CHAPTER 5
DISCUSSION

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CHAPTER-5
DISCUSSION

The first varietal trial was a field experiment conducted to compare sewage wastewater irrigation with groundwater irrigation, taking five triticale cultivars to study their performance in comparison with a local popular wheat taken as check. The second field experiment was a fertilizer trial to compare the effect of six nitrogen doses on triticale TL-419, grown with wastewater and groundwater. The third and fourth field experiments were conducted on two contrasting triticales, namely TL-419 and Juppa'S', whose performance was again checked against wheat. The crops were irrigated with sewage wastewater only and received various doses of nitrogen (Experiment 3) and phosphorus (Experiment 4). In the last field trial (Experiment 5), different combinations of nitrogen and phosphorus were applied to TL-419 and Juppa'S'. The criteria for selecting the best treatments and cultivars were, growth characteristics, leaf NAR, leaf N, P and K contents, grain yield characteristics and grain quality in all the experiments. In the following pages, the morphophysiological implications of all the data are discussed together for the sake of convenience under the headings growth characteristics, leaf N, P and K contents, NAR, yield characteristics and grain quality.
5.1 Growth characteristics

In Experiments 1 and 2, sewage wastewater proved superior to groundwater for the growth parameters of five triticales and wheat, giving higher leaf number, tiller number, fresh weight and dry matter production. This may be because of essential nutrients present in sewage wastewater, like nitrogen, phosphorus, sulphur, calcium, potassium and some of the micro-nutrients (Table 2) resulting in increased growth. Similar views have been expressed by Sullivan (1970), Bole and Bell (1978), Wallace et al. (1978), Overman (1975, 1979 a), Baddesha et al. (1986), Veer and Kusumlata (1987), Neilsen et al. (1989) and Pratibha (1991) who cultivated different crops with wastewater. It may be pointed out that, wastewater specially sewage is rich in mineral elements and provide nutrients which are neccessary for proper growth and development of plants, as reported by Sopper and Kardos (1973), Lance and Gerba (1977), Shuval (1977), Brar and Miller (1978), Marten (1980) and Hundal et al. (1990). The role of these nutrients is well known. For example, nitrogen is esential for cell division and expansion (Hewitt, 1963; Gardner et al., 1985; Devlin and Witham, 1986); sulphur for certain amino acids and vitamins, phosphorus for energy transfer compounds, nucleic acids, cell membranes and phosphoprotein; potassium for its role in photosynthesis by directly increasing growth and leaf area index and as
cofactor for many enzymes (Gardner et al., 1985); calcium for cell division and elongation and for the selective regulatory function of cell membranes while magnesium is the centre of the chlorophyll molecule and is also essential for various enzymatic reactions (Gardner et al., 1985). Micronutrients, like copper, iron, manganese and zinc etc. are constituents of various enzymes or are activators which are directly or indirectly involved in metabolic processes (Devlin and Witham, 1986).

Regarding the cultivar differences (Experiment 1), Delfin was superior with regard to almost all growth parameters at each stage while TL-419 and HD-2204 followed it, while Juppa'S' and Mula'S', on the other hand, gave the lowest values (Tables 3-8). The better growth performance of Delfin and TL-419 compared with the wheat check would be expected as HD-2204 was a dwarf cultivar of wheat with a lower inherent capacity for tillering (Table 3) and leaf production (Table 4). As is evident from Table 7 and 8, fresh weight and dry weight were higher in Delfin and TL-419 when compared with other cultivars. This might be due to their greater photosynthetic area (Moss, 1988) because of higher tiller and leaf number as noted at the three stages of growth. The present data confirms the findings, on triticale cultivars, of Gerek and Kutluk (1972); Sethi and Singh (1972); Kiss (1973); Saini and Nanda (1974); Inam (1978); Abbas et al. (1983 a); Moinuddin et al. (1985);
Abdalla et al. (1986); Samiullah et al. (1987); Moinuddin et al. (1990 a) and Fatima (1993).

In Experiments 3, 4 and 5, TL-419 performed better than Juppa 'S' for almost all growth parameters, confirming some of the findings of Fatima (1993). The wheat cv. HD-2204 closely followed TL-419 with regard to most of the growth parameters (Experiments 3 and 4). There are a number of reports from India and abroad where new triticales have proved superior to wheat in growth and development (Inam, 1992).

Addition of fertilizer N and P to the crop had a beneficial effect on all the vegetative characteristics (Experiments 2 and 3). The growth of plant organs results from orderly cell division, expansion and differentiation. These processes are dependent on proper supply of nutrients (Moorby and Besford, 1983; Marschner, 1986) that influences plant growth and development directly by providing important macro-molecules and indirectly by their effect on the supply of assimilates and growth hormones. The present findings also confirmed that, during the vegetative phase, requirement for fertilizers increased with age which is well known for plants in general. The beneficial effect of fertilizer application on triticale cultivars revealed in the present study is in conformity with the results of a large number of workers in India and abroad (Acosta, 1973; Kiss, 1973; Afridi et al., 1977; Inam, 1978; Tahir, 1978;
Growth, it may be recalled is a manifestation of the interplay of the meristematic and metabolic processes. Among these, cell division, elongation and expansion, nitrogen metabolism and dry matter production, which are responsible for meristematic activity, leading to branching, elongation and increase in volume and weight, are known to be particularly enhanced in response to nitrogen application (Hewitt, 1963; Devlin and Witham, 1986).

In the present study (Experiment 3), N₁₁₂₀ proved optimum for the growth of plants, as higher doses of nitrogen (N₁₅₀, N₁₈₀ and N₂₁₀) proved at par with it, indicating luxury consumption of this nutrient. Fertilization leading to such luxury consumption is, however, counter productive economically.

Interestingly, P₄₀ proved optimum among the doses of phosphorus applied in Experiment 4 with sewage wastewater. In this trial, whereas P₆₀ accounted for luxury consumption, P₂₀ appeared inadequate. The data thus confirm the well established role of phosphorus in cell division and expansion (Hewitt, 1963; Black, 1968; Patnaik, 1987). Adequate provision of this nutrient at sowing by the application of P₄₀ together with supplementation through wastewater (Tables 51-56) might have promoted tissue and organ formation optimally which resulted in enhanced growth culminating in increased leaf and tiller formation (Tamhane
et al., 1970). Expectedly, the additional leaf area would result in higher photosynthetic rate as reported for phosphorus application in other crops, including wheat (Natr, 1972; Osman et al., 1977; Longstreth and Nobel, 1980) and produce more dry matter which is the best measure of plant vigour.

The treatment N$_{120}$P$_{40}$ (Experiment 5) proved optimum exhibiting a well defined synergistic effect between applied phosphorus and nitrogen, as both are known to accelerate root proliferation (Grunes and Krantz, 1958) thus facilitating the uptake of nutrients and water. It is, therefore, not surprising that N$_{120}$P$_{40}$ enhanced all growth parameters maximally. These observations confirm the beneficial role of phosphorus in the presence of sufficient quantities of nitrogen in various processes of growth. In this connection it is relevant to emphasize that balanced nutrition plays an important role in bringing about the maximum benefit of the genetic potential in terms of growth and development of a crop (Milthorpe and Moorby, 1979; Noggle and Fritz, 1986; Fatima, 1993).

In general, in all the five experiments, the tiller number of triticales increased upto 70-100 DAS but was arrested thereafter, while the number of leaves remained highest at 100 DAS and decreased at 120 DAS (Table 40). The decline in leaf number after its increase in the initial stages may be due to senescence of older leaves. The same
trend was also noted in leaf area. The concentration of the labile nutrients in young leaves is normally maintained through their transport from the older leaves and can lead to early senescence (Greenway and Quinn, 1966; Akhtar, 1986). However, transfer of mineral nutrients from older to younger leaves is not the only cause of leaf senescence. Being a part of the process of plant development, it is under genetic control (Thomas and Stoddard, 1980; Akhtar, 1986). As is well known, the development of sink (grain in the present study) is a death message to the older leaves as most of the mobile nutrients get translocated towards the developing organs (Bidwell, 1979). Plant height, fresh weight and dry weight were generally found to increase in linear fashion up to the last sampling (120 DAS) in all the experiments. However, it may be pointed out that the increase was more sharp at the early stages and slow during the later period of growth which is a common phenomenon in the case of cereals.

5.2 Leaf N, P and K contents

5.2.1 Nitrogen

In Experiments 1 and 2 (Tables 9-11 & 25-27), leaf nitrogen, phosphorus and potassium contents increased as a result of the application of sewage wastewater. It may probably be due to additional nutrients supplied by the wastewater as noted in Table 2 (Sullivan 1970; Lance and
Gerba, 1977; Bole and Bell, 1978; Brar and Miller, 1978; Reynolds et al., 1978; Sopper, 1978; Wallace et al., 1978; Day et al., 1979; Hocking, 1985; Baddesha et al., 1986; Patterson and Allan, 1989).

In Experiment 5 treatments \( N_{60}P_{20} \), \( N_{90}P_{20} \) and \( N_{60}P_{60} \) were at par with \( N_{0}P_{0} \), probably (Table 1) soil provided the required nitrogen because of sewage irrigation.

In Experiments 2 and 3, leaf nitrogen concentration was found to increase appreciably with the application of fertilizer nitrogen (Tables 25 & 41), being more in plants receiving higher doses of nitrogen as fertilizer. In Experiment 5, in general, irrespective of the \( P \) dose, \( N_{120} \) was responsible for accumulation of more leaf nitrogen. Such an observation is not unexpected as there are a number of reports from this laboratory and outside where nitrogen accumulation was unaffected by the doses of phosphorus (Lundegordh, 1951; Grunes and Krantz, 1958; Sundara Rao and Krishna, 1963; Safaya, 1971; and Inam, 1978).

For nitrogen content, varieties differed in their response from one experiment to another. Delfin was found superior to the other triticales and wheat (Experiment 1). In Experiments 3 and 4, TL-419 proved superior to Juppa 'S' and wheat and in Experiment 5, again TL-419 performed better than Juppa 'S'. Such varietal differences are understandable as mineral nutrition of crop plants is known to be under genetic control as indicated by the numerous
nutritional differences among the cultivars and strains. In some cases, major nutritional features are under the control of a single gene pair. However, in many cases more genetic systems are involved (Marschner, 1986).

5.2.2 Phosphorus

In Experiment 2, application of higher doses of nitrogen to plants did not enhance leaf phosphorus content, \(N_{120}\) giving the maximum leaf phosphorus content. In Experiment 4, when \(P_{40}\) was applied the leaf phosphorus content was maximum in \(P_{40}\). Application of \(P_{60}\) did not result in any increase, indicating that \(P_{40}\) was sufficient when applied with sewage wastewater. Generally, \(P_{60}\) is the recommended dose of phosphorus (Inam, 1978) for triticale s under local conditions. However, with wastewater being given to the crops, additional phosphorus was available to them, which enabled \(P_{40}\) to suffice. In Experiment 5, a comparison of different phosphorus doses indicated that \(P_{40}\) and \(P_{60}\) produced equal effect on leaf phosphorus content which was clearly higher than noted in \(P_{20}\). In comparison with \(P_0\) and \(P_{20}\) applied with \(N_{60}, N_{90}\) and \(N_{120}\), various combinations of \(P_{40}\) and \(P_{60}\) with \(N_{60}, N_{90}\), and \(N_{120}\) gave higher leaf phosphorus content, indicating the insufficiency of the lower phosphorus doses (\(P_0\) and \(P_{20}\)) irrespective of the dose of nitrogen applied with them, as is evident from Table 74.
For varietal response (Experiment 1), Delfin proved best and TL-419 came close to it after 100 DAS for phosphorus accumulation. Variety TL-419 (Experiment 4) also proved superior to Juppa'S' as well as HD-2204 at all stages. Similarly, in Experiment 5, TL-419 accumulated more phosphorus than Juppa'S' throughout the growing period. Apparently, these differences may be due to the differences in genetic make up. Genotypes are known to differ considerably in their ability to absorb and distribute nutrients among various parts of the plants (Vose, 1963; Epstein and Jefferies, 1964; Langer, 1966; Inam, et al., 1982 b; Abbas et al., 1983; Moinuddin, 1989; Fatima, 1993).

5.2.3 Potassium

In general, the effect of different doses of nitrogenous and phosphatic fertilizers on leaf potassium content was non-significant. Where significant, there was considerable overlapping in the treatment effect. It might be because potassium was applied uniformly as basal dose. Interestingly, leaf nitrogen contents were higher than potassium contents in almost all the experiments but phosphorus contents were lower as expected. The lower potassium contents than those of nitrogen noted in the present study are in contradiction of the earlier studies on triticcales by Inam (1978). This may be mainly attributed to
the difference in the potassium status of the two soils where the studies were conducted.

In Experiment 1, Delfin proved the best triticale variety, followed by HD-2204 as far as leaf potassium content was concerned. It is interesting to note that HD-2204 was superior to TL-419. Again in Experiment 4, HD-2204 proved best followed by Juppa' S' and TL-419. As explained earlier, these differences might be traced to differences in the efficiency of absorption and utilization of the nutrient constituents of the soil by the cultivars.

It is clear from the Tables 9-11, 25-27, 41-43, 57-59 and 73-75 of Experiments 1 to 5, that leaf nitrogen, phosphorus and potassium concentration increased only up to 70 DAS and decreased with age. It is an established fact that nutrients attain highest concentration in plants during early stages of development which declines progressively towards maturity. It may be due to the exponential growth (weight and volume) of plants due to which any increase in nutrient concentration is nullified and appears to be less when expressed on per unit basis and is commonly termed as "dilution with growth effect". Other workers in our lab have also made similar observations on triticales (Inam, 1982 b; Moinuddin, 1989; Samiullah et al., 1991; Fatima, 1993).
5.3 Net assimilation rate (NAR)

In Experiments 1 and 2, NAR of triticale plants seemed to increase under wastewater irrigation. This may be due to the noted increase in such growth attributes as, leaf number, leaf area and dry matter (Table 2).

In Experiment 2, NAR increased with the increase in nitrogen upto $N_{120}$, while higher doses did not increase it any further. Contrary to it, in Experiment 3, initially $N_0$ gave comparatively higher NAR, followed by $N_{60}$ while lower NAR was recorded in treatments $N_{90}$ and $N_{120}$. It might be because at early stage increased nutrient absorption led to more vigorous growth which in turn led to increase in number of leaves thereby increasing leaf area for photosynthesis; but due to shadowing of lower leaves the total exposed area was reduced. With $N_{60}$ and $N_{90}$ (Experiment 2) there was no over-crowding of leaves, thus the leaf area was not shadowed (or reduced) by over-crowding of leaves, thus the total leaf area was available for photosynthesis. In Experiment 3 at later stage of growth, the condition was reversed, i.e application of $N_{60}$, $N_{90}$ and $N_{120}$ gave similar NAR values but these were distinctly higher than those in $N_0$. For both the treatments ($N_0$ and higher, NAR was calculated using the total leaf area (here mention may be made that NAR is a measure of the average net $CO_2$ exchange rate per unit of leaf area in the plant) present in the plant. But plants treated with $N_0$ having lesser leaf area could expose all
the area towards sun, whereas in plants treated with higher nitrogen experienced mutual shadowing due to higher leaf area. This might be the reason for lesser NAR due to increased N dose at initial stage. At 100-120 DAS stage the reverse happened i.e. the leaves of N0 plants dried up and exposed lesser leaf area to sun for photosynthesis and in higher N treatment the leaves were green but lesser exposed leaf area so there was no natural shadowing and so the NAR increased when compared to N0 treatment (Gardner et al. 1985). Interestingly, in Experiment 3, N60 proved optimum treatment for NAR at later stage of growth, while, N0 gave higher NAR at the initial stage. The reason might be the supply of nitrogen through wastewater which might be adequate for the initial growth to attain optimum leaf area. In Experiment 4, in which different phosphorus doses were applied, P40 gave higher NAR throughout the growth period. In Experiment 5, at the early stage of growth, N60P40, the dose containing lower nitrogen, had higher NAR. While, at later stage of growth, almost reverse trend was noted where combinations containing higher nitrogen doses proved effective. In P deficiency there is insufficient cell expansion and limited leaf growth rate thereby causing lower LAI and NAR while P40 being the optimum dose in present study provided sufficient leaf area for proper NAR (Marchner, 1986). There are number of studies where inadequate P supply lowers the rate of photosynthesis and
the activity of various enzymes (Khasawneh et al., 1980).

In Experiment 1, TL-419 surpassed all varieties including Delfin and HD-2204 during both samplings. In Experiment 3, TL-419 proved to be a better variety at the later stage while, Juppa'S' gave better results at the earlier growth stage. In Experiments 4 and 5, TL-419 gave higher NAR values at early period of growth but Juppa'S' took its place in later period of growth. Interestingly in experiment 5, compared with Juppa'S', TL-419 gave higher NAR values with lower nitrogen doses in the nutrient combinations applied which goes to prove the higher efficiency of TL-419 over Juppa'S' in utilizing the applied nutrient at the initial stage itself. While at the later stage, both varieties responded better to combinations containing higher nitrogen doses.

5.4 Yield characteristics

5.4.1 Nutrient effect

In Experiments 1 and 2, compared to groundwater, sewage wastewater irrigation increased all the yield characteristics, including grain yield. It may be recalled that wastewater also proved superior in its effect on growth parameters as discussed earlier. It is reasonable, therefore, to presume that the better effect on these characteristics manifested itself in improving such yield parameters as ear number, ear weight, 1,000 grain weight and
grain number which cumulatively accounted for higher grain yield (Tables 13-16 & 29-32). The higher straw yield under wastewater irrigation could be expected on the basis of the better vegetative growth. These findings are confirmed by the earlier reports from CPHERI (1970) Sopper (1978), Day et al. (1979), Overman (1979 a), Cordonnier and Johnston (1983), Veer and Kusumlata (1987), Papadopoulos and Stylianou (1988 a) and Neilsen et al., (1989). In Experiment 2, out of six nitrogen treatments, $N_{120}$ gave the maximum yield while, $N_{150}$, $N_{180}$ and $N_{210}$ consumed luxuriently as these treatments could not increase the yield further inspite of higher nitrogen accumulation in the leaves (Tables 25 & 32).

In Experiment 3 also, $N_{120}$ gave the highest grain yield confirming the findings of Experiment 2. As explained above, yield is the expression of the total effect of the yield parameters, like ear number per plant, length per ear, spikelet number per ear, grain number per ear, ear weight per plant and 1,000 grain weight, most of which were beneficially affected by the application of $N_{120}$. In fact, the aim of the cereal breeder/physiologist is fulfilled if he succeeds in increasing one or more of these ear characteristics. There is considerable literature where higher grain yield has been obtained in this manner. Of these, Samiullah (1971), Langer and Liew (1973), Ahmad (1975), Inam (1978), Aziz (1991), Fatima (1993), and Yahiya
In Experiment 4, more grain was produced when \( P_{40} \) was applied while \( P_{60} \) proved wasteful, probably due to its luxury consumption. In general, the yield attributing parameters were benefited most with \( P_{40} \) application which in turn promoted grain yield. This finding is not in agreement with the findings of Fatima (1993), Moinuddin et al., (1990 a) and Samiullah et al., (1991) of our laboratory who have reported \( P_{60} \) to be the optimum dose for triticale and allied crops. It may, however, be noted that their crops were irrigated with groundwater. As in the present experiment, sewage wastewater was used for irrigation, it is reasonable to believe that it would have furnished additional phosphorus to the crop. The data of Experiment 5 confirms this assumption indirectly. Like other yield parameters, grain yield was noted to be maximum in treatments \( N_{120} P_{40} \) and \( N_{120} P_{60} \) which were at par in their effect while \( P_{20} \) with all doses of nitrogen proved inferior. The treatments \( N_{120} P_{40} \) and \( N_{120} P_{60} \) gave similar effect on ear number per plant. The treatments \( N_{120} P_{20}, N_{90} P_{60} \) and \( N_{90} P_{40} \) were also equally effective for number of ear per plant. These three treatments affected most of the yield parameters similarly as noted above, indicating that with higher dose of nitrogen, lower dose of phosphorus may be given and vice-versa. It may be pointed out here that the doses containing more nitrogen were responsible for
higher production of ears. In general it may be summarised that $N_{60}$ was poor, $N_{90}$ was medium and $N_{120}$ was optimum and $P_{20}$ was poor, $P_{40}$ was optimum and $P_{60}$ exhibited luxury consumption.

5.4.2 Varietal differences

In Experiment 1, the cultivar Delfin performed best. The superior yielding ability of this variety has been established earlier by Moinuddin et al., (1990 a, b) and Aziz, (1991) under local conditions. It was followed by TL-419 which in turn was superior to local wheat check. The superiority of these cultivars of triticale over wheat manifested itself early at the tillering stage and was maintained throughout the growth period resulting in higher fresh and dry weight (Tables 7 & 8). The superiority of Delfin and TL-419 over wheat on the one hand and the poor performance of Juppa'S', Mula'S' and Tigre'S' on the other can be attributed to genetic variations. In fact, sufficient information is available where genotypes have been found to differ considerably in their ability not only in absorption but also in translocation and accumulation of nutrients. Such varietal differences are well known in cereals including triticale (Millikan, 1961; Vose, 1963; Langer, 1966; Inam, 1978; Ashfaq, 1986; Moinuddin, 1987; Aziz, 1991; Fatima, 1993). The poor performance of the three triticale cultivars (Juppa'S', Mula'S' and Tigre'S') may be because
of the lower values obtained for various yield parameters (Tables 13-16). In Experiments 3, 4 and 5 also, TL-419 proved superior in almost all the yield parameters, including grain yield (Tables 48, 64 & 80). Moreover in Experiment 3 when interaction was studied, it was marked that, following the pattern of growth parameters, $N_{120} \times TL-419$ gave the best yield and $N_{90} \times TL-419$ followed it. It is to be pointed out that TL-419 interacted well even with lower doses of nitrogen e.g. $N_{60} \times TL-419$ gave similar yield as $N_{120} \times$ wheat while $N_{90} \times TL-419$ recorded even higher grain yield than $N_{120} \times$ wheat, probably an inherent genetic factor whereby TL-419 was able to extract nutrients more efficiently. Juppa'S' could not match TL-419, thereby indicating that Juppa'S' did not have this character of utilizing lower doses of nitrogen. From agronomical point of view and in an operational sense, genotypical differences in the nutrient utilization efficiency of crop plants are usually defined by the differences in relative growth or in yield when grown in a deficient soil. For a given genotype nutrient efficiency is reflected by the ability to produce high yield in a soil that is limiting in one or more mineral nutrient for a standard genotype. This is an important topic for the selection and breeding of genotypes adapted to low nutrient availability in soils and with a high efficiency in the utilization of soil and fertilizer nutrients (Marschner, 1986).
5.5 Grain quality

5.5.1 Nutrient effect

Plants draw from the soil a number of essential nutrients and water which they utilize not only for their growth and yield but also for attaining the quality of their produce. If any of these inputs is deficient, the quality of the crop is likely to be affected as they are involved in the biosynthesis of various metabolites.

In Experiment 1 and 2, wastewater benefitted plants by improving their grain protein and carbohydrate yields through higher grain yield over groundwater irrigation. In Experiment 2, grain protein and carbohydrate yields increased up to $N_{120}$, showing that this dose was sufficient to produce optimum results as nitrogen applied beyond this level did not bring about any further increase in protein and carbohydrate yields. In Experiment 3, $N_{90}$ and $N_{120}$ proved equally effective in terms of total protein content while $N_{120}$ proved to be the best treatment for grain carbohydrate content. Interestingly, $N_{60}$ and $N_{90}$ produced similar effect to that of $N_0$. This could be due to sewage wastewater irrigation providing sufficient nitrogen for protein and carbohydrate production. However, for protein and carbohydrate yield the treatment $N_{120}$ performed best, confirming the data of Experiment 2. In Experiment 4, grain protein and carbohydrate yields were equally affected by $P_{40}$ and $P_{60}$ which gave the best results, thus exhibiting
the same pattern as noted in grain yield and other characteristics. In Experiment 5, $N_{120}P_{40}$ proved optimum for total protein content, while it was at par with $N_{120}P_{60}$ for protein and carbohydrate yield indicating that increased nitrogen fertilization, irrespective of P fertilizer dose, results in higher protein and carbohydrate yield. The manurial ingredients of wastewater not only effectively aid the healthy development of crops but also improves the total grain yield substantially. There are reports where the wastewater irrigation adversely affects the grain quality in terms of protein and carbohydrate contents (Veer and Kusumalata, 1987; Aziz et al., 1995). However, in the present study the effect of wastewater was non-significant. When the protein and carbohydrate were computed with total yield which was significantly higher under wastewater irrigation, the total protein and carbohydrate yields were also higher indicating the feasibility of sewage wastewater irrigation at least when sufficient groundwater is not available. After reviewing comparative yields of crops grown in western United States, Hutchins (1979) reported higher yields with sewage wastewater than with other waters (surface and underground).

Nitrogen doses containing $N_{90}$ to $N_{120}$ with $P_{40}$ proved optimum in comparison to higher doses, may be due to the sufficient manurial ingredients supplied to crops by the sewage (Table 2) particularly the nitrogen, phosphorus and potassium. This association renders the sewage a complete or
balanced fertilizing agent (Mahida, 1981).

5.5.2 Varietal differences

In experiment 1, total protein content of Delfin and HD-2204 (wheat) was highest. It was followed by TL-419 and other cultivars. While carbohydrate content and protein yield were highest in Delfin and TL-419, HD-2204 following it. In Experiments 4 and 5, TL-419 remained superior for grain protein yield and carbohydrate content over Juppa’s.

The progress of triticale in terms of productivity and quality during the last 20 years was significant. A specie with poor germinating ability, low yield and shrivelled grains was transformed into chemically viable crop with enormous potential under different environments. In the present study triticale (Delfin, TL-419) proved its superiority over wheat in protein as well as carbohydrate yield. Also $N_{120} \times TL-419$ proved best for protein yield. It may be because of higher grain yield in triticcales in comparison to wheat (Experiment 1). In Experiment 3 and 4, triticale (TL-419) yielded more protein and carbohydrate in comparison to wheat (HD-2204) when calculated. On the basis of the higher grain yield in the former crop. The superiority of TL-419 was also reported by Kaur and Takkar (1987) while evaluating the eight wheat lines with TL-419 under alkaline soil (pH 8.8) with manganese deficiency. Triticale cultivar Juppa’s was the poorest when compared
yield. The differences between triticales and wheat for such variations demonstrate the immense genetic variability among the genotypes tested in the present study (Baier, 1991). Considering the protein contents however TL-419 lagged behind the wheat. It may be because of the dilution effect (Inam, 1978 & Aziz, 1991) a phenomenon generally associated with higher yields as noted in Experiment 1, 2 and 4.

5.6 Proposals for future work

The experiments discussed above have clarified fewer problems pertaining to sewage wastewater irrigation, crop triticale and fertilizer doses. However, it may be admitted that the study being original, was handicapped by several drawbacks including meagre samples of grain to start with. Also, the number of available varieties was limited. Now that more and better responding triticales are available it is proposed to extend the present study in future on the following lines:

1. More varieties must be tested than the present one.
2. Pathological analysis of sewage wastewater must be undertaken.
3. Heavy metals should be analysed in plant tissue including grain.
4. Lysine content of the protein may be analysed in grains.
5. Seasonal variations in sewage wastewater composition may also be undertaken.