Research Article

Quality and Yield of Wheat Grown Under Organic and Inorganic Nutrients Management

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Abstract | Organic agriculture is a climate friendly and sustainable farming system to produce quality foods. An experiment on comparison of organic and inorganic wheat production was designed to study the field performance and quality of wheat grown under two regimes. The experiment was carried out at National Tea and High Value Crops Research Institute (NTHRI) Shinkiari, Mansehra, Khyber Pakhtunkhwa, Pakistan in 2019. Seven wheat cultivars (Atta Habib, Faisalabad, ASS, Punjab 2011, Lasani, NARC-11 and Pakistan-13) were sown using randomized complete block design (RCBD) with three replications. Source of organic manure was compost, poultry manure and farm yard manure while for inorganic treatments commercial fertilizers urea and di-amonium phosphate fertilizers were applied at recommended doses. Data was recorded on various morphological, yield and quality parameters. The result revealed that organically sown wheat varieties took more days to anthesis and maturity while more tillers, biological yield, grains yield and leaf area were recorded in inorganic treatments. Quality of organic produced wheat was comparatively better than inorganic wheat as more 13.67 % more crude protein and 2.41 % more crude fiber fat were recorded in organically grown wheat. Therefore, for high quality and environment safe production of wheat, organic fertilizer may be applied at recommended rates (compost 12 t ha^{-1}, poultry manure 6 t ha^{-1} and farmyard manure (12.5 t ha^{-1}).

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Introduction

The availability of eco-friendly and sufficient food to the public is the ultimate goal of organic farming. Organic farming provides echo friendly food because of no chemical use in this type of farming and thus it also increases soil fertility on sustainable basis. In organic farming we may use farm yard manure, kitchen waste, dry leaves, animal manure, poultry manure and compost etc. Even though it is a cumbersome practice, it improves the farming on the long run and it is also safe for both health and environment (Blair *et al*., 2006).

Wheat is the major cereal crop and staple food of Pakistan grown on 9.05 m ha^{-1} and occupies

approximately 50% of the cultivated area in winter season of the country. Wheat production is 25.75 million metric tons and average yield is 2711 kg ha^{-1} (Pakistan Bureau of Statistics, 2020-21). In Pakistan, there is inadequate attention available towards organic production of crops due to more input cost and slow action of organic resources, however in near future it can be improved through enhancing farmer's technical skills and research demonstrations.

In Pakistan, several wheat cultivars are grown on different parts of the country as single variety. These varieties are grown under excessive use of inorganic fertilizers and pesticides. Basically, pesticides have MRL (Minimum Residual Limits) and these pesticides are used in heavy doses without any safety precautions. During application of these pesticides, the workers don't use safety glasses, masks and gloves thus in most of the cases they face injury or poisonous effects. The pesticides include herbicides (kill weeds), insecticides (kill insects), fungicides (kill fungus), and disinfectants (kill bacteria) which are deleterious for plants. Despite of knowing the harmful effects caused by these chemicals why are we not taking precautions in the use of such chemicals in order to protect ourselves and our environment? There are almost 70 well known pesticides which are declared as probable or possible carcinogens. Because of the intensive and widespread utilization, the left over pesticides can be found almost anywhere. Not only on the food we eat, but traces of pesticides are often found in homes too.

While comparing yield of organic and inorganic wheat, it is cleared that more yield is produced under inorganic farming however food produced under organic farming is safe to environment and nutritious (Lairon, 2010; Draghici *et al*., 2011). Currently, a trend and awareness in public regarding purchase of organic foods has been developed in Pakistan (Chang *et al*., 2003).

Materials and Methods

Experimental materials

The present research was conducted in order to assess wheat varieties under organic and inorganic fertilizer regimes at national tea and high value crops research institute (NTHRI) Shinkiari, Mansehra, Khyber Pakhtunkhwa, Pakistan. During 2019 crop growing season, seven wheat varieties namely Atta Habib, Faisalabad, ASS, Punjab-2011, Lasani, NARC-11 and Pakistan-13 for various morphological and physiological traits. Randomized complete block with three replications was used as an experimental design. Every wheat variety was sown in a plot of three rows and the length of each row was maintained at 3 m. A distance of 30 cm was kept between row to row and plant to plant, respectively.

Experimental treatments

Organic nutrients: Organic source of nutrients were compost, poultry manures, kitchen wastes, farm yard manure, while no amendments were used in combination with disease and pests. The chemical composition of different organic nutrients are as follows:

Chemical composition of compost: Composts typically include around 2% nitrogen, 0.5-1% phosphate, and about 2% potassium.

Chemical composition of poultry manure: Poultry manure has a nitrogen content of 0.5% to 0.9%, a phosphorus content of 0.4% to 0.5% and a potassium content of 1.2% to 1.7%.

Chemical composition of farmyard manure: Well-decomposed farmyard manure includes 0.5 % nitrogen, 0.2 % phosphorus, and 0.5 % potassium.

Organic nutrients	**Recommended dose**
Compost	12 tonnes ha^{-1}
Poultry manures	6 tonnes ha^{-1}
Farmyard manure	12.5 t ha^{-1}

Inorganic fertilizers

For inorganic source of nutrients, urea and dap were used and for the prevention of diseases and insect, pest no chemical was applied in inorganic wheat. All other agronomic practices were applied in line with recommended dose.

Inorganic fertilizer	**Recommended dose**
Di-ammonium phosphate (DAP)	160 kg ha^{-1}
Urea	13.7 kg ha^{-1}

Data collection

Data was recorded on the following parameters:

Agronomic parameters

Days to anthesis: Data was collected from sowing date to the date when 50% plants of each plot completed anther emergence.

Number of tillers m^{-2}: Tillers were calculated from plants within 1 meter square plot and mean was calculated.

Number of leaves $tiller^{-1}$: Five different tillers from different plants were randomly selected, the number of leaves was counted from each tiller and mean was calculated.

Leaf area (cm^2): Five different tillers were selected and leaf area was calculated for all leaves. Length of leaf was measured from start of leaf blade to the tip of leaf with a measuring tape. Leaf width was estimated from broader part of leaf using measuring tape. Leaf area were calculated using the given formula:

Leaf area= leaf length x leaf width x correction factor

Days to maturity: Days till maturity were counted from the sowing till the date when 80% of the seeds on panicle of each entry got matured.

Biological yield (kg ha^{-1}): Following harvest and sun-drying dry mass of the plot was calculated by using balance to calculate biological yield in kg and the data was then converted to kilogram per hectare.

Grains yield (kg ha^{-1}): After harvesting, gain yield whole plot was calculated by using electronic balance and the data was then converted to kilogram per hectare.

Proximate analysis and quality

For proximate analysis one kg composite green sample was collected from five different spots in each plot, dried in oven and grind with the help of grinder. All samples were analyzed for proximate analysis according to Sullivan and Carpenter (1993).

- Crude protein (%)
- Crude fats (%)
- Moisture content (%)
- Ash content (%)
- Gluten (%)

Statistical analysis

The data was analyzed using the proper analysis of variance for the randomized complete block design. The LSD test was used to differentiate means at the 0.05 level of probability (Steel and Torrie, 1980).

Results and Discussion

Agronomic parameters

Days to anthesis: Experimental results for days to anthesis showed that there was no significant difference for days to anthesis in organic and inorganic treatments. Mean values shows that more days to anthesis were noted for organically grown wheat as compared to inorganic (Table 1). Among varieties more days to anthesis (137 days) was recorded for wheat variety narc while minimum days to anthesis (135 days) was recorded for wheat variety Faisalabad and AAS. The outcome is in agreements with Ali *et al.* (2015) who reported more days to anthesis in organic produced wheat as compared to inorganically produced. Similar results were reported by Badruddin 1999 in a field experiment to check if changes to recommended daily cultivation techniques might enhance yield potential of wheat in participating regions with hot climate. The trials revealed that using animal manure and husk mulch as organic fertilizer, as well as higher rates of inorganic fertilizers, increased yields in comparison to existing norms.

Table 1: *Days to anthesis, tillers m^{-2} leaves $tiller^{-1}$ of wheat as affected by varieties as affected by organic and inorganic treatments.*

Variety	Days to anthesis			Tillers m^{-2}			Leaves $tiller^{-1}$		
	Organic	Inorganic	Mean	Organic	Inorganic	Mean	Organic	Inorganic	Mean
Atta Habib	135.00±2.73	140.00±1.33	137.50	77.67±1.33	67.33±5.78	72.50	4.93±0.13	5.50±0.26	5.22
Faisalabad	136.67±2.73	136.00±12.85	136.33	85.33±12.858	82.00±7.05	83.67	5.94±0.29	6.17±0.00	6.06
ASS	136.67±1.76	134.00±13.86	135.33	86.00±13.860	75.33±9.29	80.67	5.61±0.22	5.39±0.11	5.50
Punjab 2011	138.67±2.60	136.00±4.096	137.33	82.33±4.096	78.67±18.20	80.50	5.06±0.11	5.50±0.19	5.28
Lasani	137.33±1.53	137.67±2.60	137.50	70.00±2.603	60.67± 9.07	65.33	5.61±0.11	5.50±0.00	5.56
NARC	141.33±1.73	139.67±9.39	140.50	71.67±9.387	61.67±12.99	66.67	5.61±0.11	5.61±0.11	5.61
Pakistan 13	139.00±2.33	140.33±5.24	139.67	72.67±5.239	59.67±10.89	66.17	5.72±0.22	5.61±0.11	5.67
Mean	137.81	137.67		77.95	69.33		5.50	5.61	

Values are presented with percent increase for each trait as a result of organic and inorganic fertilizers. Values presented as the mean standard error of three independent replicates.

Number of tillers m^{-2}: Statistical analysis for tillers m^{-2} showed that variation in number of tillers m^{-2} was significant among wheat varieties and treatments. Mean data of varieties shows that maximum number of tillers (83 m^{-2}) was recorded for wheat variety Faisalabad; followed by ASS and Punjab-2011 having tillers (80 m^{-2}) and minimum number of tillers (65) was recorded for Lasani (Table 1). Overall means shows that 3.3% more number of tillers was recorded in organic treats as compared to inorganic. The difference in number of tillers for various wheat varieties is due to its genetics and adoptability in a particular environment. Organic sources provide better balanced nourishment to plants, particularly micronutrients, which increase the number of tillers in plants. Singh *et al.* (2011) found more tiller m^{-2} in wheat due to continues supply of nitrogen. It has been concluded that heavy application of organic fertilizers can also reduce the potential growth of certain agronomic parameters e.g., tillers m^2 etc.

Number of leaves $tiller^{-1}$: Statistical analysis shows non-significant differences for leaves $plant^{-1}$ among various wheat varieties and treatments. Mean values for varieties showed that maximum numbers of leaves (6) were recorded for wheat variety Faisalabad 2008, while Atta Habib has shown minimum number (5) of leaves (Table 1). Overall mean values shows that wheat varieties produced almost same number of leaves in both organic and inorganic treatments. Ali *et al.* (2015) studied the impact of inorganic and organic fertilizers supplication among wheat phenotypic expression and development. The study indicated that an increased dose of organic and inorganic fertilizers eventually enhanced leaves per tiller and a reduced amount of nitrogen fertilizer drastically decreased this number.

Leaf area (cm^2): Statistical analysis of the data for leaf area (cm^2) shows significant difference leaf area per tiller. Mean values for varieties showed that maximum of leaf area (136 cm^2) was recorded for organic treatments while minimum leaf area (128.67 cm^2) was noted for inorganic treatments. Among varieties maximum leaf area (246.11cm^2) was noted for wheat variety NARC, while minimum leaf area (132 cm^2) was noted for Atta Habib (Table 2). Ali *et al.* (2011) noted same results for organic and inorganic application of fertilizers management in maize and concluded that the use of organic and inorganic nitrogen resulted in better yield and yield components of maize and hence recommends for improved productivity.

Days to maturity: Experimental results for maturity days show no significant difference in number of days to maturity in both organic and inorganic treatments. Mean data regarding days to maturity shows that there were maximum number of days (190) taken to maturity by wheat variety ass when it was sown inorganically while minimum number of days (185) are taken by wheat variety Pakistan in organic plots (Table 2). Overall mean data has shown that maximum number of days (188) is taken by inorganically treated wheat varieties as compared to organic regime (185). Present results are in in line with Vaccari *et al.* (2011) who found same results for various plants parameters in organic treatments among durum different wheat cultivars.

Table 2: *Leaf area (cm^2), days to maturity and biological yield ($kg\ ha^{-1}$) of wheat as affected by varieties as affected by organic and inorganic treatments.*

Variety	Leaf area (cm^2)			Days to maturity			Biological Yield ($kg\ ha^{-1}$)		
	Organic	Inorganic	Mean	Organic	Inorganic	Mean	Organic	Inorganic	Mean
Atta Habib	136.00±6.56	128.67±6.17	132.33	186.67±3.33	171.00±2.90	178.83	5833.33±833.3	6666.67±3004.6	6250.00
Faisalabad	162.78±20.63	233.89±14.12	198.33	181.67±6.02	174.00±5.77	177.83	17500.00±1443.3	17166.67±1740.1	17333.33
ASS	176.44±10.26	197.89±12.43	187.17	188.33±1.66	181.00±5.01	184.67	14166.67±833.33	16666.67±2204.8	15416.67
Punjab 2011	168.22±15.82	247.33±27.06	207.78	187.00±3.05	186.00±2.90	186.50	10833.33±2204.8	12666.67±6457.1	11750.00
Lasani	160.44±11.03	246.44±12.60	203.44	187.67±1.45	182.00±0.33	184.83	12833.33±1166.6	18333.33±1666.6	15583.33
NARC	255.11±12.40	237.11±4.46	246.11	188.00±1.60	184.00±1.33	186.00	11666.67±3632.1	12833.33±2905.9	12250.00
Pakistan 13	202.22±1619	213.56±8.50	207.89	182.00±2.88	180.00±3.17	181.00	9166.67±4409.5	9166.67±3004.4	9166.67
Mean	136.00	128.67		185.90	179.71		11714.29	13357.14	

Values are presented with percent increase for each trait as a result of organic and inorganic fertilizers. Values presented as the mean standard error of three independent replicates.

Table 3: *Grains yield (kg ha^{-1}), crude protein (%) and crude fats (%) of wheat as affected by varieties as affected by organic and inorganic treatments.*

Variety	Grains yield kg ha^{-1}			Crude protein %			Crude fats %		
	Organic	Inorganic	Mean	Organic	Inorganic	Mean	Organic	Inorganic	Mean
Atta Habib	2018.50±65.06	2100.63±159.85	2059.57	11.82±0.44	10.57±0.28	11.20	2.48±0.035	2.06±0.095	2.27
Faisalabad	3895.00±594.35	3333.33±245.39	3614.17	12.15±0.19	9.74±0.63	10.95	2.37±0.133	2.14±0.162	2.26
ASS	3365.00±137.871	3845.00±491.99	3605.00	11.00±0.58	10.15±1.07	10.57	2.19±0.128	2.15±0.098	2.17
Punjab 2011	1964.33±72.12	2518.67±346.53	2241.50	11.85±0.45	11.14±0.07	11.50	2.29±0.050	2.11±0.171	2.20
Lasani	2216.67±210.89	3253.33±296.68	2735.00	12.07±0.19	9.51±0.75	10.79	2.55±0.060	2.23±0.144	2.39
NARC	2361.67±579.37	2183.33±554.37	2272.50	11.62±0.31	11.67±0.33	11.65	2.51±0.089	2.44±0.127	2.48
Pakistan 13	2307.67±520.60	2746.00±287.01	2526.83	11.40±0.58	9.61±0.87	10.51	2.46±0.012	2.37±0.159	2.41
Mean	2589.83	2854.33		11.70	10.34		2.41	2.21	

Values are presented with percent increase for each trait as a result of organic and inorganic fertilizers. Values presented as the mean standard error of three independent replicates.

Biological yield (kg ha^{-1}): Data analysis shows that there was a significant difference in biological yield of various wheat varieties and treatments. Mean values shows that maximum biological yield was recorded for wheat variety Faisalabad 2008 (17333.33 kg ha^{-1}) followed by Lasani (15583.33 kg ha^{-1}) while NARC (12250 kg ha^{-1}) has shown minimum biological yield (Table 2). Overall mean values shows that inorganically produced wheat has increased biological yield (13357.14 kg ha-1) than organically produced wheat (11714.29 kg ha^{-1}). Kitchen *et al*. (2003) and Ingver *et al*. (2008) found similar results for organic and inorganic fertilizer combination and they also proposed that organic farming system and biochar can also help to cut CO_2 emissions.

Grains yield (kg ha^{-1}): Data on grain yield of wheat varieties as a result of organic and inorganic treatments is exhibited significant variation for grain yield among different wheat varieties and treatments. Mean values shows that 9.27 % more grain yield was noted for organically grown wheat as compared to inorganic wheat (Table 3). Mean data for varieties shows that more grain yield (3614 kg ha^{-1}) was noted for wheat variety Faisalabad, followed by ass (3605 kg ha^{-1}) and lower grain yield (2524 kg ha^{-1}) was recorded for wheat variety Pakistan-2013. The difference in yield of various wheat varieties aids due to its genetic and adoptability in a particular environment. Kitchen *et al*. (2003) and Hammad *et al*. (2010) assessed the effects of organic fertilizers on different wheat varieties and found that the performance of inorganic farm manures was poor due to minimum amount of nutrients while organic fertilizers resulted in maximum grain yield due to more nutrient availability.

Proximate analysis and quality

Crude protein (%): Mean data for crude protein (CP) shows that 13.67 % crude protein was recorded from organically grown wheat as compared to inorganic wheat. Among varieties more CP (11.65 %) was recorded for wheat variety NARC-11 while minimum CP (10.51 %) was recorded for wheat variety Pakistan-2013 (Table 3). The present study suggested that dose of organic fertilizers enhances crude protein content of wheat. The results are with complete agreement with Hooda (2002) who reported same results. In contrast Natika *et al*. (2008) reported more proteins in inorganically produced wheat as compared to organically produced.

Crude fats (%): The comparison of fats contents of different wheat varieties organically and inorganically grown were statistically significant. Mean values for crude fiber (CF) shows that more fat percentage was higher in organically grown i.e., 2.41 % wheat as compared to organic wheat i.e., 2.21 % (Table 3). Among varieties more fat content (9.61 %) was recorded for wheat variety Lasani while minimum fat content (9.11 %) was recorded for wheat variety Faisalabad. These findings are consistent with Shahrawat's (2000) conclusion that inorganically cultivated wheat types had higher fat levels than organically grown wheat varieties.

Moisture content (%): The comparison of moister contents of different wheat varieties organically and inorganically grown were statistically significant. Mean values shows that 14.0 % more moisture was note for inorganically grown wheat as compared to organic wheat (Table 4). Among varieties moremoisture

Table 4: *Moister content (%), Ash content (%), and Gluten content (%) of wheat as affected by varieties as affected by organic and inorganic treatments.*

Variety	Moister content (%)			Ash (%)			Gluten (g/100g)		
	Organic	Inorganic	Mean	Organic	Inorganic	Mean	Organic	Inorganic	Mean
Atta Habib	9.59±0.84	10.42±0.41	10.00	1.72±0.09	1.99±0.08	1.86	9.18±0.03	9.63±0.19	9.41
Faisalabad	9.33±0.33	11.67±0.66	10.50	1.77±0.06	1.92±0.04	1.85	9.03±0.13	9.30±0.07	9.16
ASS	10.33±0.33	11.67±0.33	11.00	1.84±0.14	1.99±0.03	1.92	9.13±0.07	9.44±0.10	9.29
Punjab 2011	9.67±0.880	11.33±0.66	10.50	1.73±0.14	1.96±0.03	1.84	9.17±0.03	9.33±0.06	9.25
Lasani	10.00±0.57	10.67±0.33	10.33	1.82±0.04	2.00±0.08	1.91	9.34±0.08	9.59±0.20	9.46
NARC	11.00±0.57	10.33±0.33	10.67	1.87±0.09	2.07±0.07	1.97	9.41±0.12	9.82±0.29	9.61
Pakistan 13	6.34±0.370	11.08±0.58	8.71	1.74±0.14	2.04±0.03	1.89	9.13±0.06	9.49±0.26	9.31
Mean	9.47	11.02		1.78	2.00		9.20	9.51	

Values are presented with percent increase for each trait as a result of organic and inorganic fertilizers. Values presented as the mean standard error of three independent replicates.

content (11.67 %) was recorded for wheat variety Faisalabad while minimum gluten content (10.33 %) was recorded for wheat variety narc. The results are in line with Krejcirova *et al*. (2006) who studied winter wheat protein content and quality from organic and conventional farming and noted high moisture content in inorganically produced wheat.

Ash content (%): The comparison of ash contents of different wheat varieties organically and inorganically grown were statistically significant. Mean values shows that gluten percentage was higher in inorganically grown wheat i.e., 2.0 % as compared to organic wheat i.e. 1.78 % (Table 4). Among varieties more ash content (2.07 %) was recorded for wheat variety NARC while minimum ash content (1.92 %) was recorded for wheat variety Faisalabad. These finding are identical with Coskuntuna *et al*. (2008) who recorded maximum gluten ash percentage in inorganically grown wheat in comparison to organically cultivated wheat varieties.

Gluten (%): Comparison of gluten percentage of different wheat varieties organically and inorganically grown were statistically significant. Mean values shows that 3.31 % more gluten was note for inorganically grown wheat as compared to organic wheat (Table 4). Among varieties more gluten content (9.61 %) was recorded for wheat variety Lasani while minimum gluten content (9.11%) was recorded for wheat variety Faisalabad. The results are in consonance with Shahrawat (2000) who reported reduced gluten percent among wheat varieties grown organically as compared to that under inorganic environment. As gluten is a predictor of flour strength and bread-making capacity, and its proportion is one of the most essential desirable bread features (Anjum and Walker, 2000; Belderok, 2000). According to the Bureau of Indian Standards, the volume of minimum dry gluten in a decent loaf of bread should be 9.5%; therefore, inorganic grown wheat is more suitable for bread-making compared to organic.

Conclusions and Recommendations

Current research suggests that wheat production under inorganic fertilizer regime is more as compared to organic fertilizer. However, for long run organic cultivation is better as it produces safe food, has beneficial effects on soil fertility and increased wheat quality as compared to inorganic fertilizer. It is pertinent to mention here that growing wheat inorganically matures early as compared to organic wheat which is a positive sign for the development of early maturing wheat varieties. But keeping in view the current climatic change scenario and water shortage; species which matures early are preferred as organic fertilizers are more climate friendly due to less hazardous effects on environment.

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Novelty statement

In Pakistan, previously no work has been done for organic inorganic system in wheat. This is for the first

time in our country that wheat has been evaluated under field conditions for organic and inorganic system.

Author's Contribution

Kainat Bibi: Performed the experiment and wrote the article.
Sajjad Khan: Designed the experiment and analyzed the data.
Zulfiqar Ali Gurmani: Helped in relevant contents and reviewed the article.
Fahad Karim Awan and Sajid Ali: Helped in write-up and to address comments from reviewers.

Conflicts of interest
The authors have declared no conflict of interest.

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