Optimum Soil: Manure to Soil Ratio for Better Germination of Triticum Seeds

Nidhi, Hanish Bansal, and Tarlochan Singh Mahajan
Department of Physics, GSS DGS Khalsa College, Patiala 147001, Punjab, India
Email: sikhsidhant@gmail.com

***Abstract*—Triticum and Rice, the two cereals are the staple food of Indians. Before green revolution, India was facing their shortage. Now India is self-sufficient. Still, there is a talk of second green revolution. In this context, it is need to boost the production of these crops to ensure sustainability. The present study is a small step in this direction. It aims at finding out the effect of cow dung/soil mixture on germination of triticum spp. (triticum) seeds. The germination of triticum seeds were studied in the soil which was mixed with cow dung in different proportions in volume wise as 1:0, 3:1, 2:1, 1:1, 1:2, 1:3, 0:1v(manure: soil) named S1, S2, S3, S4, S5, S6 and S7 (control). Obtained results showed that all the samples gave better triticum growth and improvement in germination as compared to control (0:1). Study indicated that the germination parameters like root length, shoot length, biomass etc. were increased more with appropriate mixing of organic fertilizers (cow dung) in the soil. Among the various samples, sample S6 gave the peak performance. Final results proved the prospects of using cow dung manure biochar (natural fertilizer) in respect of better germination growth of triticum.**

***Index Terms*—cow dung, germination time, germination constant, triticum**

I. Introduction

Global demand and consumption of agricultural crops for food is increasing at a rapid rate for which plant materials should be expanded [1]. Rice and triticum are the major food crops, which are cultivated over 13.5 million hectares of the Indo-Gangetic Plains (IGP) of South Asia [2]. Rice and wheat contribute more than 80% of the overall cereal production and fulfils the food requirement of millions of rural families [3]. In the Indian rural areas, 75% of daily calorie intake by human is met by rice and triticum [4]. The demand for these two cereal crops is increasing about 2% to 2.5% per annually [4]. Therefore it requires more efforts to increase the yield of these crops to ensure sustainability [3]. Triticum covers near by 25% of the total global area steadfast on cereal crops and its production needs to be enhanced to meet the growing demand [5]. India is the second largest producer of triticum in the world annually. Its production rate is 68–75 million tons for past few years [6]. Punjab tops the other Indian states with 3334.8kg/ha average yield, which is about 31% higher than the average productivity (2550.5kg/ha) of this regions [5]. Environmentalists accentuate that the excessive use of fertilizers and pesticides will create serious environmental problems, including the breakdown of resistance and the deterioration of soil fertility [7]. Some studies reveal that mineral-fertilizer (NPK and farmyard manure) recommendations are inadequate [8], [9]. The use of organic fertilizers is an important technique for better sustainability of agriculture [10]. It is assumed that average N content of animal manure is 0.7% the total manure [11]. Cow dung is high in organic materials and enrich in nutrients. India is endowed with a large number of cows and most of Indian people relied on the cows for milk and dung. In Vedic age cow dung was one of the main fuels. Cow dung was thought to be a sterilizer among ancient Indians and used to clean up home and kitchen. Cow dung could be a good source of nitrogen for Indian soil. Efficient use of animal manure specially cow could therefore improve the problem of declining land productivity in India. Irrespective of the great manure production potential in India, very little amount of the available cow dung is being utilized for crop production. This is due to unavailability of scientific basis for advising farmers on aspects such as appropriate application volume of cow dung and soil ration, and application methods. Efficient utilization of cow dung manure requires the complete understanding of the existing relationship between the plant response and nutrients in the soil following cow dung manure. Cow dung is a good moisture conservative and is also effective to ensure seed quality [9]. By applying cow manure biochar, field-saturated hydraulic conductivity of the sandy soil is improved which is beneficial for crop growth and also significantly improved the physico-chemical properties of the coarse soil [12]. Generally farmers spread cow manure biochar over the soil without mixing it in proper proportion therefore they do not get good germination which could be achieved by employing proper volume-wise mixing. Objective of the study is to get better germination by considering proper volume wise mixing of biochar and soil i.e. to get more germination rate, less germination time, more root length and shoot length etc. of triticum by mixing cow manure biochar and soil in appropriate proportion. Compost cow manure has many benefits. By mixing this compost cow dung into the soil in proper ratio, improves soil moisture-holding capacity. It allows to less watering, as the roots of plants

Manuscript received January 4, 2016; revised July 27, 2016.

doi: 10.18178/joaat.3.4.296-300

can use the absorbed water and nutrients whenever it is needed.

II. Materials and Methods

Experiment was conducted in laboratory at room temperature. During the whole span of experiment, average temperature at day time was 26 ℃ (variation 23-30 ℃) and at night 22 ℃ (variation 19-25 ℃). The humidity varied 50-88% during the observation period. The cow dung used as manure was one year old (kept under the sun for one year). Cow manure contains thought to contain ammonia and bacteria, or other microorganism that can cause disease. High ammonia levels may burn the plants Due to this reason, it is recommended that cow dung should be aged or composted prior to its use as cow manure fertilizer. The density of cow dung biochar was 0.376 grams per cubic centimeters and its appearance was blackish in color. Soil used for this experiment was loamy soil, which was mixture of sand, clay and silt. The density of soil was 1.32 grams per cubic centimeters. Seven earthen pots of equal size were used for this experiment. The upper diameter of each pot was 16cm, lower diameter 10cm and depth 15cm. Triticum grain seeds of variety HD2932 were used. Thirty seeds were placed in each pot. The depth of seed sown in each pot was one inch from neck collar. Seven samples were prepared by volume-wise mixing of cow manure biochar and soil in different proportions as 1:0, 3:1, 2:1, 1:1, 1:2, 1:3, 0:1(manure to soil ratio). These samples were named as S1, S2, S3, S4, S5, S6 and S7 (control). All the seven pots were watered regularly and simultaneously in order to maintain the proper humidity in each sample. The data collected from the laboratory studies were subjected to analysis of variance (ANOVA). Significant means were separated using the Duncan's Multiple Range Test (DMRT) at 5% level of probability. Shoot length were recorded when it was about 2 mm as germination started. The experiment was conducted for seven days. After seven days, root length and shoot length were measured using threads and scale method [12]. After that, roots and shoots were weighed using electronic compact scale having least count of 1mg. Three replicates of this experiment were considered and average results were plotted for analysis of the data. To find the number of un-geminated seeds *N* at any instant of time *t* in each set of samples a statistical equation is used [12]:

$$N = (N_k - N_i) \exp [-g (t- to)] \qquad (1)$$

N_k is the total number of seeds in the sample. N_i is the number of seeds germinated initially at time to. Substituting (t – to) = 1/g in (1), we get N = 0.368 (N_k – Ni). The germination constant g is reciprocal of time (t-to) at which, the number of seeds left in the un-germinated state reduces to 0.368 time the number of seeds in the sample at time *to* [12]. Mean germination time was calculated by using that time when germination starts i.e. *to*, it is:

$$t = (1/ g) + to \qquad (2)$$

Nested iterative procedures and least squares regressions are assimilated to estimate the germination constant [13].

III. Result and Discussion

Effect of volume wise distribution of cow dung manure and soil on germination of triticum was studied. Fig. 1 showed the germination capacity of all the samples satisfying logarithmic trend.

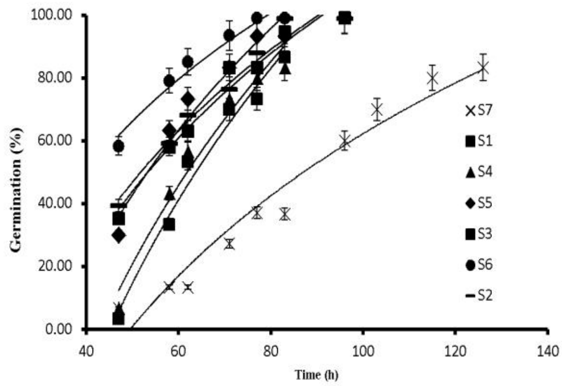

Figure 1. Variation in germination capacity (%)

Maximum germination was observed for sample S6 and S2 having manure to soil ratio of 1:3 and 3:1 respectively with same germination rate 99% in 83 hours. Germination was minimum in sample S1 (1:0) and S7 (control) with germination rate 43% and 68% respectively in the same time. The trend of germination capacity (%age of seed germination) was found to be logarithmic with R^2 approximately equal 1 (y (S1) = 88.54ln(t) - 345.4(R^2 = 0.954), y (S2) = 145.4ln(t) - 554.2(R^2= 0.977), y (S3) = 136.9ln(t) – 515(R^2= 0.965), y (S4) = 112.4ln(t) - 397.0(R^2= 0.952), y (S5) = 93.18ln(t) - 320.5(R^2 = 0.968), y (S6) = 73.26ln(t) - 220.3(R^2 = 0.960), y(S7) = 87.45ln(t) - 294.8(R^2 = 0.950)). Many authors [14] have used some statistical functions for cumulative germination like Weibull function y = M(1-exp(-k(t-z))c)), Morgan-Mercer-Flodin function y = (bk + M(tc))/(k + (tc)), Richards function y = M(1-exp(-k(t-z)))(1/(1-c)), Mitscherlich function y = M(1-exp(-k(t-z))), Gompertz function y = M(exp(-exp(-kt + b))) and logistic functions y = M/(1 + exp(-kt + b)). Many of these existing functions have no biological meaning. Presently a decay function is used to find the %age of seed left in the sample during germination with a minimum number of unknown [13]. The experimental data fitted well in the decay function as shown by R^2 values (Fig. 2) (as fitting coefficient R^2(S1) = 0.953, R^2(S2) = 0.962, R^2(S3) = 0.990, R^2(S4) = 0.958, R^2(S5) = 0.946, R^2(S6) = 0.925, R^2(S7) = 0.943).

At any time (t-to)=15h (say) %age of seeds left in sample S1-S7 were 46.66, 31.67, 36.79, 43.33, 26.66, 14.85 and 86.66 respectively (Fig. 2). It showed that germination rate in all the sample was enhanced as compared to control. With the help of decay function, number of un-germinated seeds N left in the sample can be calculated at any instant time t. The percentage of seeds left in the sample showed exponential trend followed by decay equations. From the decay equations, germination constant (g) was calculated. The germination constant was further used to determine mean germination time which was found maximum for control. Mean germination time can be defined with the help of germinating constant (g) and calculated by using formula $(1/g) + (t\text{-}t_o)$ where t_o is the initial time of germination. This equation showed that lesser the value of germinating constant more in the value of mean germination time (time taken to come from un-germinated to germinated state). Values of germination constant for different samples was calculated and found that it was highest for S6 (Fig. 3).

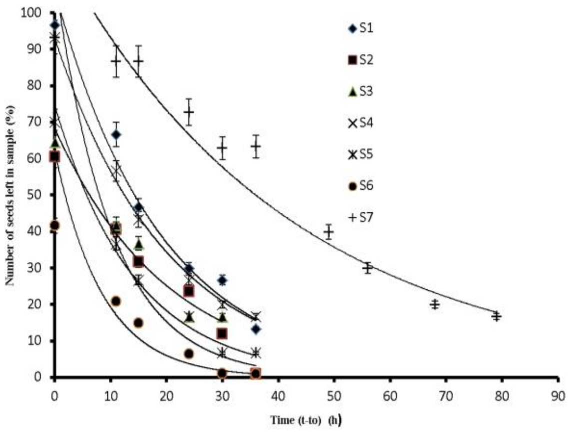

Figure 2. Percentage of number of seeds left

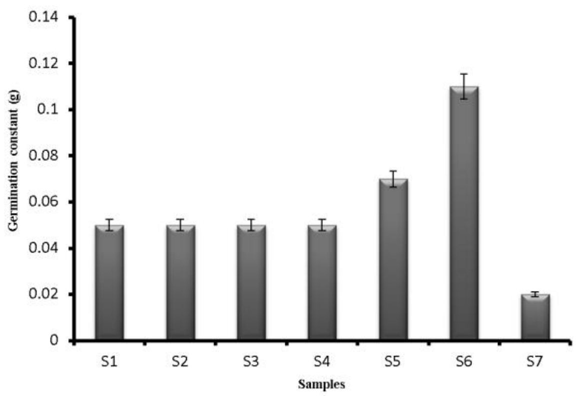

Figure 3. Showed variation of germination constant (g) which were calculated from exponential decaying equation which were obtained from Fig. 2.

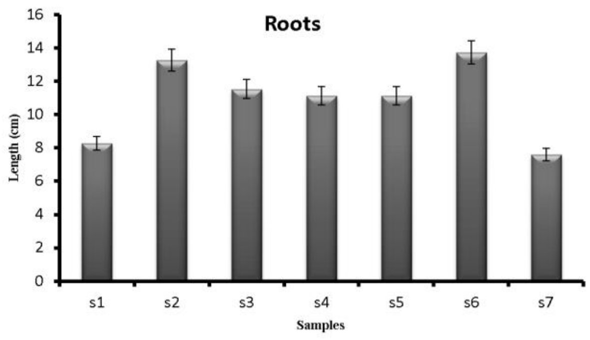

Figure 4. Bar graph showing the variation of average root length in different samples

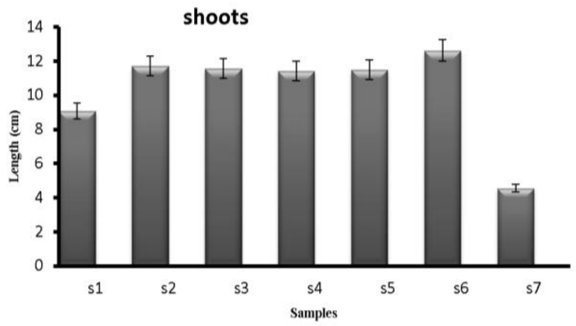

Figure 5. Bar graph showing the variation of average shoot length in different samples

Average root length and shoot length of different seven samples was shown in Fig. 4 and Fig. 5. As compared to sample S7 (control), an increase in average root length (Fig. 4) for sample S2 and S6 was 74% and 80% respectively. Average increase in shoot length (Fig. 5) of S2 and S6 as compared to sample S7 (control) was 156% and 176% respectively. In Fig. 6, biomass (the fresh mass of root length and shoot length) variation of all the samples was plotted; sample S6 had highest biomass which showed more crop yield

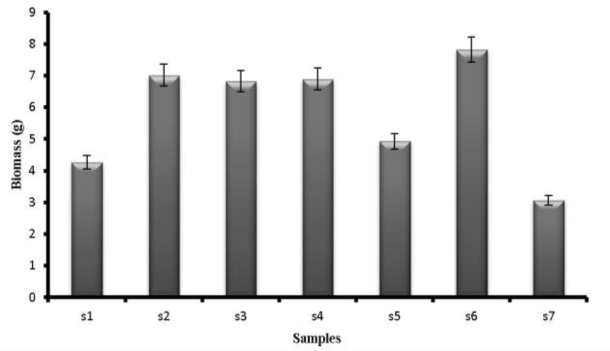

Figure 6. Variation of biomass of seven samples

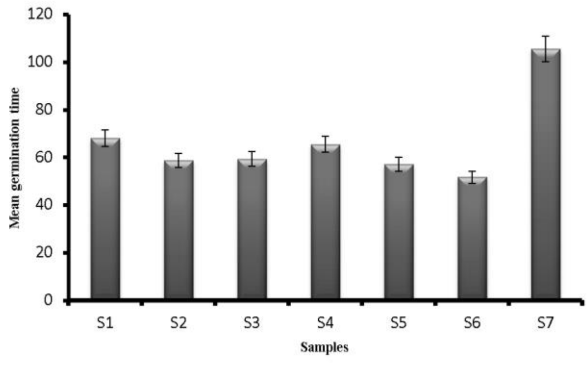

Figure 7. Variation of mean germination time

In Fig. 7, mean germination time was shown and was calculated by using the formula 1/g + (t-to). Present research showed that volume-wise mixing of cow dung with soil affected the germination process of triticum. Maximum seeds germinated (highest seed germination percentage) in sample S6 (1:3) took minimum time to germinate. The mean germination time of sample S6 (1:3), S1 (only manure) and S7 (only soil) were 51.75h, 68.14h and 105.48 h respectively (Fig. 7). Blackshaw [15] showed that composted manure gave better germination than fertilizers. Presently, one year old composted cow dung was used which had increased the germination rate (reciprocal of germination time) and found maximum for S6 sample which was $0.019h^{-1}$. Addition of cow dung compost (CDC) reduced disease and improved yield in all treatments [16]. Soil compaction can affect seedling root development by decreasing oxygen availability and increasing soil strength [16], [17]. Germination process was enhanced in sample S6 which was having 75% of soil and 25% of manure. Application of sewage sludge could be beneficial for cereal crops grown in different soils [18]. Cow dung addition to sewage sludge could improve the quality of organic matter and humidity of the substrates [19]. Sample S2 which was having 75% of cow dung manure and 25% of soil had also shown enhanced germination (more germination rate) next to S6. Annual application of cattle manure at the rate of 20 Mg ha^{-1} supplied sufficient N (nitrogen) for production of irrigated cereal silage and minimized NO_3–N leaching in a medium-textured soil [20]. Microbial numbers in the soil were highly correlated to the concentration of organic matter present in the soil [21]. Presently, mixture of cow dung and loamy soil gave better germination growth and maximum germination had seen in two samples-one with 75% of cow dung manure and the other with 75% of loamy soil. The vermicomposted FYM (Farmyard manure) also contained a considerable amount of some essential plant micronutrients e.g. Cu (0.973mg kg^{-1}), Fe (8.68mg kg^{-1}), Mn (13.64 mg kg^{-1}) and Zn (16.91g kg^{-1}) that might be responsible for better plant growth and productivity [22]. Cow dung manure was useful in reducing root knots disease of tomato by 61.7–66.6% and enhanced the plant growth in a pot experiment [23]. Ewulo [24] showed that incubation of soil with cattle and poultry manure for two month on clay soil lead to increases in. soil pH, OC, N, P, K, Ca, Mg, Na and CEC and decrease in EA. He also verified that the value of the soil chemical properties increased with amount of manure from 0 to 60g kg^{-1} and EA decreased accordingly. Maerere [11] showed that three animal manures (poultry, goat, cow) significantly increased the chemical properties of soil. Upon the application of three manures the level of N and P in soil were increased with increasing rates of applied amount. The results showed the variations among the three manures and the trend was: poultry manure > goat manure > dairy cow manure. With the application of organic manure other attributes showed improvement namely, shoot dry matter yield, taproot length and root dry weight. Maerere [11] shoed that the three types of manure, Poultry were equipped with maximum levels of total N, total P and narrowest ratios of C/N and C/P, caused superior mineralization of organic forms of N and P in the soil. Applications of the three manures could therefore immensely upgrade the fertility of this soil. It was proved that poultry manure could be a very stunning fertilizer alternative particularly for yearly crops with short growth cycle such as amaranthus. Root length and shoot length was maximum (shown in Fig. 4 and Fig. 5) in sample S6 having more volumetric percentage of soil (75% of soil and 25% of manure). Sample S6 had the maximum biomass as shown in Fig. 6 due to maximum seedling growth.

IV. Conclusions

Triticum seeds sown in a mixture of cow dung and loamy soil in different proportions were indicated that there was a critical effect on sample S6 (1:3). All the samples showed better germination parameters as compared to control. Appropriate ratio of constituents, cow dung manure and loamy soil, were responsible for better plant growth. Germination rate of all samples followed logarithmic trend with R^2 value approximately equals one. Mean germination time was minimum for sample S6 (75% of soil and 25% of manure) having maximum germination rate of $0.019h^{-1}$. Results showed that best germination of Triticum seeds happened when composed cow dung mixed with soil in ratio 1:3 (75% of soil and 25% of manure).

There is need for more research information on the relative effect of cow dung manure on different soil types (texture) and on different types of seed. Furthermore, there is a potential of further research for finding relationship between different types of animal manures and soil to manure ratio under similar field conditions.

Acknowledgment

Our foremost gratitude goes to God Almighty- for blessing us with the requisite guidance, knowledge and strength to complete this research. We are grateful to University Grants Commission (UGC) for inspiring us to pursue this type of research, could be directly beneficial to rural society.

References

[1] M. D. Edgerton, "Increasing crop productivity to meet global needs for feed, food, and fuel," *Plant Physiology*, vol. 149, no. 1, pp. 7-13, 2009.

[2] O. Erenstein, *et al.*, "On-farm impacts of zero tillage wheat in South Asia's rice–Wheat systems," *Field Crops Research*, vol. 105, no. 3, pp. 240-252, 2008.

[3] R. Gupta and A. Seth, "A review of resource conserving technologies for sustainable management of the rice–wheat cropping systems of the Indo-Gangetic Plains (IGP)," *Crop Protection*, vol. 26, no. 3, pp. 436-447, 2007.

[4] I. Cakmak, "Enrichment of fertilizers with zinc: An excellent investment for humanity and crop production in India," *Journal of Trace Elements in Medicine and Biology*, vol. 23, no. 4, pp. 281-289, 2009.

[5] H. Singh, *et al.*, "Energy consumption pattern of wheat production in India," *Energy*, vol. 32, no. 10, pp. 1848-1854, 2007.

[6] A. Joshi, *et al.*, "Wheat improvement in India: Present status, emerging challenges and future prospects," *Euphytica*, vol. 157, no. 3, pp. 431-446, 2007.

[7] M. S. Swaminathan, "An evergreen revolution," *Crop Science*, vol. 46, no. 5, pp. 2293-2303, 2006.

[8] R. Bhattacharyya, *et al.*, "Sustainability under combined application of mineral and organic fertilizers in a rainfed soybean–Wheat system of the Indian Himalayas," *European Journal of Agronomy*, vol. 28, no. 1, pp. 33-46, 2008.

[9] P. Wambugu, *et al.*, "Efficacy of traditional maize (Zea mays L.) seed storage methods in western Kenya," *African Journal of Food, Agriculture, Nutrition and Development*, vol. 9, no. 4, 2009.

[10] K. M. Hati, *et al.*, "Changes in soil physical properties and organic carbon status at the topsoil horizon of a vertisol of central India after 28 years of continuous cropping, fertilization and manuring," *Agriculture, Ecosystems & Environment*, vol. 119, no. 1, pp. 127-134, 2007.
[11] A. Maerere, G. Kimbi, and D. Nonga, "Comparative effectiveness of animal manures on soil chemical properties, yield and root growth of amaranthus (Amaranthus cruentus L.)," *African Journal of Science and Technology*, vol. 1, no. 4, 2001.
[12] K. Uzoma, *et al.*, "Effect of cow manure biochar on maize productivity under sandy soil condition," *Soil Use and Management*, vol. 27, no. 2, pp. 205-212, 2011.
[13] T. S. Mahajan and O. P. Pandey, "Effect of pre-sowing electric treatment on chickpea seed at a constant temperature," *African Journal of Biotechnology*, vol. 13, no. 3, pp. 403-412, 2014.
[14] T. S. Mahajan and O. P. Pandey, "Effect of the electric field (at different temperatures) on germination of chickpea seed," *African Journal of Biotechnology*, vol. 13, no. 1, pp. 61-67, 2014.
[15] R. Blackshaw, "Nitrogen fertilizer, manure, and compost effects on weed growth and competition with spring wheat," *Agronomy Journal*, vol. 97, no. 6, pp. 1612-1621, 2005.
[16] R. Srivastava, *et al.*, "Evaluation of arbuscular mycorrhizal fungus, fluorescent Pseudomonas and Trichoderma harzianum formulation against Fusarium oxysporum f. sp. lycopersici for the management of tomato wilt," *Biological Control*, vol. 53, no. 1, pp. 24-31, 2010.
[17] I. Bassett, R. Simcock, and N. Mitchell, "Consequences of soil compaction for seedling establishment: Implications for natural regeneration and restoration," *Austral Ecology*, vol. 30, no. 8, pp. 827-833, 2005.
[18] A. Mazen, F. A. Faheed, and A. F. Ahmed, "Study of potential impacts of using sewage sludge in the amendment of desert reclaimed soil on wheat and Jews mallow plants," *Brazilian Archives of Biology and Technology*, vol. 53, no. 4, pp. 917-930, 2010.
[19] X. Li, *et al.*, "Compositional and functional features of humic acid-like fractions from vermicomposting of sewage sludge and cow dung," *Journal of Hazardous Materials*, vol. 185, no. 2, pp. 740-748, 2011.
[20] B. M. Olson, *et al.*, "Nitrate leaching in two irrigated soils with different rates of cattle manure," *Journal of Environmental Quality*, vol. 38, no. 6, pp. 2218-2228, 2009.
[21] Y. Kazuhira, *et al.*, "Nitrogen mineralization and microbial populations in cow dung, dung balls and underlying soil affected by paracoprid dung beetles," *Soil Biology and Biochemistry*, vol. 23, no. 7, pp. 649-653, 1991.
[22] S. Suthar, "Impact of vermicompost and composted farmyard manure on growth and yield of garlic (Allium stivum L.) field crop," *International Journal of Plant Production*, vol. 3, no. 1, pp. 27-38, 2009.
[23] D. Kumar and K. Singh, "Assessment of predacity and efficacy of Arthrobotrys dactyloides for biological control of root knot disease of tomato," *Journal of Phytopathology*, vol. 154, no. 1, pp. 1-5, 2006.
[24] B. Ewulo, "Effect of poultry dung and cattle manure on chemical properties of clay and sandy clay loam soil," *J. Anim. Vet. Adv.*, vol. 4, no. 10, pp. 839-841, 2005.

Tarlochan Singh Mahajan obtained his master degree in Physics from Punjabi university Patiala in 1981. He did Post M.Sc. diploma in Electronics and TV Engg. from Punjabi University Patiala, India in 1982 and stood first in merit. Dr. Mahajan earned recently his Ph.D. from Thapar University (in March 2014). He started his carrier as Assistant Professor at Department of Physics, GSSDGS Khalsa College, Patiala, India in October 1984. Currently he is working as Head of Physics Department in the same college. His research interests include Phase conjugation (Theoretical Physics), Agriculture Physics and comparative study of Religion and Science. Dr. Mahajan has also had a public presence through his writing in state level newspaper, and TV appearances. He has many national and international conference presentations and publications to her credit. In 1993, Dr. Mahajan wrote a book 'Gurbani and Science'. This book bagged 'excellent book award' from language department Punjab. In 2006, he released a wonderful book on the topic "Present and future Science in the light of Gurbani". In this book he proved that whatever science is telling us today the same was written in Guru Granth Sahib about 500 years ago.

Hanish Bansal has an MSc in Applied Physics is an Assistant Professor at Physic Department Khalsa College, Patiala. He obtained his BSc and MSc degree from Punjabi University Patiala (Pb.) India. His main activities are related to the development of agro physics. His current research interests include germination parameters like right conditions for minimizing the dormancy of the seeds for agro-industrial sector.

Ms. Nidhi has done Master of Science in Applied Physics from Punjabi University Patiala and presently working as an Assistant Professor in Physics at Khalsa College, Patiala, India under the kind guidance of Dr. Tarlochan Singh Mahajan. Her main activities are related to the blooming of agro physics. Her current research approach to conclude the germination parameters like appropriate conditions for emphasizing the seeds dormancy for agro-industrial sector.