Effect of organic manures, fertilisers and their integrated combinations on seed quality parameters in wheat (*Triticum aestivum* L.)

V.S. Mor[1], DevRaj[2], A. Bhuker[1], A. Malik[1], N. Singh[1], V. Singh[3] and R.N. Sheokand[4]

[1]Department of Seed Science and Technology

[2]Department of Soil Science

[3] Wheat and Barley Section, Department of Genetics and Plant Breeding

[4]Computer Section, College of Basic Sciences and Humanities

CCS Haryana Agricultural University, Hisar, Haryana 125004, India

virendermor@gmail.com

Abstract

Quality seed can be created only by nourishing the crop plant in fertile soil under suitable climatic conditions. An ongoing long-term soil fertility experiment was selected to study the impact of organic manures, fertilisers and their integrated application on seed quality parameters of wheat (cv WH 711). The organic manures (15 t/ha farm yard manure (FYM), 5 t/ha poultry manure and 7.5 t/ha sugar factory waste (pressmud), and chemical fertilisers (100% recommended dose of fertilisers (RDF): 150 kgN+60 kgP_2O_5/ha and 50% RDF: 75 kgN+30 kg P_2O_5/ha) has been applied alone and in combinations since 1995. After 16 years of experimentation, results showed that the application of organic manures in combination with nitrogen (N) and phosphorous (P) fertilisers significantly increased the seed yield of wheat (5.54, 5.25 and 5.32 t/ha) when the recommended dose of N and half of P was applied in conjunction with FYM, poultry manure and pressmud respectively. Seed yield of wheat increased by 12.83, 6.82 and 8.3 per cent respectively with the application of organic manures in combination with N and P fertilisers under the same treatments when compared with the use of recommended dose of N and P fertilisers alone. Among the organic manures, the highest yield (2.75 t/ha) was obtained with pressmud application. However, application of organic manures alone resulted in poor yield and even lower than 50 per cent of the recommended dose of N and P fertilisers. All the seed quality parameters (standard germination, shoot length, root length, seedling dry weight, seedling vigor index-I and II, tetrazolium test, dehydrogenase activity, field emergence index and seedling establishment) improved with the combined application of organic manures and chemical fertilisers as compared to their individual application while thousand grain weight and electrical conductivity showed the inverse pattern. The high seed yield along with better quality was obtained with integrated approach as compared to organic manures and chemical fertilisers applied alone.

Additional keywords: Seed yield, seed quality, manures, fertilisers

Introduction

Seed quality and soil fertility are two key determinants for enhancing crop production to ensure food security. The quality and quantity of seed depends upon different factors which include soil, climate and performance of agricultural operations during the growth of the plant from planting to harvest (McDonald & Copeland 1997). Seed is the most important input in any crop production and without healthy and quality seeds all expenditure incurred on other inputs is wasted. Good quality of seed is also one of the important means to increase productivity in any crop (Lamo *et al.* 2012). Seed vigor and germination ability directly affect yield whereas seed quality affects seedling emergence (Tekrony & Egli 1991). Seeds are composed of many different types of biochemical, like all living organisms, but seeds are unique because they are a storehouse of compounds that are used as food reservoir for the next generation plant (Ferguson & Mchughlin 2009).

Wheat *(Triticum aestivum)* is the most widely grown crop in the world and the second most important food crop after rice. The global demand for wheat by 2050 is expected to increase by 31 per cent over the 683 million tons consumed in 2008 (Dixon *et al.* 2009). In India, wheat occupies about 26.7 million hectares area and contributes about 33.9 per cent of the total food grain production. This signifies the important contribution of wheat in meeting the food requirements of the country. Increasing wheat productivity is a national target to fill the gap between wheat consumption and production. Therefore, it is necessary to provide fertile soil conditions for better growth of wheat crops in achieving not only high quantity but also for quality seed yield.

Both viability and vigor are considered as the important quality characteristics of any seed. The application of fertilisers is one of the primary methods for improving the availability of soil nutrients to plants. Soil fertilization can change rates of plant growth, maturity time, size of plant parts, photochemical content of plants and seed capabilities (Mevi-Schutz *et al.* 2003). High-input practices such as heavy use of chemical fertilisers have created a variety of economic, environmental, ecological and social problems. High cost of fertilisers is not affordable by some, leading to under dose application of fertilisers to the crops. As a result, they are harvesting poor seed yield from under nourished crops. Consequently, this leads to low quality seed and hence reduces farm income (Tung & Farnandez 2007; Khadem *et al.* 2010).

Over the past decade, India has exhibited a rapid uptake of organic farming. The application of ample amounts of organic manure is the key to success of organic farming. The continuous addition of organic manures to the soil increases its humus content gradually, improves physical and chemical conditions by providing a favorable soil structure, enhancing soil cation exchange capacity, increasing the quantity and availability of plant nutrients and providing the substrate for microbial activities (Bohme & Bohme 2006). However, use of organic inputs in cropping systems often has to deal with a scarcity of readily available nutrients in contrast to high input cropping systems which relies on widely available soluble fertilisers. Thus, soil fertility can be restored effectively through adopting the concept of integrated soil fertility management (Antil *et al.* 2011)

encompassing a strategy for nutrient management based on natural resource conservation.

Integrated use of organic and inorganic nutrient sources sustain yield and build up soil quality for enhanced production (Kumara *et al.* 2013; Brar *et al.* 2015). Integrated use of organic manures like farm yard manure with mineral nitrogen sources is advocated due to its profound benefits. Continuous addition of organic manures for a long time may increase the build-up of soluble salts and nutrients in soil under arid and semi-arid conditions (Hao & Chang, 2003; Watts *et al*. 2010) which may affect plant growth and quality of produce. As the quality of seed is essential for better field emergence and optimum plant stand, the seed produced by providing different sources of nutrition need to be evaluated. Keeping in view the above facts, the present study was carried out with the objective to evaluate the seed quality of wheat produced by different organic, inorganic and integrated source of nutrients under a long-term fertility experiment in a semi-arid environment.

Materials and Methods

A long-term field experiment was initiated in 1995 at Research Farm of Department of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana (India) to study the effects of various combinations of organic manures and chemical fertilisers on productivity and fertility of soil under a pearl millet-wheat cropping sequence. The experimental site is located at 29°16'N latitude and 75°7'E longitude in the north-west part of India. The climate of the area is semi-arid with a mean annual precipitation of 443 mm and a mean annual temperature of 24.8 °C. The soil is coarse loamy, *TypicUstochrept*. The chemical properties of the surface soil (0–15 cm) analyzed at the start of the experiment (1995) and after 16 years of experimentation (2011) are presented in Table 1. The average nutrient composition of farm yard manure (FYM), poultry manure and sugar factory waste produced during purification of sugarcane juice (pressmud) applied in the experiment during past 16 years are presented in Table 2. Ten treatments with three replications were maintained since 1995 on the permanent plot size of 24×5 m in a randomized block design (Table 3). The organic manures are applied once in each year at the time of wheat sowing in winter season. However, the same doses of chemical fertilisers were applied to the succeeding crop, pearl millet in summer season. The N and P were applied through urea and DAP, respectively. The wheat crop (cv WH 711) was sown in mid November 2011 and 2012 under the recommended package of practices (CCS Haryana Agricultural University, Hisar). The seed yield was recorded from each plot and seed quality attributes: thousand grain weight, standard germination, shoot length, root length, seedling dry weight, seedling vigor index-I & II, tetrazolium test, dehydrogenase activity, electrical conductivity, field emergence index and seedling establishment were recorded in the laboratories and field as per the standard procedure of ISTA (2011).

The seed samples were digested in di-acid mixture of H_2SO_4 and $HClO_4$ in the ratio of 9:1 in a digestion chamber. The digested seed samples were analyzed for total N, P, K contents. Total N was determined calorimetrically by using Nessler's reagent method (Lindner 1944). P was determined by ammonium molybdovanadate yellow

colour method (Koening & Johnson 1942) and K was determined by flame emission photometer in acid digested plant material.

Statistical analyses were accomplished using the program SAS 9.3. DUNCAN multiple-range test was applied in various seed quality parameters in order to compare the significant differences within the treatments.

Table 1: Soil properties after 16 years of experimentation (2011) in long term field experiment at CCSHAU,Hisar. Source: Kumara, B.H. (2013).

Organic Manures		Fertiliser (kg/ha)		Soil properties					
Types of manure	Dose t/ha	N	P_2O_5	pH	EC dS/m	OC %	N mg/kg	P mg/kg	K mg/kg
No manure	0	75	30	8.10	0.39	0.36	64.5	8.9	173
	0	150	60	8.02	0.41	0.43	67.5	9.6	178
FYM	15	0	0	7.65	0.51	1.01	82.6	59.0	294
	15	150	0	7.67	0.51	0.98	82.7	26.9	298
	15	150	30	7.78	0.51	1.12	84.6	28.0	302
Poultry manure	5	0	0	7.86	0.46	0.59	78.4	28.6	247
	5	150	30	7.85	0.47	0.58	80.9	29.0	253
Pressmud	7.5	0	0	7.78	0.48	0.73	95.7	27.1	253
	7.5	75	30	7.78	0.45	0.76	95.7	27.2	261
	7.5	150	30	7.77	0.48	0.75	98.3	27.3	267
Initial in 1995				8.1	0.36	0.39	98.0	12.6	217

Table 2: Chemical composition (%) of various organic manures used in the experiment (average of 16 years).

Parameters	Farm Yard Manure	Poultry Manure	Pressmud
Organic Carbon	36.0	25.1	49.7
Nitrogen	1.23	2.52	3.25
Phosphorus	0.96	1.83	1.11
Potassium	1.87	1.73	0.87
C:N ratio	29.3	9.96	15.3

Table 3: Treatment details of organic manures, fertilisers and their integrated combinations used for randomized block design of longterm field experiment.

Sr. No.	Treatment details /ha	Treatments as shown in Tables			
		Organic manures		Fertiliser kg/ha	
		Type	Dose t/ha	N	P_2O_5
T_1	75 kg N + 30 kg P_2O_5	No manure	0	75	30
T_2	150 kg N + 60 kg P_2O_5		0	150	60
T_3	15 t FYM	Farm yard manure	15	0	0
T_4	15 t FYM + 150 kg N		15	150	0
T_5	15 t FYM + 150 kg N + 30 kg P_2O_5		15	150	30
T_6	5 t Poultry Manure	Poultry manure	5	0	0
T_7	5 t Poultry Manure + 150 kg N + 30 kg P_2O_5		5	150	30
T_8	7.5 t Pressmud	Sugar factory waste produced during purification of sugarcane juice	7.5	0	0
T_9	7.5 t Pressmud + 75 kg N + 30 kg P_2O_5		7.5	75	30
T_{10}	7.5 t Pressmud + 150 kg N + 30 kg P_2O_5		7.5	150	30

Results

Seed yield of wheat

The seed yield of wheat (cv WH 711) varied from 2.45 to 5.48 and 2.61 to 5.60 t/ha under different treatment combinations of organic and inorganic sources of nutrients during 2011–2012 and 2012–2013, respectively. The lowest grain yield of wheat was recorded when either 15 t FYM or 5 t poultry manure or 7.5 t pressmud/ha was applied alone (Table 4). When FYM was applied in combination with the recommended dose of N fertiliser, a significant increase in yield was recorded over FYM applied alone which was similar to the recommended dose of NP fertilisers. The seed yield was further increased when half of the recommended dose of P was added. The highest pooled seed yield of wheat (5.54 t/ha) was recorded with the application of $FYM_{15}N_{150}P_{30}$ but this was not statistically different to $pressmud_{7.5}N_{150}P_{30}$ (5.32 t/ha). Seed yield of wheat increased by 118.97, 101.34 and 93.53 per cent with application of 15 t FYM, 5 t poultry manure and 7.5 t pressmud/ha along with recommended N and half of the recommended dose of P over manures applied alone, respectively. Seed yield of wheat increased by 12.83, 6.82 and 8.39% under the same treatments when compared with the recommended dose of N and P fertilisers. The seed yield of wheat was significantly lower than that of 50% of the recommended dose of NP fertilisers even after application of organic manures alone for 16 years in the same plot.

Table 4: Effect of long-term application of organic manures, fertilisers and their integrated combinations on seed yield (t/ ha) of wheat.

Organic Manures		Fertiliser (kg/ha)		Seed Yield (t/ha)
Type of manure	Dose (t/ha)	N	P_2O_5	
No manure	0	75	30	3.46^{E}
	0	150	60	4.91^{C}
FYM	15	0	0	2.53^{F}
	15	150	0	5.11^{BC}
	15	150	30	5.54^{A}
Poultry Manure	5	0	0	2.61^{F}
	5	150	30	5.25^{ABC}
Pressmud	7.5	0	0	2.75^{F}
	7.5	75	30	4.19^{D}
	7.5	150	30	5.32^{AB}
General Mean				4.17
Range				2.53 - 5.54
F-Value				100.67**
CV (%)				4.14

** - Significant at 1%, * - Significant at 5%, NS - Non Significant
Means with one letter common are not statistically significant using DUNCAN's Multiple Range Test

Seed quality of wheat

All physiological seed quality parameters in laboratory viz: standard germination, shoot and root length, seedling length, seedling dry weight, seedling vigor index-I and –II and in field viz: field emergence index and seedling establishment were improved with combined application of organic manures and fertilisers as compared to their individual application (Table 5). However, thousand grain weight showed an opposite trend. The pooled data of thousand grain weight varied from 37.99 to 41.64 g, standard germination from 89.67 to 96.67 per cent, shoot length from 10.91 to 12.36 cm, root length from 20.58 to 23.34 cm, seedling length from 32.76 to 35.27 cm, seedling dry weight from 0.145 to 0.168 mg, seedling vigor index-I from 2,990 to 3,345 and vigor index-II from 1.35 to 1.61, field emergence index from 6.91 to 8.47 and seedling establishment from 66.50 to 74.67 per cent under different treatment combinations. All of the seed quality parameters except thousand grain weight showed better value under integrated application of manures and fertilisers, whereas thousand grain weight was found highest under application of manure alone.

Table 5: Effect of long-term application of organic manures, fertilisers and their integrated combinations on physiological seed quality parameters of wheat.

Organic Manures		Fertiliser (kg/ha)		Seed Quality Parameters									
Type of manure	Dose (t/ha)	N	P_2O_5	Thousand grain weight (g)	Standard germination (%)	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Seedling dry weight (mg)	Vigour index-I	Vigour index-II	Field emergence index	Seedling establishment (%)
No manure	0	75	30	41.64	89.67^{E}	11.80	21.53	33.34	0.155	2990	1.39^{DE}	7.29^{D}	68.00^{CD}
	0	150	60	38.10	93.17^{BC}	12.42	21.96	34.38	0.165	3202	1.54^{ABC}	8.18^{AB}	72.50^{AB}
FYM	15	0	0	41.16	91.17^{DE}	10.91	22.21	33.12	0.160	3019	1.46^{BCDE}	7.06^{D}	67.17^{CD}
	15	150	0	38.85	94.17^{B}	11.97	22.55	34.53	0.164	3252	1.55^{AB}	7.36^{D}	68.67^{CD}
	15	150	30	39.34	94.83^{AB}	11.93	23.34	35.27	0.168	3345	1.61^{A}	8.12^{ABC}	74.67^{A}
Poultry manure	5	0	0	40.81	93.17^{BC}	12.19	20.58	32.76	0.145	3053	1.35^{E}	7.15^{D}	66.50^{D}
	5	150	30	38.07	96.67^{A}	12.36	21.24	33.60	0.165	3248	1.59^{AB}	7.50^{CD}	69.83^{BC}
Pressmud	7.5	0	0	41.00	91.33^{CDE}	11.72	21.91	33.64	0.155	3072	1.42^{CDE}	6.91^{D}	67.00^{CD}
	7.5	75	30	39.92	91.67^{CD}	11.90	22.10	34.00	0.165	3116	1.51^{ABCD}	7.53^{BCD}	69.33^{CD}
	7.5	150	30	37.99	92.00^{CD}	12.12	22.54	34.66	0.165	3189	1.52^{ABCD}	8.47^{A}	73.50^{A}
General Mean				39.69	92.78	11.93	22.00	33.93	0.1607	3149	1.49	7.56	69.72
Range				37.99 - 41.64	89.67- 96.67	10.91- 12.42	20.58 - 23.34	32.76 - 35.27	0.145 - 0.168	2990 - 3345	1.35 - 1.61	6.91 - 8.47	66.50 - 74.67
F Value				1.36^{NS}	23.25**	1.60^{NS}	0.62^{NS}	0.65^{NS}	2.72^{NS}	1.56^{NS}	4.08*	6.09**	10.24**
CV (%)				4.31	0.65	4.00	6.27	4.03	3.93	4.18	4.10	4.00	1.83

** - Significant at 1%, * - Significant at 5%, NS - Non Significant

Means with one letter common are not statistically significant using DUNCAN's Multiple Range Test

Table 6: Effect of long-term application of organic manures, fertilisers and their integrated combinations on biochemical seed quality parameters of wheat.

Organic Manures		Fertiliser (kg/ha)		Seed Quality Parameters					
Type of manure	Dose (t/ha)	N	P_2O_5	Electrical conductivity (µS/cm/seed)	Tetrazolium Test (%)	DHA (OD)	N (%)	P (%)	K (%)
No manure	0	75	30	1.12^{C}	90.50^{D}	0.48^{E}	2.62^{A}	0.48^{G}	0.33^{DE}
	0	150	60	0.99^{C}	95.50^{AB}	0.55^{B}	2.60^{A}	0.50^{F}	0.31^{E}
FYM	15	0	0	1.41^{AB}	92.17^{CD}	0.49^{DE}	2.43^{CD}	0.55^{AB}	0.34^{D}
	15	150	0	1.08^{C}	95.17^{AB}	0.58^{A}	2.64^{A}	0.52^{DE}	0.37^{BC}
	15	150	30	1.09^{C}	96.17^{AB}	0.59^{A}	2.59^{AB}	0.50^{F}	0.35^{CD}
Poultry manure	5	0	0	1.57^{A}	95.17^{AB}	0.49^{D}	2.46^{BCD}	0.56^{A}	0.34^{D}
	5	150	30	1.11^{C}	97.17^{A}	0.59^{A}	2.55^{ABC}	0.55^{AB}	0.38^{AB}
Press mud	7.5	0	0	1.26^{BC}	92.00^{CD}	0.52^{C}	2.34^{D}	0.54^{BC}	0.37^{BC}
	7.5	75	30	1.06^{C}	93.67^{BC}	0.54^{B}	2.65^{A}	0.53^{CD}	0.37^{BC}
	7.5	150	30	1.01^{C}	93.50^{BC}	0.55^{B}	2.57^{AB}	0.51^{EF}	0.40^{A}
General Mean				1.17	94.10	0.54	2.54	0.52	0.35
Range				0.99 - 1.57	90.50 - 97.17	0.48 - 0.59	2.34 - 2.65	0.48 - 0.56	0.31 - 0.40
F -Value				14.55**	9.89**	98.02**	5.95**	25.19**	14.21**
CV (%)				5.95	1.00	1.11	2.33	1.49	2.75

** - Significant at 1%, * - Significant at 5%, NS - Non Significant

Means with one letter common are not statistically significant using DUNCAN's Multiple Range Test

Among all physiological seed quality parameters, standard germination, field emergence index and seedling establishment showed significant difference at P<0.01, while vigor index- II at P<0.05 and rest parameters did not show any significant difference under above mentioned treatments.

All biochemical seed quality parameters in laboratory viz: tetrazolium test (%), dehydrogenase activity (OD), seed nitrogen and potassium content per cent were significantly improved (P<0.01) with combined application of organic manures and fertilisers as compared to their individual application (Table 6), whereas electrical conductivity and seed phosphorus content per cent showed an inverse trend. The pooled data of tetrazolium test varied from 90.50 to 97.17 per cent, dehydrogenase activity from 0.48 to 0.59 OD, electrical conductivity from 0.99 to 1.41µS/cm/seed, N content in seed ranged from 2.34 to 2.65 per cent, P from 0.48 to 0.56 per cent and K from 0.31 to 0.40 per cent under different treatment combinations. All biochemical seed quality parameters except electrical conductivity and P content showed higher quality under integrated combination of manure and fertiliser, whereas electrical conductivity and P content were found to be highest under manure application alone.

Discussion and Conclusion

Seed yield and quality parameters (physiological and biochemical) increased with the combined application of organic manures and fertilisers. Application of organic manures alone resulted in poor yield attributes. In addition to low nutrient content in manures, the organic forms mineralize slowly and cannot fulfill the nutrient demands of the growing crop. Continuous application of organic manures alone for 16 years in the same field could not produce the higher yield compared with the recommended dose of chemical fertilisers. This may be due to continuous loss of mineralized N from the soil by leaching and volatilization processes, reducing the N uptake by wheat crop. Thus organic manures alone cannot supply enough N to the crops. However, the higher yield of wheat (WH 711) that was observed with the application of FYM over other manures may be due to better soil quality developed with FYM application. The pooled data reveal that the seed yield of wheat under different combinations of organic and inorganic source of nutrients follow the trend: FYM > pressmud > poultry manure. The supply of plant nutrients by fertilisers and mineralized nutrients from organic manures meet the need of the crop slowly but continuously along with readily available macro and micronutrients which result in a better plant canopy. Consequently, the higher rate of photosynthesis resulted in increased productivity.

Narwal & Antil (2005) and Brar *et al.* (2015) also reported the superiority of combined application of FYM and recommended dose of chemical fertilisers in increasing the productivity of pearl millet-wheat cropping system as compared to application of recommended dose of chemical fertilisers alone.

All the seed quality parameters, except thousand grain weight and electrical conductivity, improved with the combined application of manures and fertilisers over their individual applications. The higher thousand grain weight observed with the application of organic manures alone was

due to less seed setting under poor availability of nutrients during seed formation and development stages. So, the application of organic manure alone gave low seed yield with high thousand grain weight. The high electrical conductivity of seeds produced with the application of organic manure alone may be due to more absorption of salts by the plant from the soil in absence of sufficient quantity of available nutrients, which is an indication of poor quality of seed. The improved seed quality in integrated combinations was due to better filled seeds with accumulation of higher quantities of seed constituents under well-nourished conditions. This was also indicated by higher N content in the seed harvested under above condition in the present study (Table 6). The results of the present study are in conformity of previous findings of short-term field experiments (Channabasanagowda *et al.* 2008 in wheat and Peerzada *et al.* 2016 in fenugreek). However, the present study was conducted in the conditions where application of organic manures was in practice over the last 16 years.

Integrated use of organic manures and chemical fertilisers provided nutrients that were readily available in soil and resulted in an increase of N, P and K concentrations and uptake which resulted in better absorption of water and nutrients by the plants (Antil *et al.* 2011; Brar *et al.* 2015). The higher nutrient content in seed with integrated use of FYM and fertilisers were also reported by other workers (Chesti *et al.* 2013; Parmer 2014). In the present study, the organic manures with narrow C: N ratio (<30) tended to decompose faster and release nutrients for crop uptake.

These results show that combined application of organic manures and chemical fertilisers not only gave better yield and seed quality but also improve the nutrient uptake by the plants as compared to organic manures and fertilisers applied alone. Therefore it is concluded that more focus should be given to the use of combined application of organic manures and chemical fertilisers to soil for sustainable quality seed production under eco-friendly cultivation.

Acknowledgements

Authors are highly thankful to Dr. (Mrs) Poonam Mor, Assistant Professor, Department of Haryanvi Culture and Languages, CCS HAU Hisar for language editing of the manuscript.

References

Antil, R.S.; Narwal, R.P.; Singh, B.; Singh, J.P. 2011. Integrated nutrient management for sustainable soil health and crop productivity. *Indian Journal of Fertilizers 7*: 14-32.

Bohme, L.; Bohme, F. 2006. Soil microbiological and biochemical properties affected by plant growth and different long-term fertilization. *European Journal of Soil Biology 42*: 1-12.

Brar, B.S.; Singh, J.; Singh, G.; Kaur, G. 2015. Effects of long term application of inorganic and organic fertilizers on soil organic carbon and physical properties in maize-wheat rotation. *Agronomy 5*: 220-238.

Channabasanagowda, N.K.; Patil, B.; Patil, B.N.; Awaknavar, J.S.; Ninganur, B.T.; Hunje, R. 2008. Effect of organic manures on growth, seed yield and quality of wheat. *Karnataka Journal of Agricultural Sciences 21:* 366-368.

Chesti, M.H.; Kohli, A.; Sharma, A.K. 2013. Effect of integrated nutrient management on yield of and nutrient uptake by wheat and soil properties under intermediate zone of Jammu and Kashmir. *Journal of Indian Society of Soil Science 61:* 1-6.

Dixon, J.; Braun, H.J.; Crouch, J. 2009. Transitioning wheat research to serve the future needs of the developing world. In: Wheat Facts and Futures. International Maize and Wheat Improvement Centre (CIMMYT), DF, Mexico.

Ferguson J.M.; Mchughlin, F.W. 2009. *Seed and seed quality* (pp. 25-66). North Carolina Department of Agriculture Seed Program.

ISTA 2011. International rules for seed testing. International Seed Testing Association. Baserdorf, Switzerland.

Khadem S.A.; Galavi, M.; Ramrodi, M.; Mousavi, S.R.; Rousta, M.J.; Rezvani, M.P. 2010. Effect of animal manure and superabsorbent polymer on corn leaf relative water content, cell membrane stability and leaf chlorophyll content under dry condition. *Australian Journal of Crop Sciences 4:* 642-647.

Koening, R.A.; Johnson, C.R. 1942. Colorimetric determination of phosphorus in biological materials. *Indian English Chemical Analysis 14:* 155-156.

Kumara, B.H. 2013. Long term effects of organic manures and fertilizers on soil organic carbon pools and nitrogen fractions. Ph.D. thesis submitted to CCS Haryana Agricultural University, Hisar.

Kumara, B.H.; Antil, R.S.; Dev Raj. 2013. Long term effects of nutrient management on soil health and crop productivity under Pearl millet-wheat cropping system. *Indian Journal of Fertilizers 9:* 86-97.

Lamo K.B.; Korla, N.; Ahukla, Y.R. 2012. Effect of different organic and inorganic nutrient sources on leaf chlorophyll content under dry condition. *Australian Journal of Crop Sciences 4:* 642-647.

Lindner, R.C. 1944. Rapid analytical methods for some of the more common inorganic constituents in plant tissue. *Plant Physiology 19:* 76-86.

McDonald, M.B.; Copeland. L.O. 1997. Seed Production, Principles seed priming treatments on emergence and seedling growth of *Sorghum bicolor* and *Pennisetumglaucum*in pot trials under greenhouse conditions. *Journal of Agronomy & Crop Sciences 182:* 135-141.

Mevi Schutz, T.; Goverde, J.M.; Erhardt, A. 2003. Effects of fertilization and elevated CO2 on larval food and butterfly nectar amino acid preference in *Coenonymphapamphilus*L. *Behavioral Ecology and Sociobiology 54:* 36-43.

Narwal, R.P.; Antil, R.S. 2005. Integrated nutrient management in pearl millet-wheat cropping system. In: Kapoor, K.K.; Sharma, K.K.; Dudeja, S.S.; Kundu, B.S. (eds), Proceedings of National Symposium on Management of Organic Wastes for Crop Production. Department of Microbiology, CCS Haryana Agricultural University. Hisar, India. pp. 205-213.

Parmer, D.K. 2014. Yield, produce quality and soil health under vegetable cropping systems as influenced by integrated nutrient management in mid-hill zone of Himachal Pradesh. *Journal of Indian Society of Soil Science 62:* 45-51.

Peerzada, O.H.; Mor, V.S.; Abhinav, D.; Axay, B.; Dahiya, O.S.; Pandey, V.; Anzer, U.I.; Mohammad, S.R. 2016. Influence of integrated nutrient management on seed quality of fenugreek (*Trigonella Foenumgraecum* L.). *Environment and Ecology 34:* 2226-2230.

Tekrony, D.M.; Egli, D.B. 1991. Relationship of seed vigour to crop yields: a review. *Crop Science 31:* 816-822.

Tung, L.D.; Fernandez, P.G. 2007. Yield and seed quality of modern and traditional soybean (glycine max) under organic, biodynamic and chemical production practices in the Mekong delta of Vietnam. O*monrice 15:* 75-85.