | 5.48 | 4.11 | 1.08 | 5.00 |
| $T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5% | 2.26 | 4.59 | 3.68 | 3.97 | 2.70 | 2.68 | 2.57 | 3.85 | 4.90 | 2.93 | 1.71 | 4.69 |
| $T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 2.12 | 3.73 | 2.82 | 3.32 | 3.62 | 2.61 | 3.37 | 4.60 | 6.09 | 3.96 | 1.01 | 4.70 |

$CD_{0.05}$ for:

Treatments x Months = 0.09

**Table 9d. Effect of Integrated Nutrient Management treatments on turf growth ($cm^2$) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | July | | August | | September | | October | | November | | December | | January | | February | | March | | April | | May | | June | |
| Treatments | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ |
| $T_1$ | 2.05 | 1.78 | 4.16 | 1.94 | 2.98 | 2.37 | 1.96 | 1.35 | 1.96 | 2.37 | 1.97 | 1.50 | 2.72 | 2.00 | 3.94 | 4.24 | 5.18 | 3.88 | 4.54 | 3.58 | 0.66 | 0.26 | 3.34 | 3.17 |
| $T_2$ | 2.86 | 2.74 | 5.37 | 3.47 | 5.53 | 3.07 | 2.48 | 2.92 | 2.02 | 3.08 | 2.37 | 3.16 | 3.39 | 2.26 | 5.44 | 3.58 | 5.74 | 4.26 | 5.03 | 3.30 | 1.06 | 1.44 | 5.94 | 5.18 |
| $T_3$ | 2.45 | 2.15 | 5.23 | 3.13 | 2.46 | 3.33 | 2.83 | 3.58 | 2.01 | 3.19 | 2.70 | 2.88 | 3.11 | 2.62 | 5.13 | 4.18 | 4.14 | 4.33 | 5.63 | 3.64 | 0.96 | 1.43 | 4.50 | 4.07 |
| $T_4$ | 2.37 | 2.14 | 4.50 | 2.27 | 3.53 | 4.16 | 2.17 | 2.64 | 2.05 | 2.46 | 2.94 | 4.18 | 3.12 | 2.58 | 4.55 | 4.35 | 5.38 | 3.97 | 4.68 | 3.66 | 1.43 | 0.54 | 4.15 | 3.93 |
| $T_5$ | 3.03 | 2.68 | 4.03 | 2.77 | 4.15 | 3.18 | 3.45 | 6.74 | 3.91 | 3.45 | 2.84 | 1.86 | 3.23 | 2.86 | 4.95 | 5.58 | 8.13 | 4.95 | 5.14 | 4.24 | 1.16 | 0.77 | 6.03 | 5.04 |
| $T_6$ | 2.77 | 2.47 | 4.47 | 4.84 | 4.37 | 2.48 | 2.45 | 3.25 | 3.21 | 4.12 | 3.83 | 2.93 | 4.13 | 3.08 | 6.23 | 5.15 | 5.14 | 5.36 | 5.15 | 4.86 | 0.53 | 1.16 | 6.50 | 5.86 |
| $T_7$ | 2.88 | 2.43 | 3.60 | 2.87 | 4.26 | 5.28 | 4.44 | 3.84 | 3.53 | 2.71 | 2.55 | 2.26 | 3.85 | 3.05 | 5.53 | 5.28 | 5.51 | 4.93 | 5.76 | 4.34 | 0.87 | 1.24 | 6.44 | 5.16 |
| $T_8$ | 2.92 | 2.48 | 5.37 | 2.50 | 4.37 | 4.16 | 5.08 | 1.94 | 3.62 | 5.23 | 4.07 | 4.07 | 3.95 | 3.33 | 6.38 | 3.85 | 4.88 | 4.26 | 5.45 | 4.25 | 1.68 | 1.45 | 6.47 | 4.98 |
| $T_9$ | 2.13 | 2.23 | 3.26 | 2.04 | 2.54 | 2.97 | 2.86 | 3.16 | 2.05 | 3.55 | 3.23 | 2.06 | 2.75 | 2.45 | 5.64 | 3.34 | 6.88 | 4.18 | 4.13 | 4.66 | 1.13 | 1.66 | 5.36 | 4.28 |
| $T_{10}$ | 2.13 | 2.23 | 3.41 | 3.63 | 3.26 | 1.58 | 3.56 | 3.53 | 2.81 | 5.33 | 4.68 | 4.18 | 2.77 | 2.37 | 5.36 | 5.84 | 5.88 | 5.08 | 5.13 | 3.08 | 1.88 | 0.28 | 5.36 | 4.64 |
| $T_{11}$ | 2.28 | 2.23 | 4.73 | 4.45 | 3.98 | 3.38 | 2.33 | 5.61 | 3.06 | 2.35 | 3.08 | 2.28 | 2.67 | 2.46 | 4.56 | 3.14 | 4.45 | 5.35 | 3.5 | 2.35 | 1.76 | 1.65 | 5.03 | 4.36 |
| $T_{12}$ | 2.07 | 2.16 | 4.68 | 2.77 | 3.07 | 2.56 | 3.93 | 2.70 | 3.67 | 3.56 | 2.08 | 3.13 | 3.85 | 2.89 | 4.74 | 4.45 | 5.43 | 6.76 | 4.08 | 3.84 | 0.96 | 1.06 | 5.15 | 4.24 |

$CD_{0.05}$ for:
Genotypes x Months x Treatments 0.13

$T_1$ Control (no application)
$T_2$ 100 % RDF + FYM
$T_3$ FYM + Biofertilizers
$T_4$ Vermicompost + Biofertilizers
$T_5$ 100 % RDF + FYM + Biofertilizers
$T_6$ 100 % RDF + Vermicompost + Biofertilizers
$T_7$ 75 % RDF + FYM + Biofertilizers
$T_8$ 75 % RDF + Vermicompost + Biofertilizers
$T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5%
$T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 %
$T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5%
$T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 %

**$G_1$ : Amenity type**
**$G_2$ : Agricultural type**

which Agricultural type was grown and treated with treatment $T_1$ resulted in minimum turf growth (0.26 $cm^2$) during May, 2010, which was statistically at par with $T_{10}$ in Agricultural type during May, 2010.

## 4.6 VISUAL QUALITY RATING

### a) Aesthetic appearance

Aesthetic appearance has been presented in Table 10a, b, c and d. Perusal of data presented in Table 10a reveals that higher score for aesthetic appearance (4.54) was obtained by Amenity type as compared to Agricultural type (3.84). Amongst the treatments, maximum score for aesthetic appearance (4.39) was obtained when the plots were treated with $T_4$ which was found to be statistically

**Table 10a. Effect of Integrated Nutrient Management treatments on aesthetic appearance* of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|---|
| $T_1$ | Control (no application) | 3.69 | 3.15 | 3.42 |
| $T_2$ | 100 % RDF + FYM | 4.56 | 3.80 | 4.18 |
| $T_3$ | FYM + Biofertilizers | 4.48 | 4.04 | 4.26 |
| $T_4$ | Vermicompost + Biofertilizers | 4.70 | 4.09 | 4.39 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 4.61 | 3.85 | 4.23 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 4.79 | 3.90 | 4.35 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 4.48 | 3.81 | 4.15 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 4.63 | 3.86 | 4.24 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 4.52 | 3.90 | 4.21 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 4.64 | 3.92 | 4.28 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 4.54 | 3.89 | 4.21 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 4.83 | 3.82 | 4.33 |
| | Mean | 4.54 | 3.84 | 4.19 |

*Rated on a scale of 1 to 5, 5= maximum

$CD_{0.05}$ for:

| | |
|---|---|
| Genotypes | 0.05 |
| Treatments | 0.12 |
| Genotypes x Treatments | 0.17 |

at par with $T_6$ and $T_9$, however, minimum score for aesthetic appearance (3.42) was obtained in plots treated with $T_1$. Interaction, genotypes x treatments reveals that maximum score for aesthetic appearance (4.83) was obtained by Amenity type when it was treated with $T_{12}$ which was at par with $T_6$ and $T_4$. Minimum score (3.15) was recorded when plots were treated with $T_1$ in Agricultural type.

It is evident from Table 10b that maximum score for aesthetic appearance (4.69) was obtained during March, 2010, which was found to be statistically at par with April, 2010, and December, 2009, whereas, minimum score for aesthetic appearance (3.51) was recorded during September, 2009. Interaction, genotypes x months reveals that Amenity type obtained maximum score for aesthetic appearance (4.96) during December, 2009, which was statistically at par with March, 2010, April, 2010, February, 2010 and November, 2009. Minimum score (3.03) was recorded in Agricultural type during September, 2009, which was at par with Agricultural type during August, 2009.

Non-significant results were obtained for interaction, treatments x months (Table 10c) and interaction, genotypes x months x treatments (Table 10d) (Appendix-II).

**Table 10 b. Effect of Integrated Nutrient Management treatments on the aesthetic appearance* of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Months | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|
| July, 2009 | 4.26 | 3.40 | 3.83 |
| August, 2009 | 4.27 | 3.19 | 3.73 |
| September, 2009 | 4.00 | 3.03 | 3.51 |
| October, 2009 | 4.42 | 4.01 | 4.21 |
| November, 2009 | 4.80 | 4.19 | 4.50 |
| December, 2009 | 4.96 | 4.36 | 4.66 |
| January, 2010 | 4.64 | 3.99 | 4.32 |
| February, 2010 | 4.79 | 4.04 | 4.41 |
| March, 2010 | 4.94 | 4.44 | 4.69 |
| April, 2010 | 4.90 | 4.44 | 4.67 |
| May, 2010 | 4.26 | 3.50 | 3.88 |
| June, 2010 | 4.24 | 3.42 | 3.83 |

*Rated on a scale of 1 to 5, 5= maximum

$CD_{0.05}$ for:

| | |
|---|---|
| Months | 0.12 |
| Genotypes x Months | 0.17 |

**Table 10c Effect of Integrated Nutrient Management treatments on aesthetic appearance* of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | 2010 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | Months | | | | | | | | | | | |
| | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb | March | April | May | June |
| $T_1$ Control (no application) | 3.33 | 2.96 | 2.67 | 3.25 | 3.79 | 4.17 | 3.29 | 3.58 | 4.00 | 4.00 | 3.00 | 3.00 |
| $T_2$ 100 % RDF + FYM | 3.79 | 3.71 | 3.46 | 4.29 | 4.56 | 4.63 | 4.42 | 4.46 | 4.67 | 4.67 | 3.75 | 3.77 |
| $T_3$ FYM + Biofertilizers | 4.08 | 4.19 | 3.5 | 4.13 | 4.42 | 4.71 | 4.38 | 4.46 | 4.67 | 4.71 | 3.92 | 4.00 |
| $T_4$ Vermicompost + Biofertilizers | 4.08 | 4.00 | 3.75 | 4.42 | 4.65 | 4.75 | 4.46 | 4.63 | 5.00 | 4.83 | 4.08 | 4.08 |
| $T_5$ 100 % RDF + FYM + Biofertilizers | 3.67 | 3.77 | 3.54 | 4.38 | 4.61 | 4.71 | 4.50 | 4.50 | 4.67 | 4.71 | 3.92 | 3.79 |
| $T_6$ 100 % RDF + Vermicompost + Biofertilizers | 3.92 | 3.88 | 3.75 | 4.38 | 4.63 | 4.71 | 4.50 | 4.58 | 4.83 | 4.79 | 4.25 | 3.94 |
| $T_7$ 75 % RDF + FYM + Biofertilizers | 3.75 | 3.44 | 3.42 | 4.17 | 4.42 | 4.58 | 4.25 | 4.38 | 4.83 | 4.79 | 3.92 | 3.83 |
| $T_8$ 75 % RDF + Vermicompost + Biofertilizers | 3.83 | 3.58 | 3.38 | 4.38 | 4.59 | 4.67 | 4.42 | 4.50 | 4.83 | 4.77 | 4.04 | 3.94 |
| $T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 3.92 | 3.75 | 3.58 | 4.29 | 4.48 | 4.63 | 4.42 | 4.46 | 4.67 | 4.67 | 3.83 | 3.88 |
| $T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 % | 3.83 | 3.90 | 3.67 | 4.21 | 4.56 | 4.79 | 4.29 | 4.42 | 4.83 | 4.79 | 4.08 | 3.96 |
| $T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5% | 3.79 | 3.58 | 3.5 | 4.29 | 4.63 | 4.79 | 4.38 | 4.46 | 4.67 | 4.71 | 3.92 | 3.86 |
| $T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 4.00 | 4.00 | 3.96 | 4.42 | 4.65 | 4.79 | 4.50 | 4.50 | 4.67 | 4.65 | 3.88 | 3.94 |

*Rated on a scale of 1 to 5, 5= maximum

$CD_{0.05}$ for:

Treatments x Months = NS

**Table 10d. Effect of Integrated Nutrient Management treatments on aesthetic appearance* of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Months** | **July** | | **August** | | **September** | | **October** | | **November** | | **December** | | **January** | | **February** | | **March** | | **April** | | **May** | | **June** | |
| **Treatments** | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ |
| $T_1$ | 3.58 | 3.08 | 3.34 | 2.58 | 2.92 | 2.42 | 3.08 | 3.42 | 3.92 | 3.67 | 4.50 | 3.83 | 3.50 | 3.08 | 4.00 | 3.17 | 4.33 | 3.67 | 4.33 | 3.67 | 3.33 | 2.67 | 3.46 | 2.54 |
| $T_2$ | 4.25 | 3.33 | 4.25 | 3.17 | 3.83 | 3.08 | 4.58 | 4.00 | 5.00 | 4.13 | 5.00 | 4.25 | 4.83 | 4.00 | 4.92 | 4.00 | 5.00 | 4.33 | 4.92 | 4.42 | 4.00 | 3.50 | 4.13 | 3.42 |
| $T_3$ | 4.50 | 3.67 | 4.46 | 3.92 | 3.67 | 3.33 | 4.17 | 4.08 | 4.58 | 4.25 | 5.00 | 4.42 | 4.58 | 4.17 | 4.67 | 4.25 | 5.00 | 4.33 | 4.92 | 4.50 | 4.00 | 3.83 | 4.25 | 3.75 |
| $T_4$ | 4.67 | 3.5 | 4.33 | 3.67 | 4.17 | 3.33 | 4.58 | 4.25 | 4.92 | 4.38 | 5.00 | 4.50 | 4.75 | 4.17 | 5.00 | 4.25 | 5.00 | 5.00 | 4.92 | 4.75 | 4.50 | 3.67 | 4.58 | 3.58 |
| $T_5$ | 4.0 | 3.33 | 4.25 | 3.29 | 3.83 | 3.25 | 4.75 | 4.00 | 5.00 | 4.21 | 5.00 | 4.42 | 5.00 | 4.00 | 5.00 | 4.00 | 5.00 | 4.33 | 5.00 | 4.42 | 4.33 | 3.50 | 4.17 | 3.42 |
| $T_6$ | 4.50 | 3.33 | 4.67 | 3.08 | 4.50 | 3.00 | 4.67 | 4.08 | 5.00 | 4.25 | 4.92 | 4.42 | 4.92 | 4.08 | 5.00 | 4.17 | 5.00 | 4.67 | 5.00 | 4.58 | 4.83 | 3.67 | 4.38 | 3.50 |
| $T_7$ | 4.0 | 3.50 | 4.04 | 2.83 | 3.92 | 2.92 | 4.33 | 4.00 | 4.75 | 4.09 | 5.00 | 4.17 | 4.50 | 4.00 | 4.75 | 4.00 | 5.00 | 4.67 | 5.00 | 4.58 | 4.33 | 3.50 | 4.17 | 3.50 |
| $T_8$ | 4.33 | 3.33 | 4.17 | 3.00 | 3.75 | 3.00 | 4.75 | 4.00 | 5.00 | 4.17 | 5.00 | 4.33 | 4.83 | 4.00 | 5.00 | 4.00 | 5.00 | 4.67 | 4.96 | 4.58 | 4.42 | 3.67 | 4.38 | 3.50 |
| $T_9$ | 4.33 | 3.50 | 4.33 | 3.17 | 4.25 | 2.92 | 4.33 | 4.25 | 4.71 | 4.25 | 5.00 | 4.25 | 4.50 | 4.33 | 4.50 | 4.42 | 5.00 | 4.33 | 4.92 | 4.42 | 4.17 | 3.50 | 4.25 | 3.50 |
| $T_{10}$ | 4.33 | 3.33 | 4.54 | 3.25 | 4.33 | 3.00 | 4.33 | 4.08 | 4.79 | 4.33 | 5.00 | 4.58 | 4.50 | 4.08 | 4.67 | 4.17 | 5.00 | 4.67 | 5.00 | 4.58 | 4.67 | 3.50 | 4.50 | 3.42 |
| $T_{11}$ | 4.00 | 3.58 | 4.08 | 3.08 | 4.00 | 3.00 | 4.58 | 4.00 | 4.96 | 4.30 | 5.00 | 4.58 | 4.75 | 4.00 | 4.92 | 4.00 | 5.00 | 4.33 | 4.92 | 4.50 | 4.17 | 3.67 | 4.08 | 3.63 |
| $T_{12}$ | 4.67 | 3.33 | 4.75 | 3.25 | 4.83 | 3.08 | 4.83 | 4.00 | 5.00 | 4.30 | 5.00 | 4.58 | 5.00 | 4.00 | 5.00 | 4.00 | 5.00 | 4.33 | 4.96 | 4.33 | 4.42 | 3.33 | 4.54 | 3.33 |

*Rated on a scale of 1 to 5, 5= maximum

$CD_{0.05}$ for:
Genotypes x Months x Treatments = NS

$T_1$ Control (no application)
$T_2$ 100 % RDF + FYM
$T_3$ FYM + Biofertilizers
$T_4$ Vermicompost + Biofertilizers
$T_5$ 100 % RDF + FYM + Biofertilizers
$T_6$ 100 % RDF + Vermicompost + Biofertilizers
$T_7$ 75 % RDF + FYM + Biofertilizers
$T_8$ 75 % RDF + Vermicompost + Biofertilizers
$T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5%
$T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 %
$T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5%
$T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 %

**$G_1$ : Amenity type**
**$G_2$ : Agricultural type**

### b) Turf colour

Turf colour has been presented in Table 11 a,b,c and d.

It was evident from Table 11a that higher score for turf colour (4.48) was obtained by Amenity type as compared to Agricultural type (4.34). Amongst the treatments, maximum score for turf colour (4.59) was obtained when the plots were treated with $T_6$ which was found to be statistically at par with $T_4$, $T_3$, $T_{12}$ and $T_{10}$, whereas, minimum score for turf colour (3.72) was obtained in plots treated with $T_1$. Interaction, genotypes x treatments reveals that when Amenity type was treated with $T_6$ maximum score for turf colour (4.75) was recorded which was statistically at par with $T_{10}$, $T_{12}$, $T_4$ and $T_3$, whereas, minimum (3.60) was recorded with $T_1$ in Agricultural type.

**Table 11a. Effect of Integrated Nutrient Management treatments on turf colour* of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|---|
| $T_1$ | Control (no application) | 3.84 | 3.60 | 3.72 |
| $T_2$ | 100 % RDF + FYM | 4.43 | 4.30 | 4.37 |
| $T_3$ | FYM + Biofertilizers | 4.58 | 4.52 | 4.55 |
| $T_4$ | Vermicompost + Biofertilizers | 4.59 | 4.56 | 4.58 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 4.52 | 4.29 | 4.41 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 4.75 | 4.43 | 4.59 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 4.41 | 4.44 | 4.43 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 4.42 | 4.43 | 4.43 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 4.50 | 4.37 | 4.43 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 4.68 | 4.34 | 4.51 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 4.42 | 4.34 | 4.38 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 4.63 | 4.43 | 4.53 |
| | Mean | 4.48 | 4.34 | 4.41 |

*Rated on a scale of 1 to 5, 5= best colour

$CD_{0.05}$ for:

| | |
|---|---|
| Genotypes | 0.05 |
| Treatments | 0.12 |
| Genotypes x Treatments | 0.17 |

Data presented in Table 11b reveals that amongst the months, maximum score for turf colour (4.97) was obtained during July, 2009, while minimum score for turf colour (3.68) was observed during May, 2010. Interaction, genotypes x months reveals that maximum score for turf colour (4.98) was obtained by Amenity type during July, 2009, and March, 2010 and was at par with Agricultural type during July, 2009. Minimum score (3.55) was recorded in Agricultural type during October, 2009, which was at par with May, 2010, in both the genotypes. Interaction, treatments x months (Table 11c) and interaction, genotypes x months x treatments (Table 11d) were found to be non-significant (Appendix-II).

**Table 11b. Effect of Integrated Nutrient Management treatments on turf colour of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Months | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|
| July, 2009 | 4.98 | 4.96 | 4.97 |
| August, 2009 | 4.73 | 4.71 | 4.72 |
| September, 2009 | 4.51 | 4.46 | 4.48 |
| October, 2009 | 4.21 | 3.55 | 3.88 |
| November, 2009 | 4.72 | 4.35 | 4.54 |
| December, 2009 | 4.38 | 4.16 | 4.27 |
| January, 2010 | 4.38 | 4.15 | 4.26 |
| February, 2010 | 4.53 | 4.37 | 4.45 |
| March, 2010 | 4.81 | 4.69 | 4.75 |
| April, 2010 | 4.62 | 4.65 | 4.64 |
| May, 2010 | 3.67 | 3.69 | 3.68 |
| June, 2010 | 4.24 | 4.32 | 4.28 |

*Rated on a scale of 1 to 5, 5= best colour

$CD_{0.05}$ for:

| | |
|---|---|
| Months | 0.12 |
| Genotypes x Months | 0.17 |

**Table 11c Effect of Integrated Nutrient Management treatments on turf colour* of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | | 2009 | | | | | | 2010 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | | Months | | | | | | | | | | | |
| | | July | August | September | October | November | December | January | February | March | April | May | June |
| $T_1$ | Control (no application) | 4.63 | 4.38 | 4.08 | 2.96 | 3.78 | 3.67 | 3.33 | 3.54 | 4.08 | 4.00 | 2.75 | 3.46 |
| $T_2$ | 100 % RDF + FYM | 5.00 | 4.75 | 4.50 | 3.54 | 4.37 | 4.25 | 4.29 | 4.50 | 4.67 | 4.67 | 3.71 | 4.17 |
| $T_3$ | FYM + Biofertilizers | 5.00 | 4.75 | 4.50 | 3.92 | 4.63 | 4.46 | 4.46 | 4.63 | 4.83 | 4.79 | 4.08 | 4.54 |
| $T_4$ | Vermicompost + Biofertilizers | 5.00 | 4.75 | 4.50 | 4.40 | 4.89 | 4.46 | 4.54 | 4.67 | 4.92 | 4.67 | 3.75 | 4.38 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 5.00 | 4.75 | 4.58 | 4.25 | 4.71 | 4.33 | 4.42 | 4.58 | 4.67 | 4.33 | 3.17 | 4.08 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 5.00 | 4.75 | 4.58 | 4.21 | 4.73 | 4.38 | 4.33 | 4.67 | 4.92 | 4.83 | 4.25 | 4.46 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 5.00 | 4.75 | 4.54 | 3.65 | 4.39 | 4.13 | 4.08 | 4.38 | 4.92 | 4.79 | 4.00 | 4.50 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 5.00 | 4.75 | 4.50 | 3.67 | 4.48 | 4.33 | 4.42 | 4.67 | 4.75 | 4.67 | 3.58 | 4.29 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 5.00 | 4.75 | 4.50 | 3.92 | 4.59 | 4.29 | 4.25 | 4.38 | 4.83 | 4.67 | 3.67 | 4.33 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 5.00 | 4.75 | 4.50 | 4.00 | 4.63 | 4.33 | 4.29 | 4.38 | 4.92 | 4.83 | 4.00 | 4.50 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 5.00 | 4.75 | 4.50 | 3.75 | 4.50 | 4.25 | 4.29 | 4.50 | 4.67 | 4.58 | 3.50 | 4.25 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 5.00 | 4.75 | 4.50 | 4.29 | 4.75 | 4.38 | 4.42 | 4.50 | 4.83 | 4.79 | 3.75 | 4.38 |

*Rated on a scale of 1 to 5, 5= best colour

$CD_{0.05}$ for:

Treatments x Months = NS

**Table 11d. Effect of Integrated Nutrient Management treatments on turf colour* of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Months** | **July** | | **August** | | **September** | | **October** | | **November** | | **December** | | **January** | | **February** | | **March** | | **April** | | **May** | | **June** | |
| **Treatments** | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ |
| $T_1$ | 4.75 | 4.50 | 4.50 | 4.25 | 4.17 | 4.00 | 3.08 | 2.83 | 3.92 | 3.65 | 3.75 | 3.58 | 3.50 | 3.17 | 3.75 | 3.33 | 4.33 | 3.83 | 4.08 | 3.92 | 2.83 | 2.67 | 3.42 | 3.50 |
| $T_2$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.50 | 4.50 | 3.96 | 3.13 | 4.63 | 4.11 | 4.42 | 4.08 | 4.50 | 4.08 | 4.67 | 4.33 | 4.67 | 4.67 | 4.5 | 4.83 | 3.58 | 3.83 | 4.00 | 4.33 |
| $T_3$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.50 | 4.50 | 4.08 | 3.75 | 4.79 | 4.46 | 4.75 | 4.17 | 4.67 | 4.25 | 4.75 | 4.50 | 5.00 | 4.67 | 4.67 | 4.92 | 3.67 | 4.50 | 4.33 | 4.75 |
| $T_4$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.50 | 4.50 | 4.42 | 4.38 | 4.92 | 4.86 | 4.50 | 4.42 | 4.58 | 4.50 | 4.67 | 4.67 | 4.83 | 5.00 | 4.67 | 4.67 | 3.83 | 3.67 | 4.42 | 4.33 |
| $T_5$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.67 | 4.50 | 4.67 | 3.83 | 4.92 | 4.50 | 4.50 | 4.17 | 4.58 | 4.25 | 4.67 | 4.50 | 4.67 | 4.67 | 4.33 | 4.33 | 3.33 | 3.00 | 4.17 | 4.00 |
| $T_6$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.67 | 4.50 | 4.58 | 3.83 | 4.92 | 4.54 | 4.58 | 4.17 | 4.50 | 4.17 | 4.83 | 4.50 | 4.83 | 5.00 | 5.00 | 4.67 | 4.83 | 3.67 | 4.50 | 4.42 |
| $T_7$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.58 | 4.50 | 3.92 | 3.38 | 4.54 | 4.23 | 4.17 | 4.08 | 4.08 | 4.08 | 4.25 | 4.50 | 5.00 | 4.83 | 4.67 | 4.92 | 3.67 | 4.33 | 4.33 | 4.67 |
| $T_8$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.50 | 4.50 | 3.83 | 3.50 | 4.59 | 4.38 | 4.42 | 4.25 | 4.50 | 4.33 | 4.67 | 4.67 | 4.67 | 4.83 | 4.58 | 4.75 | 3.33 | 3.83 | 4.17 | 4.42 |
| $T_9$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.50 | 4.50 | 4.33 | 3.50 | 4.79 | 4.38 | 4.33 | 4.25 | 4.25 | 4.25 | 4.33 | 4.42 | 5.00 | 4.67 | 4.67 | 4.67 | 3.67 | 3.67 | 4.33 | 4.33 |
| $T_{10}$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.50 | 4.50 | 4.67 | 3.33 | 4.92 | 4.34 | 4.33 | 4.33 | 4.33 | 4.25 | 4.42 | 4.33 | 5.00 | 4.83 | 5.00 | 4.67 | 4.50 | 3.50 | 4.75 | 4.25 |
| $T_{11}$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.50 | 4.50 | 4.25 | 3.25 | 4.79 | 4.21 | 4.33 | 4.17 | 4.42 | 4.17 | 4.67 | 4.33 | 4.67 | 4.67 | 4.42 | 4.75 | 3.17 | 3.83 | 4.08 | 4.42 |
| $T_{12}$ | 5.00 | 5.00 | 4.75 | 4.75 | 4.50 | 4.50 | 4.75 | 3.83 | 4.96 | 4.54 | 4.50 | 4.25 | 4.58 | 4.25 | 4.67 | 4.33 | 5.00 | 4.67 | 4.83 | 4.75 | 3.67 | 3.83 | 4.33 | 4.42 |

*Rated on a scale of 1 to 5, 5= best colour

$CD_{0.05}$ for:
Genotypes x Months x Treatments NS

$T_1$ Control (no application)
$T_2$ 100 % RDF + FYM
$T_3$ FYM + Biofertilizers
$T_4$ Vermicompost + Biofertilizers
$T_5$ 100 % RDF + FYM + Biofertilizers
$T_6$ 100 % RDF + Vermicompost + Biofertilizers
$T_7$ 75 % RDF + FYM + Biofertilizers
$T_8$ 75 % RDF + Vermicompost + Biofertilizers
$T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5%
$T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 %
$T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5%
$T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 %

**$G_1$ : Amenity type**
**$G_2$ : Agricultural type**

## 4.7 TURF COLOUR (R.H.S.)

Distinct colour variations were exhibited by the genotypes during different times of the year. These colour variations have been presented in Table 12a, b, c and d.

During July to September, 2009, the genotypes exhibited colours ranging between Green group (137-A-B to 143-A-B). However, during, October, 2009 to January, 2010 and April, 2010 to June, 2010, the colours exhibited by the genotypes varied between Greyed Yellow (161-A-C), Yellow (13-A-C), Greyed Brown (199-C) and Greyed Orange (164-A-B) group. During February, 2010 and March, 2010, the genotypes exhibited colours ranging between Green group-137-A to Yellow Green group-146-A.

## 4.8 LEAF BLADE TEXTURE

Texture of the leaf blade of the two genotypes during July, 2009 to June, 2010 has been presented in Table 13 which shows that Amenity type had very fine texture while Agricultural type had fine texture.

## 4.9 MULTIPLICATION RATE

It is evident from the Table 14 that more propagules (123.86) were formed in Amenity type, as compared to Agricultural type (93.22). Treatment $T_6$ resulted in maximum number of propagules (119.26) and was at par with $T_{12}$ and $T_{10,}$ whereas, $T_1$ resulted in minimum number of propagules (81.79), amongst the treatments. Interaction, genotypes x treatments reveals that maximum number of propagules (143.03) were achieved when Amenity type was treated with $T_9$ which was found to be statistically at par with $T_{12}$, $T_6$ and $T_2$, while, minimum number of propagules (69.37) were recorded when Agricultural type was treated with $T_1$.

**Table 12a. Effect of Integrated Nutrient Management treatments on turf colour of two genotypes of *Lolium perenne* L. in different months of the year**

| Year | July, 2009 | | August, 2009 | | September, 2009 | |
|---|---|---|---|---|---|---|
| **Treatments** | **Amenity type** | **Agricultural type** | **Amenity type** | **Agricultural type** | **Amenity type** | **Agricultural type** |
| $T_1$ Control (no application) | Green gp-137-B | Green gp-143 -A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143- B |
| $T_2$ 100 % RDF + FYM | Green gp-137-B | Green gp-143- A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_3$ FYM + Biofertilizers | Green gp-137-B | Green gp-143 -A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_4$ Vermicompost + Biofertilizers | Green gp-137-B | Green gp-143- A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_5$ 100 % RDF + FYM + Biofertilizers | Green gp-137-B | Green gp-143- A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_6$ 100 % RDF + Vermicompost + Biofertilizers | Green gp-137-B | Green gp-143- A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_7$ 75 % RDF + FYM + Biofertilizers | Green gp-137-B | Green gp-143- A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_8$ 75 % RDF + Vermicompost + Biofertilizers | Green gp-137-B | Green gp-143 -A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | Green gp-137-B | Green gp-143 -A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5% | Green gp-137-B | Green gp-143 -A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5% | Green gp-137-B | Green gp-143- A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |
| $T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | Green gp-137-B | Green gp-143 -A | Green gp-137 -A | Green gp -143- B | Green gp-137 -A | Green gp -143 -B |

**Contd….**

**Table 12b. Effect of Integrated Nutrient Management treatments on turf colour of two genotypes of *Lolium perenne* L. in different months of the year**

| Year | | October, 2009 | | November, 2009 | | December, 2009 | |
|---|---|---|---|---|---|---|---|
| Treatments | | Amenity type | Agricultural type | Amenity type | Agricultural type | Amenity type | Agricultural type |
| $T_1$ | Control (no application) | Green gp-137-A and Greyed Brown gp-199 -C and Greyed Yellow gp-161-A | Green gp-143 -B and Yellow gp-13-C | Green gp-137 -A and Greyed Brown gp-199 -C | Green gp-143 -B and Yellow gp-13-B | Green gp-137 -A and Greyed Yellow gp-161 -A | Yellow Green gp-143-B and Yellow gp-13-B |
| $T_2$ | 100 % RDF + FYM | Green gp-137-A and Yellow gp-13- C | Green gp-143- B and Yellow gp- 13-C | Green gp-137- A and Yellow gp-13-B | Green gp-143- B and Yellow gp -13-C | Green gp-137-A and Yellow gp-13- A | Yellow Green gp-143-B and Yellow gp- 13-B |
| $T_3$ | FYM + Biofertilizers | Green gp-137-A and Greyed Yellow gp-161-A | Green gp-143- B and Yellow gp -13-C | Green gp-137 -A and Greyed Brown gp-199- C | Green gp-143- B and Yellow gp- 13-B | Green gp-137 -A and Greyed Yellow gp-16 -A | Green gp-143- B and Yellow gp -13-A |
| $T_4$ | Vermicompost + Biofertilizers | Green gp-137-A and Yellow gp-13-C | Green gp-143- B and Yellow gp -13-C | Green gp-137 -A and Greyed Yellow gp-161- B | Green gp-143- B and Yellow gp- 13-C | Green gp-137 -A and Greyed Yellow gp161- B | Green gp-143- B and Yellow gp -13-C |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | Green gp-137-A and Greyed Brown gp-199- C | Green gp-143 -B and Greyed Yellow gp-161-C | Green gp – 137-A and Yellow gp-13-B | Green gp-143- B and Greyed Yellow gp-161-B | Green gp – 137-A and Yellow gp-13- A | Green gp-143- B and Yellow gp -161-A |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | Green gp-137-A and Yellow gp-13- C | Green gp-143- B and Yellow gp- 13-C | Green gp – 137-A and Greyed Brown gp-199- C | Green gp-143- B and Yellow gp -13-B | Green gp – 137-A and Greyed Yellow gp-161-A | Green gp-143- B and Yellow gp- 13-A |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | Green gp-137-A and Greyed Brown gp-199- C | Green gp-143-B and Yellow gp -13-C | Green gp – 137-A and Greyed Brown gp-199 -C | Green gp-143 -B and Yellow gp -13-B | Green gp – 137-A and Greyed Yellow gp-161-A | Green gp-143- B and Yellow gp -13-A |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | Green gp-137-A and Greyed Brown gp-199- C | Green gp-143 -B and Greyed Brown gp-199-C | Green gp – 137-A and Greyed Brown gp-199- C | Green gp-143- B and Yellow gp -13 -B | Green gp – 137-A and Greyed Yellow gp-161 -A | Green gp-143- B and Yellow gp -13-A |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | Green gp-137-A and Greyed Brown gp-199- C | Green gp-143- B and Greyed Brown gp-199- C | Green gp – 137-A and Greyed Brown gp-199 -C | Green gp-143 -B and Greyed Brown gp- 199-C | Green gp – 137-A and Greyed Yellow gp-161-A | Green gp-143- B and Yellow gp- 161-A |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5% | Green gp-137-A and Yellow gp-13-C | Green gp-143- B and Yellow gp -13-C | Green gp – 137-A and Greyed Brown gp-199 -C | Green gp-143- B Brown and Yellow gp-13-B | Green gp – 137-A and Greyed Yellow gp-161-A | Green gp-143- B and Yellow gp -13-B |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | Green gp-137-A and Greyed Brown gp-199- C | Green gp-143- B and Greyed Brown gp-199-C | Green gp – 137-A and Greyed Brown gp-199 -C | Green gp-143 -B and Yellow gp- 13 -B | Green gp – 137-A and Greyed Yellow gp-161 -A | Green gp-143- B and Yellow gp -13-A |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | Green gp-137-A and Greyed Yellow gp-161-C | Green gp-143 -B and Greyed Brown gp-199- C | Green gp – 137-A and Greyed Yellow gp-161- C | Green gp-143- B and Greyed Brown gp-199 -C | Green gp – 137-A and Greyed Yellow gp-161 -A | Green gp-143-B and Yellow gp -161-A |

**Contd….**

**Table 12c. Effect of Integrated Nutrient Management treatments on turf colour of two genotypes of *Lolium perenne* L. in different months of the year**

| Year | | January, 2010 | | February, 2010 | | March, 2010 | |
|---|---|---|---|---|---|---|---|
| Treatments | | Amenity type | Agricultural type | Amenity type | Agricultural type | Amenity type | Agricultural type |
| $T_1$ | Control (no application) | Green gp-137-A and Greyed Orange gp-164-A | Green gp-143-B and Yellow gp-13-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_2$ | 100 % RDF + FYM | Green gp-137-A and Yellow gp-13 B | Green gp-143-B and Greyed Orange gp-164-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_3$ | FYM + Biofertilizers | Green gp-137-A and Greyed Orange gp-164-B | Green gp-143-B and Yellow gp-13-B | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_4$ | Vermicompost + Biofertilizers | Green gp -137-A and Greyed Orange gp-164-B | Green gp-143-B and Yellow gp-13-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | Green gp-137-A and Yellow gp-13 B | Green gp-143-B and Greyed Orange gp-164-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | Green gp-137-A and Greyed Orange gp -164-B | Green gp-143-B and Yellow gp-13-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | Green gp-137-A and Greyed Orange gp-164-B | Green gp-143-B and Yellow gp-13-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | Green gp-137-A and Greyed Orange gp-164-A | Green gp-143-B and Yellow gp-164-B | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | Green gp-137-A and Greyed Orange gp-164-A | Green gp-143-B and Greyed Orange gp-164-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5% | Green gp-137-A and Greyed Orange gp-164-A | Green gp-143-B and Yellow gp-13-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | Green gp-137-A and Greyed Orange gp-164-B | Green gp-143-B and Yellow gp-13-A | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | Green gp-137-A and Greyed Orange gp-164-A | Green gp-143-B and Greyed Orange gp-164-B | Green gp-137-A | Yellow Green gp-146-A | Green gp-137-A | Yellow Green gp-146-A |

**Contd….**

**Table 12d. Effect of Integrated Nutrient Management treatments on turf colour of two genotypes of *Lolium perenne* L. in different months of the year**

| Year | | April, 2010 | | May, 2010 | | June, 2010 | |
|---|---|---|---|---|---|---|---|
| Treatments | | Amenity type | Agricultural type | Amenity type | Agricultural type | Amenity type | Agricultural type |
| $T_1$ | Control (no application) | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-A | Green gp-137-A and Greyed Yellow gp-161-C | Yellow Green gp -146-A and Greyed Orange gp-164-D | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-B |
| $T_2$ | 100 % RDF + FYM | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-A | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-B | Green gp-137-A and Greyed Yellow gp-161-A | Yellow Green gp -146-A and Greyed Orange gp-164-A |
| $T_3$ | FYM + Biofertilizers | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-B | Green gp-137-A and Greyed Yellow gp-161-C | Yellow Green gp -146-A and Greyed Orange gp-164-D | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-B |
| $T_4$ | Vermicompost + Biofertilizers | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-B | Green gp-137-A and Greyed Yellow gp-161-C | Yellow Green gp -146-A and Greyed Orange gp-164-D | Green gp-137-A and Greyed Yellow gp-161-A | Yellow Green gp -146-A and Greyed Orange gp-164-B |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-A | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-D | Green gp-137-A and Greyed Yellow gp-161-A | Yellow Green gp -146-A and Greyed Orange gp-164-A |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-A | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-D | Green gp-137-A and Greyed Yellow gp-161-A | Yellow Green gp -146-A and Greyed Orange gp-164-A |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-A | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-D | Green gp-137-A and Greyed Yellow gp-161-A | Yellow Green gp -146-A and Greyed Orange gp-164-A |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-A | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-D | Green gp-137-A and Greyed Yellow gp-161-A | Yellow Green gp -146-A and Greyed Orange gp-164-A |
| $T_9$ | 50 % RDF + FYM + Foliar application of N @ 0.5% | Green gp-137-A and Greyed Yellow gp161-C | Yellow Green gp-146-A and Greyed Orange gp-164-A | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-D | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-B |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5% | Green gp-137-A and Greyed Yellow gp161-C | Yellow Green gp-146-A and Greyed Orange gp-164-A | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-C | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-B |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-B | Green gp-137-A and Greyed Yellow gp-161-C | Yellow Green gp -146-A and Greyed Orange gp-164-C | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-B |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | Green gp-137-A and Greyed Yellow gp161-B | Yellow Green gp-146-A and Greyed Orange gp-164-B | Green gp-137-A and Greyed Yellow gp-161-C | Yellow Green gp -146-A and Greyed Orange gp-164-B | Green gp-137-A and Greyed Yellow gp-161-B | Yellow Green gp -146-A and Greyed Orange gp-164-B |

**Table 13. Effect of Integrated Nutrient Management treatments on texture of the leaf blade of two genotypes of *Lolium perenne* L. during July, 2009 to June 210**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) |
|---|---|---|---|
| $T_1$ | Control (no application) | Very fine | Fine |
| $T_2$ | 100 % RDF + FYM | Very fine | Fine |
| $T_3$ | FYM + Biofertilizers | Very fine | Fine |
| $T_4$ | Vermicompost + Biofertilizers | Very fine | Fine |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | Very fine | Fine |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | Very fine | Fine |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | Very fine | Fine |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | Very fine | Fine |
| $T_9$ | 50% RDF + Vermicompost + Foliar application of N @ 0.5% | Very fine | Fine |
| $T_{10}$ | 50% RDF + FYM + Foliar application of N @ 0.5% | Very fine | Fine |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | Very fine | Fine |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | Very fine | Fine |

**Table 14. Effect of Integrated Nutrient Management treatments on multiplication rate of two genotypes of *Lolium perenne* L.**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|---|
| $T_1$ | Control (no application) | 94.2 | 69.37 | 81.79 |
| $T_2$ | 100 % RDF + FYM | 138.69 | 83.63 | 111.16 |
| $T_3$ | FYM + Biofertilizers | 105.61 | 84.74 | 95.18 |
| $T_4$ | Vermicompost + Biofertilizers | 112.93 | 110.28 | 111.61 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 114.81 | 104.82 | 109.81 |
| $T_6$ | 100 % RDF + Vermicopost + Biofertilizers | 139.75 | 98.77 | 119.26 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 111.99 | 100.46 | 106.23 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 135.73 | 90.15 | 112.94 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 143.03 | 82.43 | 112.73 |
| $T_{10}$ | Foliar application of N @ 0.5 % | 121.99 | 108.87 | 115.43 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 126.23 | 94.53 | 110.38 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 141.30 | 90.54 | 115.92 |
| | Mean | 123.86 | 93.22 | 108.54 |

$CD_{0.05}$ for:

| | |
|---|---|
| Genotypes | 1.96 |
| Treatments | 4.81 |
| Genotypes x treatments | 6.79 |

## 4.10 ROOTING BEHAVIOUR

### 4.10.1 Total length of roots / clump (m)

An inquisition of data in Table 15 reveals that Amenity type exhibited more root length (15.44 m) as compared to Agricultural type (12.68 m) Amongst the treatments, plots treated with $T_5$ resulted in maximum root length (16.41 m), whereas, minimum root length (10.32 m) was observed in untreated plots ($T_1$). Interaction, genotypes x treatments reveals that maximum root length (18.39 m) was recorded in plots where Amenity type was grown with $T_5$, however, minimum root length (9.26 m) was recorded in untreated plots ($T_1$) of Agricultural type.

### 4.10.2 Fresh weight of roots (g)

More fresh root weight (25.61g) was observed in Amenity type, while, lesser fresh root weight (22.93 g) was recorded in Agricultural type (Table 15). Amongst the treatments, plots treated with $T_6$ resulted in maximum fresh root weight (30.84 g) while plots treated with $T_1$ resulted in minimum fresh root weight (14.59 g). Interaction, genotypes x treatments reveals that the maximum fresh root weight (32.50 g) was obtained by plots of Amenity type treated with $T_6$, whereas, minimum fresh root weight (13.46 g) was obtained by plots of Agricultural type treated with $T_1$ .

### 4.10.3 Dry weight of roots (g)

Higher dry weight of roots (2.85 g) was obtained in Amenity type while lesser dry weight of roots (2.71 g) was obtained in Agricultural type. Maximum dry root weight (4.02 g) was observed when the plots were treated with $T_5$ which was found to be statistically at par with $T_6$, while, minimum dry root weight (1.06 g) was observed when the plots were not treated ($T_1$).

Interaction, genotypes x treatments reveals that maximum dry root weight (4.18 g) was recorded in plots where Amenity type was grown with $T_5$ which was found to be statistically at par with $T_6$. Minimum dry root weight (1.05 g), however, was recorded in plots where Agricultural type was grown with $T_1$ and was at par with $T_1$ of Amenity type.

**Table 15. Effect of Integrated Nutrient Management treatments on the rooting behaviour of two genotypes of *Lolium perenne* L.**

| Treatments | | Total root length/clump (m) | | | Fresh weight of roots (g) | | | Dry weight of roots (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean |
| $T_1$ | Control (no application) | 11.37 | 9.26 | 10.32 | 15.72 | 13.46 | 14.59 | 1.06 | 1.05 | 1.06 |
| $T_2$ | 100 % RDF + FYM | 13.38 | 12.03 | 12.70 | 29.63 | 26.45 | 28.04 | 2.99 | 2.94 | 2.96 |
| $T_3$ | FYM + Biofertilizers | 14.34 | 12.15 | 13.25 | 22.44 | 20.49 | 21.47 | 1.78 | 1.72 | 1.75 |
| $T_4$ | Vermicompost + Biofertilizers | 14.55 | 12.19 | 13.37 | 23.69 | 20.10 | 21.90 | 1.94 | 1.88 | 1.91 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 18.39 | 14.44 | 16.41 | 30.18 | 25.66 | 27.92 | 4.18 | 3.86 | 4.02 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 17.40 | 13.85 | 15.62 | 32.50 | 29.18 | 30.84 | 4.10 | 3.93 | 4.01 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 16.33 | 13.41 | 14.87 | 28.38 | 25.55 | 26.97 | 3.09 | 2.98 | 3.03 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 15.92 | 13.05 | 14.48 | 26.68 | 24.59 | 25.64 | 3.16 | 2.98 | 3.07 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 16.41 | 13.08 | 14.75 | 25.63 | 23.62 | 24.63 | 3.14 | 2.94 | 3.04 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 17.54 | 14.13 | 15.83 | 24.39 | 21.86 | 23.13 | 3.05 | 2.91 | 2.98 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 14.61 | 11.89 | 13.25 | 24.45 | 22.39 | 23.42 | 2.88 | 2.69 | 2.79 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 15.08 | 12.66 | 13.87 | 23.62 | 21.78 | 22.70 | 2.78 | 2.64 | 2.71 |
| | Mean | 15.44 | 12.68 | 14.06 | 25.61 | 22.93 | 24.27 | 2.85 | 2.71 | 2.78 |

$CD_{0.05}$ for:

| | | Total root length/clump (m) | Fresh weight of roots (g) | Dry weight of roots (g) |
|---|---|---|---|---|
| Genotypes | = | 0.06 | 0.14 | 0.03 |
| Treatments | = | 0.16 | 0.35 | 0.06 |
| Genotypes x Treatments | = | 0.22 | 0.49 | 0.09 |

**$G_1$ = Amenity type**
**$G_2$ = Agricultural type**

## 4.11 CHLOROPHYLL CONTENT (mg/100g)

### 4.11.1 Chlorophyll content (mg/100g) in monsoon season (July – September)

It is evident from Table 16 that chlorophyll content was higher in Amenity type (2.36 mg/100 g) as compared to Agricultural type (2.05 mg/ 100g). Amongst the treatments, $T_5$ and $T_6$ were effective in increasing the chlorophyll content (2.57 mg/100g), whereas, $T_1$ resulted in minimum chlorophyll content (1.26 mg/100g). Interaction, genotypes x treatments shows that maximum chlorophyll content (2.80 mg/100g) was recorded in Amenity type when treated with $T_6$, whereas, minimum chlorophyll content (1.22 mg/100g) was obtained in Agricultural type with $T_1$.

### 4.11.2 Chlorophyll content (mg/100g) in post-monsoon season (October-December)

During post-monsoon season (Table 16) maximum chlorophyll content (1.59 mg/100g) was recorded in Amenity type while minimum chlorophyll content was recorded in Agricultural type (1.34 mg/100g). Amongst the treatments, maximum chlorophyll content (1.62 mg/100g) was obtained with treatment $T_6$, whereas, minimum chlorophyll content (1.26 mg/100g) was obtained when treated with $T_1$. Interaction, genotypes x treatments reveals that maximum chlorophyll content (1.80 mg/100g) was recorded in Amenity type when treated with $T_6$ and minimum chlorophyll content (1.24 mg/100g) was recorded in Agricultural type with $T_1$.

### 4.11.3 Chlorophyll content (mg/100g) in winter season (January-March)

During winter season (Table 16) maximum chlorophyll content (2.16 mg/100g) was recorded in Amenity type, whereas, minimum (1.88 mg/100 g) was recorded in Agricultural type. Among the various treatments, $T_6$ was effective in increasing the chlorophyll content (2.47 mg/100g) and was at par with $T_5$, whereas, $T_1$ resulted in minimum chlorophyll content (1.20 mg/100g). Interaction, genotypes x treatments reveals that maximum chlorophyll content (2.74 mg/100g) was obtained in Amenity type when treated with $T_6$, while, minimum chlorophyll content (1.16 mg/100g) was obtained in Agricultural type when treated with $T_1$ which was found to be statistically at par with $T_1$ in Amenity type.

**Table 16. Effect of Integrated Nutrient Management treatments on chlorophyll content (mg/100 g) of two genotypes of *Lolium perenne* L. during different seasons of the year**

| Treatments | | Monsoon Season (July-Sept.) | | | Post-monsoon Season (Oct.-Dec.) | | | Winter Season (Jan.-March) | | | Summer Season (April-June) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean |
| $T_1$ | Control (no application) | 1.30 | 1.22 | 1.26 | 1.28 | 1.24 | 1.26 | 1.24 | 1.16 | 1.20 | 1.04 | 1.02 | 1.03 |
| $T_2$ | 100 % RDF + FYM | 2.66 | 2.29 | 2.48 | 1.75 | 1.39 | 1.57 | 2.23 | 2.04 | 2.14 | 1.50 | 1.39 | 1.45 |
| $T_3$ | FYM + Biofertilizers | 2.12 | 1.65 | 1.89 | 1.42 | 1.30 | 1.36 | 1.83 | 1.38 | 1.61 | 1.07 | 1.03 | 1.05 |
| $T_4$ | Vermicompost + Biofertilizers | 2.29 | 1.69 | 1.99 | 1.43 | 1.29 | 1.36 | 1.86 | 1.37 | 1.62 | 1.08 | 1.03 | 1.06 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 2.79 | 2.34 | 2.57 | 1.77 | 1.43 | 1.60 | 2.57 | 2.18 | 2.38 | 1.52 | 1.37 | 1.45 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 2.80 | 2.33 | 2.57 | 1.80 | 1.45 | 1.62 | 2.74 | 2.20 | 2.47 | 1.63 | 1.29 | 1.46 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 2.50 | 2.25 | 2.38 | 1.69 | 1.37 | 1.53 | 2.26 | 2.12 | 2.19 | 1.39 | 1.24 | 1.32 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 2.50 | 2.38 | 2.44 | 1.66 | 1.36 | 1.51 | 2.31 | 2.14 | 2.23 | 1.44 | 1.24 | 1.34 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 2.54 | 2.22 | 2.38 | 1.59 | 1.35 | 1.47 | 2.43 | 2.08 | 2.25 | 1.18 | 1.12 | 1.15 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 2.57 | 2.21 | 2.39 | 1.60 | 1.33 | 1.47 | 2.44 | 2.27 | 2.35 | 1.16 | 1.13 | 1.15 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 2.12 | 2.02 | 2.07 | 1.51 | 1.29 | 1.40 | 1.93 | 1.80 | 1.87 | 1.12 | 1.10 | 1.11 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 2.16 | 2.02 | 2.09 | 1.52 | 1.30 | 1.41 | 2.04 | 1.82 | 1.93 | 1.14 | 1.10 | 1.12 |
| | Mean | 2.36 | 2.05 | 2.21 | 1.59 | 1.34 | 1.46 | 2.16 | 1.88 | 2.02 | 1.27 | 1.17 | 1.22 |

$CD_{0.05}$ for:

| | | | | | |
|---|---|---|---|---|---|
| Genotypes | = | 0.0003 | 0.0001 | 0.04 | 0.03 |
| Treatments | = | 0.0008 | 0.0004 | 0.09 | 0.06 |
| Genotypes x Treatments | = | 0.0010 | 0.0003 | 0.13 | 0.09 |

**$G_1$ = Amenity type**
**$G_2$ = Agricultural type**

#### 4.11.4 Chlorophyll content (mg/100g) in summer season (April - June)

During summer season (Table 16) maximum chlorophyll content (1.27mg/100g) was obtained in Amenity type while minimum chlorophyll content (1.17mg/100g) was obtained in Agricultural type. Amongst the treatments, $T_6$ was effective in increasing the chlorophyll content (1.46mg/100g) and was at par with $T_2$ and $T_5$, whereas, minimum chlorophyll content (1.03mg/100g) was recorded with $T_1$ which was found to be statistically at par with $T_3$ and $T_4$. Interaction, genotypes x treatments reveals that maximum chlorophyll content (1.63mg/100g) was obtained in Amenity type when treated with $T_6$, while, minimum chlorophyll content (1.02mg/100g) was obtained in Agricultural type when treated with $T_1$ which was found to be statistically at par with$T_3$ and $T_4$ in Agricultural type and $T_1$, $T_3$ and $T_4$ in Amenity type.

## 4.12 SOIL ANALYSIS

### 4.12.1 pH (1:2)

Perusal of data presented in Table 17a reveals that higher pH (7.47) was recorded from plots where Amenity type was grown, whereas, lower pH (7.43) was recorded in plots where Agricultural type was grown. Treatment $T_5$ resulted in increasing the pH (7.63), whereas, untreated plots ($T_1$) resulted in lowest soil pH (7.20). The interaction, genotypes x treatments reveals that maximum pH (7.65) was obtained when plots of Amenity type were treated with $T_5$ which was at par with $T_3$ and $T_2$ and $T_5$ in Agricultural type, whereas, lowest pH (7.21) was recorded when Agricultural type was treated with $T_{12}$ which was at par with $T_1$ in Amenity type.

### 4.12.2 EC ($dSm^{-1}$)

Highest EC (0.246) was recorded in plots where Amenity type was grown, whereas, lowest EC (0.239) was recorded in plots where Agricultural type was grown (Table 17a). Amongst the treatments, highest EC (0.299) was recorded when plots were treated with $T_{5,}$ however, minimum EC (0.148) was obtained in untreated plots ($T_1$). Interaction, genotypes x treatments reveals that highest EC (0.359) was observed when the plots in which Amenity type was grown were treated with $T_{11}$, whereas, minimum

(0.147) was observed when Amenity type was grown in untreated plots ( $T_1$) and was at par with $T_1$ in Agricultural type .

### 4.12.3 Organic Carbon (%)

An inquisition of data in Table 17a reveals that highest organic carbon content (3.09 %) was found in plots where Amenity type was grown, whereas, lowest organic carbon content (2.99%) was recorded in plots where Agricultural type was grown. Amongst the treatments, plots treated with $T_5$ resulted in highest OC content (3.43 %), whereas, plots treated with $T_1$ resulted in minimum OC content (2.04 %). Interaction, genotypes x treatments reveals that plots in which Amenity type was grown and were treated with $T_6$ resulted in maximum OC content (3.97 %), whereas, untreated plots ($T_1$) of Amenity type resulted in minimum OC content (2.01 %).

### 4.12.4 Nitrogen (kg/ha)

Perusal of data presented in Table 17b reveals that high available nitrogen (367.14 kg/ha) was recorded from the plots where Amenity type was grown, whereas, low available nitrogen (350.89 kg/ha) was recorded from plots where Agricultural type was grown. Amongst the treatments, plots treated with $T_5$ resulted in maximum available nitrogen (425.21 kg/ha), whereas, untreated plots ($T_1$) resulted in minimum available nitrogen (247.56 kg/ha). Interaction, genotypes x treatments reveals that in plots where Amenity type was grown and treated with $T_6$ resulted in maximum available nitrogen (498.71 kg/ha), whereas, minimum available nitrogen (246.48 kg/ha) was recorded from plots where Amenity type was grown and treated with $T_1$ and was at par with $T_1$ in Agricultural type.

### 4.12.5 Phosphorus (kg/ha)

Data presented in Table 17b reveals that genotypes were non-significant for available phosphorus (Appendix-II). Amongst the treatments, maximum available phosphorus content (292.41 kg/ha) was recorded when plots were treated with

**Table 17a. Effect of Integrated Nutrient Management treatments on the soil pH (1:2), EC ($dSm^{-1}$) and OC (%) of two genotypes of *Lolium perenne* L.**

| Treatments | pH (1:2) | | | EC ($dSm^{-1}$) | | | OC (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean |
| $T_1$ Control (no application) | 7.22 | 7.17 | 7.20 | 0.147 | 0.148 | 0.148 | 2.01 | 2.06 | 2.04 |
| $T_2$ 100 % RDF + FYM | 7.52 | 7.62 | 7.57 | 0.241 | 0.218 | 0.229 | 3.43 | 3.21 | 3.32 |
| $T_3$ FYM + Biofertilizers | 7.62 | 7.33 | 7.47 | 0.273 | 0.270 | 0.272 | 2.88 | 2.96 | 2.92 |
| $T_4$ Vermicompost + Biofertilizers | 7.49 | 7.47 | 7.48 | 0.184 | 0.292 | 0.238 | 2.97 | 3.13 | 3.05 |
| $T_5$ 100 % RDF + FYM + Biofertilizers | 7.65 | 7.62 | 7.63 | 0.247 | 0.350 | 0.299 | 3.19 | 3.66 | 3.43 |
| $T_6$ 100 % RDF + Vermicompost + Biofertilizers | 7.52 | 7.59 | 7.55 | 0.240 | 0.347 | 0.294 | 3.97 | 2.66 | 3.32 |
| $T_7$ 75 % RDF + FYM + Biofertilizers | 7.40 | 7.40 | 7.40 | 0.208 | 0.166 | 0.187 | 3.41 | 2.82 | 3.12 |
| $T_8$ 75 % RDF + Vermicompost + Biofertilizers | 7.53 | 7.54 | 7.54 | 0.350 | 0.238 | 0.204 | 3.10 | 3.13 | 3.12 |
| $T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 7.44 | 7.44 | 7.44 | 0.275 | 0.202 | 0.238 | 2.67 | 3.18 | 2.93 |
| $T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 % | 7.43 | 7.44 | 7.44 | 0.243 | 0.293 | 0.268 | 3.21 | 2.92 | 3.07 |
| $T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5% | 7.46 | 7.29 | 7.38 | 0.359 | 0.222 | 0.291 | 3.42 | 3.01 | 3.22 |
| $T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 7.38 | 7.21 | 7.30 | 0.187 | 0.126 | 0.157 | 2.82 | 3.10 | 2.96 |
| Mean | 7.47 | 7.43 | 7.45 | 0.246 | 0.239 | 0.243 | 3.09 | 2.99 | 3.04 |

$CD_{0.05}$ for:

| | | pH (1:2) | EC ($dSm^{-1}$) | OC (%) |
|---|---|---|---|---|
| Genotypes | = | 0.02 | 0.002 | 0.03 |
| Treatments | = | 0.04 | 0.001 | 0.07 |
| Genotypes x Treatments | = | 0.05 | 0.001 | 0.10 |

**$G_1$ = Amenity type**
**$G_2$ = Agricultural type**

**Contd….**

**Table 17b. Effect of Integrated Nutrient Management treatments on the available nitrogen, phosphorus and potassium (kg/ha) of two genotypes of *Lolium perenne* L.**

| Treatments | | Nitrogen (kg/ha) | | | Phosphorus (kg/ha) | | | Potassium (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean |
| $T_1$ | Control (no application) | 246.48 | 248.63 | 247.56 | 186.47 | 160.98 | 173.72 | 481.92 | 450.54 | 466.19 |
| $T_2$ | 100 % RDF + FYM | 443.08 | 344.94 | 394.01 | 252.42 | 270.14 | 261.28 | 685.81 | 507.73 | 596.77 |
| $T_3$ | FYM + Biofertilizers | 316.20 | 322.57 | 319.39 | 245.21 | 248.21 | 246.71 | 524.53 | 441.65 | 483.09 |
| $T_4$ | Vermicompost + Biofertilizers | 345.02 | 374.66 | 359.84 | 280.00 | 249.91 | 264.95 | 536.48 | 475.63 | 506.05 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 374.70 | 475.71 | 425.21 | 316.59 | 268.22 | 292.41 | 603.31 | 663.04 | 633.17 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 498.71 | 291.99 | 395.35 | 248.86 | 323.31 | 286.09 | 663.79 | 586.13 | 624.96 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 375.06 | 410.45 | 392.76 | 247.59 | 256.03 | 251.81 | 617.12 | 509.60 | 563.36 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 370.40 | 375.19 | 372.80 | 254.71 | 256.03 | 255.37 | 567.84 | 606.67 | 587.25 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 303.73 | 376.54 | 340.14 | 248.91 | 210.93 | 229.92 | 567.84 | 506.24 | 537.04 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 377.95 | 316.47 | 347.21 | 239.23 | 247.52 | 243.38 | 684.32 | 444.64 | 564.48 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 436.09 | 300.22 | 368.16 | 236.04 | 249.31 | 242.68 | 588.37 | 647.41 | 617.89 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 318.22 | 373.32 | 345.77 | 249.91 | 263.50 | 256.70 | 644.69 | 504.00 | 574.35 |
| | Mean | 367.14 | 350.89 | 359.02 | 250.50 | 250.34 | 250.42 | 597.17 | 528.60 | 562.88 |

$CD_{0.05}$ for:

| | | Nitrogen | Phosphorus | Potassium |
|---|---|---|---|---|
| Genotypes | = | 3.26 | NS | 5.66 |
| Treatments | = | 7.99 | 3.23 | 13.86 |
| Genotypes x Treatments | = | 11.31 | 4.56 | 19.61 |

**$G_1$ = Amenity type**
**$G_2$ = Agricultural type**

$T_5$, whereas, minimum available phosphorus content (173.72 kg/ha) was recorded in untreated plots ($T_1$). Interaction, genotypes x treatments shows that maximum available phosphorus content (323.31 kg/ha) was recorded when the plots where Agricultural type was grown and treated with $T_6$, whereas, minimum available phosphorus content (160.98 kg/ha) was recorded from the plots where Agricultural type was grown and were kept untreated ($T_1$) .

### 4.12.6 Potassium (kg/ha)

Data pertaining to potassium content is presented in Table 17b. More available potassium (597.17 kg/ha) was observed in plots where Amenity type was grown while less available potassium (528.60 kg/ha) was recorded from plots where Agricultural type was grown. Among the various treatments, maximum available potassium (633.17 kg/ha) was recorded when the plots were treated with $T_5$ which was found to be statistically at par with $T_6$, whereas, minimum available potassium (466.19 kg/ha) was observed in plots which were untreated ($T_1$). Interaction, genotypes x treatments reveals that in plots where Amenity type was grown and treated with $T_2$ resulted in maximum available potassium (685.81 kg/ha) which was found to be statistically at par with $T_{10}$ in Amenity type, whereas, minimum available potassium (441.65 kg/ha) was obtained when the plots in which Agricultural type was grown were treated with $T_3$ , which was statistically at par with $T_1$ and $T_{10}$ in Agricultural type.

## 4.13 PLANT NUTRIENT ANALYSIS

### 4.13.1 Nitrogen (%)

Data presented in Table 18 reveals that maximum leaf nitrogen content (3.15%) was recorded in Amenity type, whereas, minimum leaf nitrogen content (3.08 %) was recorded in Agricultural type. Amongst the treatments, maximum leaf nitrogen content (3.78 %) was recorded when treated with $T_5$ and was at par with $T_6$, whereas, minimum leaf nitrogen content (2.07 %) was obtained when no treatment was applied ($T_1$). Interaction, genotypes x treatments shows that maximum leaf nitrogen content (4.02 %) was recorded when Agricultural type was treated with $T_2$, whereas, minimum leaf nitrogen content (2.05 %) was recorded in Amenity type with $T_1$ and was at par with $T_1$ in Agricultural type.

### 4.13.2 Phosphorus (%)

A cursory glance of data presented in Table 18 reveals that more leaf phosphorus content (0.58 %) was obtained from Amenity type, whereas, less leaf phosphorus content (0.51 %) was recorded from Agricultural type. Amongst the treatments, maximum leaf phosphorus content (0.65 %) was recorded when treated with $T_5$, whereas, minimum leaf phosphorus content (0.41 %) was recorded when no treatment was given $T_1$. Interaction, genotypes x treatments reveals that maximum leaf phosphorus content (0.80 %) was recorded when Amenity type was treated with $T_6$, whereas, minimum leaf phosphorus content (0.40 %) was recorded in Agricultural type without any treatment ($T_1$).

### 4.13.3 Potassium (%)

A perusal of data presented in Table 18 reveals that more leaf potassium content (2.66 %) was recorded in Amenity type, whereas, less leaf potassium content (2.30 %) was recorded in Agricultural type . Among the different treatments, maximum leaf potassium content (2.95 %) was obtained when the plots were treated with $T_5$ and was at par with $T_6$ , whereas, minimum leaf potassium content (2.03 %) was obtained in untreated plots ( $T_1$) and was at par with $T_4$. Interaction, genotypes x treatments shows that more leaf potassium content (3.30 %) was recorded when Amenity type was treated with $T_6$, whereas, less leaf potassium content (2.00 %) was obtained when Agricultural type was treated with $T_3$, $T_{11}$ and $T_9$ and was at par with $T_4$, $T_7$ and $T_{10}$ and $T_1$ and $T_4$ in Amenity type.

**Table 18. Effect of Integrated Nutrient Management treatments on the total leaf nitrogen, phosphorus and potassium content (%) of two genotypes of *Lolium perenne* L.**

| Treatments | | Nitrogen (%) | | | Phosphorus (%) | | | Potassium (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean | $G_1$ | $G_2$ | Mean |
| $T_1$ | Control (no application) | 2.05 | 2.09 | 2.07 | 0.41 | 0.40 | 0.41 | 2.03 | 2.03 | 2.03 |
| $T_2$ | 100 % RDF + FYM | 3.39 | 4.02 | 3.70 | 0.63 | 0.61 | 0.62 | 3.00 | 2.45 | 2.73 |
| $T_3$ | FYM + Biofertilizers | 3.38 | 3.41 | 3.39 | 0.48 | 0.49 | 0.48 | 3.15 | 2.00 | 2.56 |
| $T_4$ | Vermicompost + Biofertilizers | 3.91 | 3.36 | 3.64 | 0.48 | 0.46 | 0.47 | 2.10 | 2.10 | 2.10 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 3.92 | 3.63 | 3.78 | 0.66 | 0.63 | 0.65 | 2.90 | 3.00 | 2.95 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 3.65 | 3.83 | 3.74 | 0.80 | 0.44 | 0.62 | 3.30 | 2.55 | 2.93 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 2.79 | 2.74 | 2.77 | 0.48 | 0.62 | 0.55 | 3.00 | 2.10 | 2.55 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 2.22 | 2.83 | 2.52 | 0.65 | 0.46 | 0.56 | 2.30 | 2.70 | 2.50 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 2.79 | 2.24 | 2.51 | 0.61 | 0.47 | 0.54 | 2.55 | 2.00 | 2.28 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 3.06 | 2.55 | 2.81 | 0.63 | 0.47 | 0.55 | 2.60 | 2.15 | 2.38 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 3.36 | 3.65 | 3.51 | 0.47 | 0.63 | 0.55 | 2.95 | 2.00 | 2.48 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 3.31 | 2.59 | 2.95 | 0.61 | 0.47 | 0.54 | 2.05 | 2.55 | 2.30 |
| | Mean | 3.15 | 3.08 | 3.12 | 0.58 | 0.51 | 0.54 | 2.66 | 2.30 | 2.48 |

$CD_{0.05}$ for:

| | | Nitrogen | Phosphorus | Potassium |
|---|---|---|---|---|
| Genotypes | = | 0.02 | 0.00069 | 0.06 |
| Treatments | = | 0.05 | 0.0024 | 0.15 |
| Genotypes x Treatments | = | 0.07 | 0.0017 | 0.21 |

**$G_1$ = Amenity type**
**$G_2$ = Agricultural type**

## 4.14 PRESENTABILITY

The presentability of genotypes was assessed on the basis of number of mowings required, weed population/$m^2$, turf growth ($cm^2$), visual quality rating (aesthetic appearance and turf colour). The scores out of hundred, thus, obtained have been presented in Table 19a, b, c and d.

**Table 19a. Effect of Integrated Nutrient Management treatments on the presentability scores (out of hundred) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Treatments | | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|---|
| $T_1$ | Control (no application) | 72.63 | 60.38 | 66.51 |
| $T_2$ | 100 % RDF + FYM | 78.39 | 69.93 | 74.16 |
| $T_3$ | FYM + Biofertilizers | 76.11 | 66.90 | 71.51 |
| $T_4$ | Vermicompost + Biofertilizers | 78.20 | 67.38 | 72.79 |
| $T_5$ | 100 % RDF + FYM + Biofertilizers | 78.60 | 71.10 | 74.85 |
| $T_6$ | 100 % RDF + Vermicompost + Biofertilizers | 80.63 | 73.11 | 76.87 |
| $T_7$ | 75 % RDF + FYM + Biofertilizers | 77.31 | 70.11 | 73.71 |
| $T_8$ | 75 % RDF + Vermicompost + Biofertilizers | 80.94 | 70.72 | 75.83 |
| $T_9$ | 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 77.36 | 69.61 | 73.49 |
| $T_{10}$ | 50 % RDF + FYM + Foliar application of N @ 0.5 % | 79.21 | 69.11 | 74.16 |
| $T_{11}$ | FYM + Biofertilizers + Foliar application of N @ 0.5% | 77.92 | 68.87 | 73.39 |
| $T_{12}$ | Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 78.25 | 68.17 | 73.21 |
| | Mean | 77.96 | 68.78 | 73.37 |

$CD_{0.05}$ for:

| | |
|---|---|
| Genotypes | 0.10 |
| Treatments | 0.24 |
| Genotypes x Treatments | 0.35 |

Perusal of data presented in Table 19a reveals that amongst the genotypes, Amenity type had better presentability with a score of 77.96 as compared to Agricultural type (68.78). Amongst the treatments, plots treated with $T_6$ exhibited best presentability with a score of 76.87, whereas, untreated plots ($T_1$) scored least score (66.51). Interaction, genotypes x treatments reveals that highest score was attained by Amenity type (80.94) when treated with $T_8$ and was statistically at par with $T_6$ while Agricultural type attained least score of 60.38 when grown in untreated plots ($T_1$).

An inquisition of data in Table 19b reveals that amongst the months, highest score of 87.43 was recorded during April, 2010, whereas, during August, 2009, least score (58.95) was recorded. Interaction, genotypes x months reveals that Amenity type was most presentable during March, 2010, with a score of 94.68, whereas, Agricultural type had the least presentability (54.20) during August, 2009.

**Table 19b. Effect of Integrated Nutrient Management treatments on the presentability scores (out of hundred) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Months | Amenity type ($G_1$) | Agricultural type ($G_2$) | Mean |
|---|---|---|---|
| 1. July, 2009 | 64.49 | 57.21 | 60.85 |
| 2. August, 2009 | 63.70 | 54.20 | 58.95 |
| 3. September, 2009 | 63.46 | 56.58 | 60.02 |
| 4. October, 2009 | 74.53 | 63.24 | 68.88 |
| 5. November, 2009 | 81.24 | 73.50 | 77.37 |
| 6. December, 2009 | 81.18 | 74.39 | 77.79 |
| 7. January, 2010 | 82.74 | 72.81 | 77.77 |
| 8. February, 2010 | 89.27 | 78.22 | 83.75 |
| 9. March, 2010 | 94.68 | 78.72 | 86.70 |
| 10. April, 2010 | 92.81 | 82.06 | 87.43 |
| 11. May, 2010 | 73.49 | 68.25 | 70.87 |
| 12. June, 2010 | 73.97 | 66.24 | 70.11 |

$CD_{0.05}$ for:

| | |
|---|---|
| Months | 0.24 |
| Genotypes x Months | 0.35 |

An appraisal of data presented in Table 19c shows the interaction, treatments x months. Treatment $T_7$ was most effective in enhancing the presentability of Amenity type during April, 2010, (91.25) and was at par with $T_8$ in the same month, whereas, minimum presentability (49.75) was recorded during September, 2009, when treatment of $T_3$ was given.

Data presented in Table 19d shows the interaction, genotypes x months x treatments. Amenity type was rated the best with a score of 98.33 during March, 2010, when treated with $T_5$ while Agricultural type attained a minimum score of 41.67 during August, 2009, when grown in untreated plots ($T_1$).

**Table 19c. Effect of Integrated Nutrient Management treatments on the presentability scores (out of hundred) of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | 2010 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | Months | | | | | | | | | | | |
| | July | August | September | October | November | December | January | February | March | April | May | June |
| $T_1$ Control (no application) | 59.42 | 50.69 | 54.33 | 59.67 | 68.88 | 73.92 | 66.58 | 76.33 | 81.67 | 81.58 | 66.08 | 58.92 |
| $T_2$ 100 % RDF + FYM | 58.50 | 59.33 | 62.33 | 69.25 | 76.48 | 78.75 | 79.25 | 83.92 | 86.92 | 89.17 | 71.50 | 74.50 |
| $T_3$ FYM + Biofertilizers | 60.33 | 60.67 | 49.75 | 64.92 | 75.85 | 76.17 | 77.75 | 82.14 | 83.28 | 84.83 | 71.75 | 70.67 |
| $T_4$ Vermicompost + Biofertilizers | 62.17 | 60.33 | 62.58 | 67.59 | 75.15 | 77.67 | 78.58 | 83.83 | 88.17 | 87.08 | 68.42 | 61.92 |
| $T_5$ 100 % RDF + FYM + Biofertilizers | 61.75 | 56.67 | 62.08 | 75.58 | 81.43 | 77.75 | 79.75 | 86.92 | 88.08 | 88.92 | 65.67 | 73.58 |
| $T_6$ 100 % RDF + Vermicompost + Biofertilizers | 67.00 | 66.17 | 65.00 | 69.50 | 81.80 | 79.58 | 83.08 | 86.67 | 89.33 | 89.92 | 69.08 | 75.34 |
| $T_7$ 75 % RDF + FYM + Biofertilizers | 59.33 | 55.59 | 63.92 | 69.84 | 76.32 | 74.67 | 78.67 | 85.33 | 85.42 | 91.25 | 71.75 | 72.42 |
| $T_8$ 75 % RDF + Vermicompost + Biofertilizers | 61.17 | 58.42 | 63.83 | 71.00 | 79.60 | 82.33 | 80.67 | 84.25 | 88.65 | 90.00 | 76.33 | 73.75 |
| $T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5% | 60.25 | 59.58 | 56.67 | 68.92 | 78.86 | 78.50 | 77.50 | 83.50 | 88.67 | 88.67 | 71.33 | 69.42 |
| $T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 % | 61.42 | 62.92 | 58.50 | 68.67 | 78.93 | 81.33 | 75.67 | 85.50 | 88.50 | 85.67 | 73.92 | 68.92 |
| $T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5% | 58.25 | 58.17 | 63.33 | 72.25 | 76.36 | 78.75 | 77.50 | 82.42 | 86.42 | 85.75 | 72.50 | 69.00 |
| $T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 % | 60.58 | 58.83 | 57.92 | 69.42 | 78.77 | 74.00 | 78.25 | 84.17 | 85.33 | 86.34 | 72.08 | 72.84 |

$CD_{0.05}$ for:

Treatments x Months = 0.85

**Table 19d. Effect of Integrated Nutrient Management treatments on the presentability scores (out of hundred) of two genotypes of *Lolium perenne* L. during July, 2009 to June, 2010**

| Year | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | July | | August | | September | | October | | November | | December | | January | | February | | March | | April | | May | | June | |
| Treatments | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ | $G_1$ | $G_2$ |
| $T_1$ | 65.17 | 53.67 | 59.71 | 41.67 | 57.17 | 51.50 | 65.50 | 53.83 | 71.67 | 66.10 | 78.83 | 69.00 | 73.83 | 59.33 | 84.33 | 68.33 | 91.00 | 72.33 | 87.50 | 75.67 | 72.00 | 60.17 | 64.84 | 52.99 |
| $T_2$ | 60.83 | 56.17 | 65.00 | 53.67 | 69.33 | 55.33 | 74.83 | 63.67 | 77.18 | 75.79 | 78.17 | 79.33 | 83.00 | 75.50 | 88.33 | 79.50 | 95.33 | 78.50 | 96.00 | 82.33 | 74.67 | 68.33 | 78.00 | 71.00 |
| $T_3$ | 66.50 | 54.17 | 67.67 | 53.67 | 52.17 | 47.33 | 67.50 | 62.33 | 80.85 | 70.85 | 81.50 | 70.83 | 82.00 | 73.50 | 87.78 | 76.50 | 95.06 | 71.50 | 89.33 | 80.33 | 72.17 | 71.33 | 70.83 | 70.50 |
| $T_4$ | 67.50 | 56.83 | 64.17 | 56.50 | 60.00 | 65.17 | 71.33 | 63.84 | 82.35 | 67.94 | 80.83 | 74.50 | 85.67 | 71.50 | 89.50 | 78.17 | 96.33 | 80.00 | 93.17 | 81.00 | 74.67 | 62.17 | 72.83 | 51.00 |
| $T_5$ | 64.33 | 59.17 | 58.33 | 55.01 | 64.83 | 59.33 | 78.00 | 73.17 | 85.67 | 77.19 | 80.83 | 74.67 | 86.67 | 72.83 | 89.50 | 84.33 | 98.33 | 77.83 | 95.00 | 82.83 | 66.50 | 64.83 | 75.17 | 72.00 |
| $T_6$ | 71.83 | 62.17 | 72.83 | 59.50 | 73.83 | 56.17 | 72.01 | 67.00 | 84.09 | 79.51 | 82.67 | 76.50 | 88.17 | 78.00 | 92.67 | 80.67 | 92.67 | 86.00 | 94.33 | 85.50 | 68.17 | 70.00 | 74.34 | 76.33 |
| $T_7$ | 58.83 | 59.83 | 60.51 | 50.67 | 61.83 | 66.00 | 75.83 | 63.84 | 82.52 | 70.11 | 79.50 | 69.83 | 82.67 | 74.67 | 89.33 | 81.33 | 94.00 | 76.83 | 96.00 | 86.50 | 70.83 | 72.67 | 75.83 | 69.00 |
| $T_8$ | 66.17 | 56.17 | 66.00 | 50.83 | 63.83 | 63.83 | 85.67 | 56.33 | 80.68 | 78.52 | 85.50 | 79.17 | 85.67 | 75.67 | 94.50 | 74.00 | 94.47 | 82.83 | 94.51 | 85.50 | 78.33 | 74.33 | 76.01 | 71.50 |
| $T_9$ | 63.17 | 57.33 | 61.67 | 57.50 | 63.83 | 49.50 | 72.50 | 65.33 | 80.85 | 76.87 | 80.17 | 76.83 | 77.83 | 77.17 | 89.33 | 77.67 | 96.50 | 80.83 | 93.17 | 84.17 | 75.67 | 67.00 | 73.67 | 65.17 |
| $T_{10}$ | 63.17 | 59.67 | 62.51 | 63.33 | 63.67 | 53.33 | 76.33 | 61.00 | 81.85 | 76.01 | 85.17 | 77.50 | 81.17 | 70.17 | 89.67 | 81.33 | 94.67 | 82.33 | 95.00 | 76.33 | 81.00 | 66.83 | 76.33 | 61.50 |
| $T_{11}$ | 61.83 | 54.67 | 60.17 | 56.17 | 65.33 | 61.33 | 79.17 | 65.33 | 84.35 | 68.37 | 82.67 | 74.83 | 82.50 | 72.50 | 89.17 | 75.67 | 92.50 | 80.33 | 88.67 | 82.83 | 73.67 | 71.33 | 75.00 | 63.01 |
| $T_{12}$ | 64.50 | 56.67 | 65.83 | 51.83 | 65.67 | 50.17 | 75.67 | 63.17 | 82.84 | 74.69 | 78.33 | 69.67 | 83.67 | 72.83 | 87.17 | 81.17 | 95.33 | 75.33 | 91.01 | 81.67 | 74.17 | 70.00 | 74.84 | 70.83 |

$CD_{0.05}$ for:
Genotypes x Months x Treatments = 1.20

$T_1$ Control (no application)
$T_2$ 100 % RDF + FYM
$T_3$ FYM + Biofertilizers
$T_4$ Vermicompost + Biofertilizers
$T_5$ 100 % RDF + FYM + Biofertilizers
$T_6$ 100 % RDF + Vermicompost + Biofertilizers
$T_7$ 75 % RDF + FYM + Biofertilizers
$T_8$ 75 % RDF + Vermicompost + Biofertilizers
$T_9$ 50 % RDF + Vermicompost + Foliar application of N @ 0.5%
$T_{10}$ 50 % RDF + FYM + Foliar application of N @ 0.5 %
$T_{11}$ FYM + Biofertilizers + Foliar application of N @ 0.5%
$T_{12}$ Vermicompost + Biofertilizers + Foliar application of N @ 0.5 %

**$G_1$ : Amenity type**
**$G_2$ : Agriculturalype**

# *Chapter-5*

# DISCUSSION

In sharp contrast to the production of the ornamental crops where flower quality and yield are of major importance, landscape gardening is concerned exclusively with the creation of aesthetically suitable environment for recreation and relaxation, and hence, the objectives of landscape gardening like; management of trees, shrubs, annual flowers and lawns are considerably different from those dealt within commercial floriculture.

Lawns form an integral part of any landscape design and its aesthetic quality depends upon the adaptation of a grass species to a particular environment. This is only possible if a number of grass species have been evaluated under those conditions so that few selected species could be recommended for that particular location. Preliminary studies under mid-hill conditions of H.P. have shown that *Festuca rubra* L. and *Lolium perenne* L. (Verma, 2007) performed well. Considering this fact two different genotypes i.e. Amenity type and Agricultural type of *Lolium perenne* L. were selected for the present studies.

Though, the productivity of a crop is influenced by the genetic make up as well as the edaphic and environmental factors in which it is grown, but the quality of the produce directly depends upon the favourable environmental conditions, nutritional and plant protection techniques to which it is exposed.

As the past, future may also belong to the approach of improving the genetic base, however, the yield potential is fully exploited when favourable environment is provided along with the desired manipulation of edaphic factors.

In general, management of edaphic factors play an important role in increasing the productivity. As in the other crops, in the management of turf grasses also the growing medium should be sufficiently porous, with low salinity level, and higher water holding capacity. To obtain these desired characteristics different components of growing media like soil, sand, organic manures and biofertilizers are used along with the inorganic fertilizers.

The quality of a lawn is determined by the management of the turf. Since, turf formation is a continuous process, application of fertilizers should be simpler and less time consuming. Although the application of inorganic fertilizers give quick results but the texture and structure of the medium is not taken care of which makes the use of organic fertilizers an integral part of the fertilization schedule. Therefore, the present studies were conducted with the objective of studying the effect of Integrated Nutrient Management i.e. the use of organic and inorganic fertilizers on *Lolium perenne* L.

Integrated Nutrient Management envisages the use of chemical fertilizers in conjunction with organic manures, legumes in cropping system, biofertilizers, crop residues and other locally available nutrient sources for sustaining soil health and productivity. The treatment combinations under the Integrated Nutrient Management mainly consisted of addition of biofertilizers, organic manures along with the use of inorganic/chemical fertilizers on performance of *Lolium perenne* L. for which parameters like culm length (cm), number of mowings required, weed population/$m^2$, turf growth ($cm^2$) and visual quality rating (aesthetic appearance and turf colour) were studied for one complete year. Apart from these, parameters like multiplication rate, rooting behaviour (total length of roots/clump, fresh and dry weight of roots (g)), soil pH (1:2), EC ($dSm^{-1}$), OC (%), N (kg/ha), P(kg/ha) and K (kg/ha) and plant N (%), P (%) and K (%) were recorded at the termination of the experiment while establishment rate (%) was observed at the initial stage of the experiment and chlorophyll content (mg/g) was estimated for different seasons.

In the present studies, none of the treatment was effective in increasing the establishment rate of the genotypes. However, Amenity type had better establishment rate than the Agricultural type. The Amenity type is known to be a standard turf grass whereas the Agricultural type is more bent towards forage grass (Creemers-Molennar and Beerepoot, 1992). Anonymous[2],1995 has reported that if the forage perennial rye grasses are planted out of their optimal temperature range, they tend to die thereby reducing the survival percentage which in turn resulted in less establishment rate as the growing temperature at the time of establishment was between 30.80-33.30 $^{o}$C (Appendix-I).

After studying the establishment rate, the next important parameter for determining the quality of turf grass is its presentability throughout the year. The components which contributed towards the better presentability were turf growth, aesthetic appearance, turf colour, weed population/$m^2$ and number of mowings required. Other workers have also assessed the presentability on the basis of these parameters. Rorison and Roderick (1980) also determined the turf grass quality on the basis of some factors like speed of initial establishment, persistence under mowing, freedom from weeds, texture and good appearance based on dark or light colour, uniformity of colour, absence of seasonal variation in colour (dead leaf, yellowing, etc.), absence of seed heads and grouped the various lawn grass species into three groups 'A', 'B' and 'C'. Turgeon (1980) selected the criteria like establishment vigour, leaf texture and mowing height adaptation for assessing the presentability of the lawn grasses. Marcolino *et al.* (2004) determined the turf grass quality on the basis of parameters like general appearance, density, texture and colour using visual ratings while Marchione (2004) recorded visual ratings on the basis of aesthetic general appearance and turf colour index.

In the present studies, maximum presentability was exhibited by the Amenity type during the month of March, 2010, with the treatment of 100% required dose of fertilizers, Farm Yard Manure and biofertilizers namely Azotobacter, PSB and VAM (Plate 5 & 6). This clearly indicates that along with the inorganic fertilizers, the organic manures and biofertilizers contribute towards the positive factors which influence the presentability of lawn grasses. Kotb (1998) and Hussein and Arafa (2009) observed high quality growth in grasses with the application of increased rates of inorganic N in combination with biofertilizers.

The effect of the fertilizers in enhancing the presentability during March, 2010, could be attributed to the fact that the temperature ranged between 8.4$^{o}$C-24.9$^{o}$C, R.H. being 41%, and the rainfall being 43.40 mm which together formed the ideal environmental conditions for the absorption of fertilizers. Teuton *et al*. (2009) has also reported that the activity of fertilizers is enhanced under such temperature conditions.

The presentability scores increased with the application of 100% required dose of fertilizers which included Nitrogen, phosphorus and potassium. Nitrogen is the key element in turf production and is frequently a limiting factor in the growth of the turf grasses, and its application produce dramatic improvement in the growth and appearance of the grass. It is primarily responsible for vegetative growth of grass, colour, and root development. Phosphorus is particularly important in stimulating the quick development of a good root system in newly seeded grasses and increases wearing qualities of turf grass while potassium application to turf grasses promotes root development, rapid spread, vigour, wear tolerance and resistance in plants (Vengris, 1973 and Decker and Decker, 1988).

Increased presentability with the addition of biofertilizers, and organic fertilizers was due to the fact that biofertilizers have been found to induce certain physical, chemical and biological effects. There physical effects include improvement of soil structure, providing better environment for root and microbial development, better aeration, increasing water holding capacity and control of soil erosion. Amongst the chemical effects, they add nutrients to the soil i.e. Azotobacter increases the availability of nitrogen while PSB and VAM increases the availability of phosphorus in the soil (Palaniappan and Annadurai, 1999) and the major plant nutrients in organic combination is made available to the plants for longer duration. They also supply adequate amounts of micronutrients required for plant growth in small quantities and humus enhances the utilization of fertilizer nutrient by plant and hence, reduces leaching losses. The biological effects include increase in microorganism population and their stimulation, nitrogen fixation and phosphorus solubilisation are also increased due to increased microbial activity. Tien *et al*. (1979) while working on

Plate 5. Presentability of Amenity Type with treatment of 100% RDF + FYM + Biofertilizers during March, 2010

Plate 6. Presentability of Agricultural Type with treatment of 100% RDF + FYM + Biofertilizers during March, 2010

biofertilizers like *Azospirillum* and *Azotobacter* said that they contain growth promoting hormones like IAA, IBA, GA and vitamins which may induce better growth of plants. Conwayll (1981) was of the opinion that both these microorganisms when added to the soil enhance nutrient uptake, thereby, supporting the statement of Haymann and Mosse (1973) who said that the absorption of nutrients like N, K, Mg and Zn increased as the surface area of the roots increases.

Turf growth, aesthetic appearance of turf and turf colour contributed to the increased presentability scores when Amenity type was treated with 100% required dose of fertilizers, Farm Yard Manure and biofertilizers. These results are in line with that of Trenholm *et al*. (2001) and Razmjoo and Kaneko (1993) who reported that turf growth and turf colour increased with higher nitrogen applications. Synder and Burt (1976) observed that turf appearance increased with the increase in nitrogen rates while Carrow and Johnson (1989) found increase in turf grass quality with increased levels of P. Marcolino *et al*. (2004) also observed higher quality ratings for appearance, colour and density with increased nitrogen rates. Creemers-Molennar and Beerepoot (1992) reported that Amenity type have dark green leaf blade colour than Agricultural type grasses and hence, scored more turf colour scores. The turf colour was also consistently green during March, 2010 whereas, in May, 2010 it scored least points as it degraded to yellow and grey. This variation in colour could be due to the high temperature and low rainfall during May, 2010 (Appendix-I) and it could also be associated with the decrease in photosynthetic capacity and increase in respiration rate (Liu & Huang, 2001).

As the Amenity type established more effectively, this resulted in thicker ground cover, thereby, suppressing the weed growth. Greenfield (1962) reported that *Lolium perenne*'s rapid growing and ability to cover ground quickly excludes weeds. Bo (1989) has also reported about 100% ground cover in *Lolium perenne* L. which resulted in minimum weeds to emerge. In the present studies, minimum presentability score was attained when no treatment was given. These results are in conformity with Miltner *et al*. (2005) who emphasized that unacceptable quality of turf grass was attained due to weed encroachment under lowest N applications.

The number of mowings required also determined the final presentability. During March,2010, the number of mowings required were comparatively less as compared to July, 2009 to September, 2009, because the culm length (cm) increased during July, 2009 to September, 2009 due to adequate rains (Appendix-I). Therefore, lesser number of mowings during March, 2010 added to the presentability score. Amenity type required less number of mowings than Agricultural type as it grows vertically and more slowly than forage grasses (Creemers-Molennar and Beerepoot, 1992). Also, Amenity type had more fine leaf blade texture than Agricultural type (Creemers-Molennar and Beerepoot, 1992).

Nitrogen favours good leaf density and root development under sod. Phosphorus results in the development of a good root system and potassium increases vigour in plants and promotes root development too (Vengris, 1973). Multiplication rate and rooting behaviour also shows the same results where number of propagules and fresh root weight (g) increased with 100% required dose of fertilizers, vermicompost and biofertilizers while root length and dry root weight (g) increased with 100% required dose of fertilizers, Farm Yard Manure and biofertilizers. These results are in conformity with that of Marcolino *et al.* (2004), Turgeon and Street (1979) and Trenholm *et al.* (2001) who reported that turf density, sod strength and shoot density increases with the increase in N rates, respectively. Hussein and Arafa (2009) also described that turf density and root growth increased with increasing nitrogen rates. Al-Karaki *et al.* (2007) too, advocated that more biomass and root growth was obtained with AM-fungi inoculation. Glinski *et al.* (1990) also emphasized that nitrogen helps in extensive root growth while Hussein and Mansour (2003) found that root development was more with more nitrogen in combination with the biofertilizers.

The promotion of synthesis and accumulation of chlorophyll as a result of nitrogen fertilization or the use of nitrogen fixing bacteria may be attributed to the role of N as an essential component in structure of porphyrines, which are found in many metabolically active compounds including chlorophylls. Chlorophylls are bound to and perhaps even embedded with protein molecules (Devlin, 1975). Paswan and Machahary (2000) observed that chlorophyll content increased as a result of increase in nitrogen application rates in Bahia grass. The results presented in Table 16 also shows that the total chlorophylls increased with the treatment of 100% required dose of fertilizers, Farm Yard Manure and biofertilizers and 100% required dose of fertilizers, vermicompost and biofertilizers where nitrogen fertilization was supplemented with both inorganic and organic forms as compared to control.

It has been emphasized by various workers that the medium component should not be considered for their inherent nutritive value, but for their ability to maintain and supply nutritional elements in plant root zone. To assess the impact of various nutrient treatments on soil physical properties, parameters like pH, electrical conductivity (EC) and organic carbon content were studied in present investigations. Addition of nutrients through different sources significantly influenced the physical properties of the soil on all parameters. A pH range of 6.5 to 8.5 is rated as ideal for the optimum growth for most crops (Raina *et al.,* 2007) and a range of 6.5 to 8.4 for the sufficient growth of perennial ryegrass (Hannaway *et al.,* 1999), because all essential elements are soluble and available within this range. pH influences nutrient absorption and plant growth directly by the affect of $H^+$ ions, and indirectly through the influence on the nutrient availability as well as the presence of toxic ions. Maintaining the recommended pH range is important in order to provide ideal range of nutrient solubility and optimal plant production (Brady, 1974). In the present studies, 100% required dose of fertilizers, Farm Yard Manure and biofertilizers resulted in bringing the pH to the level of 7.63 which in turn enhanced the uptake of the nutrients thereby, resulting in increasing the presentability scores. Similarly, the soil salinity level expressed as EC should be maintained below 0.8 $dSm^{-1}$ as this range is suitable for all crops (Raina *et al.,* 2007) for quick and adequate absorption of nutrients. Here again, 100% required dose of fertilizers, Farm Yard Manure and biofertilizers brought the level to 0.299 $dSm^{-1}$ which is less than 0.8 $dSm^{-1}$ and resulted in better absorption of nutrients to increase the presentability scores. The organic carbon content of the soil increased to a high level (3.43%) by treatment $T_5$ (100% required dose of fertilizers, Farm Yard Manure and biofertilizers). This level has been rated as high by Raina *et al*. (2007). This resulted in high accumulation of organic matter which inturn increased the presentability scores. Addition of nutrients through inorganic and organic sources caused a marked improvement in organic carbon content which on decomposition increased the organic carbon in the soil. These findings are in conformity to that of Dong *et al*. (2004) who reported increase in soil organic carbon content with the treatments having higher nitrogen rates.

In the present investigations, residual effect of various nutritional treatments on chemical properties of soil was studied. Macronutrients like N, P and K were quantified to assess the nutritional build up in soil profile. In general, all the treatments recorded higher available nitrogen content over control. However, the highest nitrogen build up (425.21 kg/ha) was observed in treatment receiving 100% required dose of fertilizers, Farm Yard Manure and biofertilizers which is rated as medium (272-544 kg/ha) by Raina *et al.* (2007). Highest phosphorus content was recorded with 100 % required dose of fertilizers, Farm Yard Manure and biofertilizers (292.41 kg/ha) which was rated high by Raina *et al*. (2007). Higher available potassium content was recorded with 100% required dose of fertilizers, Farm Yard Manure and biofertilizers (633.17 kg/ha) as compared to other treatments which is rated as high by Raina *et al*. (2007). High levels of available N,P and K resulted in high presentability scores due to increased turf growth, root development, aesthetic appearance and turf colour. These findings are in line to that of Dong *et al*. (2004) who found increased nitrogen content in soil with increased nitrogen rates. Nektarios *et al*. (2005) also showed increase in soil P content with the higher application rate of phosphorus. Also, Singh *et al.* (2002) and Sen (2003) reported an increase in the availability of all macronutrients by the incorporation of organic matter. However, Nektarios *et al.* (2005) recorded decrease in potassium levels despite of increased application rates of potassium which are in line with our results where decrease in K has been shown by some treatments in comparison to the initial status of soil.

Addition of nitrogen through Farm Yard Manure/ compost resulted in marked improvement in the availability of macronutrients may be due to reduction in N losses through leaching and enhancement of cation exchange capacity (CEC) of soil. Phosphorus availability too improved with addition of nutrients through inorganic or organic sources. Treatments having Farm Yard Manure and Vermicompost with or without *Azotobacter* inoculation had higher availability of phosphorus due to continuous mineralization and conversion of insoluble inorganic phosphate to organic phosphates. The results are in conformity with the findings of earlier studies where addition of fertilizers enhanced N and P availability (Singh *et al.,* 2002 and Sen, 2003). Singh *et al.* (2002) reported higher availability of N and P due to addition of Farm Yard Manure or Azotobacter with 30 kg N/ha through inorganic fertilizers whereas, Sen (2003) observed combination of organic manures and inorganic fertilizers to increase the available N, P and K contents in the soil, thereby improving the soil health and justified the need of balanced fertilization in vertisols.

Leaf analysis is the suitable diagnostic tool to analyze the status of nutrients. In the present investigations, leaf nutrient content in respect of nitrogen, phosphorus and potassium have given some promising results. N, P and K content in the plant tissues significantly increased (3.78% N, 0.65% P and 2.95% K) as a result of most fertilization treatments, compared to control with maximum increase being the result from the application of 100% required dose of fertilizers, Farm Yard Manure and biofertilizers. This shows that raising the rate of inorganic nitrogen fertilizers with organic forms resulted in a steady increase in the content of these three nutrients. A similar increase in the nitrogen content of *Zoysia matrella* as a result of increasing the rate of nitrogen application was reported by Soni *et al*. (1992), Paswan and Machahary (2000) and Richardson and Boyd (2001). Also, increasing chemical nitrogen fertilization rate increased the N, P and K contents in plant tissues (Hussein and Mansour, 2003 and Razmjoo *et al*., 1996). The effect of fertilization on N, P and K contents was generally more pronounced when inorganic nitrogen fertilization was combined with the application of biofertilizers. Plants fertilized with the combination of organic and inorganic fertilizers, in the present studies, gave significantly higher

N,P and K contents than the plants which received no fertilization at all. The favourable effect of combining biofertilizers with inorganic fertilizers has also been reported on *Festuca pratensis* which showed an increase in the N content as a result of inoculation with *Klebsiella, Enterobacter*, (Haahtela, 1986) or *Azospirillum brasilense* (Yurko, 1997). Also, Kotb (1998) reported that N and P uptakes by wheat plants or kikuyu grass in combination with bacterial inoculum were more.

# *Chapter-6*

# SUMMARY AND CONCLUSION

The present studies entitled "Effect of Integrated Nutrient Management on *Lolium perenne* L." were carried out during March, 2009 to June, 2010 at the experimental farm of the Department of Floriculture and Landscaping Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP). The experiment was laid out on two genotypes in a randomized block design with 12 treatments replicated thrice.

Parameters like establishment rate, culm length, number of mowings required, weed population/$m^2$, turf growth, visual quality rating, turf colour , leaf blade texture, multiplication rate, rooting behaviour (total length of roots/clump, fresh and dry weight of roots) and chlorophyll content were studied. Soil analysis for physico- chemical properties (pH, EC and OC) and available nutrients (N, P, and K) and plant nutrient analysis (N, P and K) were carried out. Parameters like number of mowings required, weed population/$m^2$, turf growth and visual quality rating (aesthetic appearance of turf and turf colour) were selected to assess the presentability of these species. In this chapter an attempt has been made to summarize the results obtained in the studies.

- Amenity type of *Lolium perenne* L. had more establishment rate as compared to Agricultural type.
- The minimum monthly increase in culm length (cm) was recorded in Amenity type and amongst the treatments plots treated with FYM + Biofertilizers showed minimum culm length. Further, minimum culm length was recorded during April, 2010.
- Minimum number of mowings were required by Amenity type during different months of the year.
- Minimum weed population was observed in plots where Agricultural type was grown. Amongst the treatments, the plots treated with 100 % RDF +

Vermicompost + Biofertilizers was effective in reducing the weed population. Similar results of reduced weed population were recorded during January, 2010.

- Maximum turf growth was recorded in Amenity type when treated with 100 % RDF + FYM + Biofertilizers during March, 2010.
- Amenity type scored maximum points for aesthetic appearance and turf colour. Best treatment for exhibiting good aesthetic appearance and turf colour was 100 % RDF + Vermicompost + Biofertilizers during March, 2010.
- Maximum number of propagules were formed in Amenity type when treated with 100 % RDF + Vermicompost + Biofertilizers.
- Maximum root length and dry weight of roots was recorded in Amenity type when treated with 100 % RDF + FYM + Biofertilizers.
- Maximum fresh weight of roots was obtained in Amenity type when a treatment containing 100 % RDF + Vermicompost + Biofertilizers was given.
- Amenity type was observed to have maximum chlorophyll content during monsoon season (July- September), whereas, amongst the treatments, 100 % RDF + Vermicompost + Biofertilizers was effective in increasing the chlorophyll content.
- Maximum pH , EC, OC, available N, P and K and leaf N, P and K content was recorded in Amenity type when treated with 100 % RDF + FYM + Biofertilizers.
- Amenity type was most presentable during March, 2010, when treated with 100 % RDF + FYM + Biofertilizers.

Hence, it may be concluded that under mid-hill conditions of H.P. Amenity type of *Lolium perenne* L. performed well with respect to establishment rate, culm length, number of mowings required, weed population/$m^2$, turf growth, visual quality rating, turf colour, leaf blade texture, multiplication rate, rooting behaviour and chlorophyll content. pH, EC, OC, available N, P and K and leaf N, P and K content increased with the addition of 100% required dose of fertilizers along with the combination of FYM @ 5kg per meter square and the biofertilizers namely Azotobacter, PSB and VAM @ 2g each per meter square which was effective in increasing the turf grass presentability of Amenity type of *Lolium perenne* L. during March, 2010, based on the parameters like less number of mowings required, less weed population/$m^2$, more turf growth and good visual quality rating.

# Chapter-7

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|---|---|---|
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| **Name of Student** | : | **Prerna Verma** |
| **Admission Number** | : | H-2007-12-D |
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## ABSTRACT


The present studies entitled "Effect of Integrated Nutrient Management on *Lolium perenne* L. were carried out during March 2009 to June 2010 at the experimental farm of the Department of Floriculture and Landscaping, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). The experiment was conducted on 2 genotypes of *Lolium perenne* L. viz., Amenity and Agricultural type and was laid out in a randomized block design with 12 treatment combinations replicated thrice. Treatment combinations consisted of the use of biofertilizers namely, VAM, Azotobacter & PSB, inorganic fertilizers and organic manures namely, farm yard manure and vermicompost.

Amenity type of *Lolium perenne* L. performed well with respect to establishment rate, culm length, number of mowings required, weed population/$m^2$, turf growth, visual quality rating, turf colour, leaf blade texture, multiplication rate, rooting behaviour, chlorophyll content, pH, EC, OC, available N, P and K and leaf N, P and K content.

Based on the parameters like number of mowings required, weed population/$m^2$, turf growth and visual quality rating, scores were allotted to both the genotypes and presentability was worked out accordingly. Amenity type grown with 100% required dose of fertilizers, FYM (5 kg/$m^2$) and biofertilizers namely, VAM, Azotobacter and PSB (2g each/$m^2$) performed well during most parts of the year with most presentable being in the month of March, 2010.


**Signature of Major Advisor** **Signature of Student**

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**APPENDIX –I**

**Mean monthly meteorological data of Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.) for the year 2009-10 (w.e.f. March, 2009 to June, 2010)**

| Months (2009-2010) | Temperature ($^oC$) | | | Relative humidity (%) | Rainfall (mm) |
|---|---|---|---|---|---|
| | Maximum | Minimum | Mean | | |
| | | | **2009** | | |
| March | 24.90 | 8.40 | 16.65 | 41.00 | 43.30 |
| April | 28.80 | 16.60 | 22.70 | 56.00 | 26.50 |
| May | 30.80 | 15.90 | 23.27 | 56.00 | 29.60 |
| June | 33.30 | 18.50 | 25.90 | 48.00 | 37.30 |
| July | 29.00 | 19.50 | 24.25 | 70.00 | 90.30 |
| August | 28.40 | 18.80 | 23.60 | 84.00 | 54.10 |
| September | 27.10 | 15.60 | 21.35 | 85.00 | 408.00 |
| October | 26.20 | 9.70 | 17.95 | 66.00 | 2.20 |
| November | 22.20 | 5.00 | 13.60 | 68.00 | 14.70 |
| December | 19.20 | 1.90 | 10.65 | 70.00 | 0.00 |
| | | | **2010** | | |
| January | 19.80 | 1.50 | 10.65 | 64.00 | 0.40 |
| February | 19.90 | 3.70 | 11.80 | 67.00 | 3.50 |
| March | 26.8 | 9.3 | 18.1 | 49.2 | 1.0 |
| April | 31.8 | 13.8 | 22.8 | 41.4 | 2.7 |
| May | 32.5 | 16.3 | 24.4 | 43.2 | 48.2 |
| June | 39.3 | 18.3 | 28.8 | 54.4 | 168.8 |

**Source:** Meteorological Observatory, Department of Environment Science, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) 173230

## APPENDIX-II

### ANOVA for establishment rate (%) and multiplication rate

| Source of variance | Mean sum of square | | |
|---|---|---|---|
| | Degree of freedom | Establishment rate (%) | Multiplication rate |
| **Treatments** | 11 | 11.964 | 9.995 |
| **Genotypes** | 1 | 4475.684 | 264.117 |
| **Replications** | 2 | 5.154 | 1.802 |
| **Genotypes x Treatments** | 11 | 2.681 | 9.037 |
| **Error** | 46 | 6.589 | 0.265 |

### ANOVA for culm length (cm)

| Source of variance | Degree of freedom | Mean sum of square |
|---|---|---|
| **Replications** | 2 | 230.53 |
| **Treatments** | 11 | 21.59 |
| **Genotypes** | 1 | 3600.234 |
| **Months** | 11 | 982.84 |
| **Genotypes x Treatments** | 11 | 23.98 |
| **Treatments x Months** | 121 | 1.62 |
| **Genotypes x Months** | 11 | 15.26 |
| **Genotypes x Treatments x Months** | 121 | 2.91 |
| **Error** | 574 | 4.11 |

### ANOVA for weed population /$m^2$

| Source of variance | Degree of freedom | Mean sum of square |
|---|---|---|
| **Replications** | 2 | 15.32 |
| **Treatments** | 11 | 74.12 |
| **Genotypes** | 1 | 787.76 |
| **Months** | 11 | 5629.86 |
| **Genotypes x Treatments** | 11 | 32.95 |
| **Treatments x Months** | 121 | 39.34 |
| **Genotypes x Months** | 11 | 355.07 |
| **Genotypes x Treatments x Months** | 121 | 22.13 |
| **Error** | 574 | 0.41 |

**ANOVA for turf growth ($cm^2$)**

| Source of variance | Degree of freedom | Mean sum of square |
|---|---|---|
| **Replications** | 2 | 0.061 |
| **Treatments** | 11 | 10.913 |
| **Genotypes** | 1 | 43.251 |
| **Months** | 11 | 98.094 |
| **Genotypes x Treatments** | 11 | 0.976 |
| **Treatments x Months** | 121 | 1.814 |
| **Genotypes x Months** | 11 | 5.77 |
| **Genotypes x Treatments x Months** | 121 | 1.47 |
| **Error** | 574 | 0.007 |

**ANOVA for aesthetic appearance**

| Source of variance | Degree of freedom | Mean sum of square |
|---|---|---|
| **Replications** | 2 | 2.581 |
| **Treatments** | 11 | 4.566 |
| **Genotypes** | 1 | 107.238 |
| **Months** | 11 | 12.358 |
| **Genotypes x Treatments** | 11 | 0.44 |
| **Treatments x Months** | 121 | 0.71 |
| **Genotypes x Months** | 11 | 0.770 |
| **Genotypes x Treatments x Months** | 121 | 0.086 |
| **Error** | 574 | 0.132 |

**ANOVA for turf colour**

| Source of variance | Degree of freedom | Mean sum of square |
|---|---|---|
| **Replications** | 2 | 0.955 |
| **Treatments** | 11 | 3.807 |
| **Genotypes** | 1 | 4.40 |
| **Months** | 11 | 9.59 |
| **Genotypes x Treatments** | 11 | 0.272 |
| **Treatments x Months** | 121 | 0.139 |
| **Genotypes x Months** | 11 | 0.802 |
| **Genotypes x Treatments x Months** | 121 | 0.092 |
| **Error** | 574 | 0.141 |

**ANOVA for rooting behaviour**

| Source of variance | Mean sum of square | | | |
|---|---|---|---|---|
| | Degree of freedom | Total length of roots/clump (m) | Fresh weight of roots (g) | Dry weight of roots (g) |
| **Treatments** | 11 | 16.43 | 104.546 | 4.445 |
| **Genotypes** | 1 | 137.73 | 129.551 | 0.324 |
| **Replications** | 2 | 0.223 | 0.463 | 0.030 |
| **Genotypes x Treatments** | 11 | 0.795 | 1.028 | 0.011 |
| **Error** | 46 | 0.018 | 0.089 | 0.003 |

**ANOVA for chlorophyll content (mg/100g)**

| Source of variance | Mean sum of square | | | | |
|---|---|---|---|---|---|
| | Degree of freedom | Monsoon season | Post-monsoon season | Winter season | Summer season |
| **Treatments** | 11 | 0.847 | 0.072 | 0.880 | 0.167 |
| **Genotypes** | 1 | 1.742 | 1.063 | 1.381 | 0.182 |
| **Replications** | 2 | 0.003 | 0.002 | 0.006 | 0.004 |
| **Genotypes x Treatments** | 11 | 0.045 | 0.015 | 0.038 | 0.014 |
| **Error** | 46 | 5.556 E-6 | 1.389E-6 | 0.006 | 0.003 |

**ANOVA for soil nutrient analysis**

| Source of variance | Mean sum of square | | | | | | |
|---|---|---|---|---|---|---|---|
| | Degree of freedom | pH (1:2) | EC $dSm^{-1}$ | OC (%) | N (kg/ha) | P (kg/ha) | K (kg/ha) |
| **Treatments** | 11 | 0.088 | 0.017 | 0.756 | 12547.251 | 5375.833 | 18169.705 |
| **Genotypes** | 1 | 0.038 | 0.001 | 0.193 | 4751.338 | 0.423 | 84630.465 |
| **Replications** | 2 | 0.006 | 1.35 IE-5 | 0.738 | 180.357 | 6.378 | 159.055 |
| **Genotypes x Treatments** | 11 | 0.019 | 0.011 | 0.386 | 265.580 | 1595.975 | 12823.925 |
| **Error** | 46 | 0.001 | 7.485 E-6 | 0.004 | 47.331 | 7.713 | 142.28 |

**ANOVA for plant nutrient analysis**

| Source of variance | Mean sum of square | | | |
|---|---|---|---|---|
| | Degree of freedom | N (%) | P (%) | K (%) |
| **Treatments** | 11 | 2.031 | 0.028 | 0.504 |
| **Genotypes** | 1 | 0.98 | 0.071 | 0.2308 |
| **Replications** | 2 | 0.002 | 1.210E-5 | 0.008 |
| **Genotypes x Treatments** | 11 | 0.313 | 0.032 | 0.448 |
| **Error** | 46 | 0.002 | 2.097E-5 | 0.016 |

**ANOVA for presentability scores**

| Source of variance | Degree of freedom | Mean sum of square |
|---|---|---|
| **Replications** | 2 | 176.98 |
| **Treatments** | 11 | 476.83 |
| **Genotypes** | 1 | 18199.99 |
| **Months** | 11 | 7318.51 |
| **Genotypes x Treatments** | 11 | 43.99 |
| **Treatments x Months** | 121 | 36.89 |
| **Genotypes x Months** | 11 | 149.56 |
| **Genotypes x Treatments x Months** | 121 | 4.09 |
| **Error** | 574 | 0.561 |

## CURRICULUM VITAE

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