4. Conclusions

The aim of this thesis was the evaluation of physiological and agronomic aspects of uptake and utilization of main forms of N in wheat.

Wheat belongs to the species sensitive to toxic effect of ammonium ion such as to the species with negative reaction to low pH too. In plants with NH_4^+ as the only source of nitrogen toxicity symptoms – limited root growth, lower R/S ratio, deficiency of essential cations (K^+, Ca^{2+}, Mg^{2+}) or accumulation of ammonium ions in the oldest leaves – were observed. These symptoms were largely suppressed by increasing pH of cultivation solution. Low pH also had negative effects on plants from the nitrate treatment. The toxic effect of ammonium ions is decreased by the higher availability of both forms of nitrogen. It seems that a strong acidification of rhizosphere caused by the ammonium ion uptake is the main reason of negative growing reaction of wheat plants.

Kinetic parameters of uptake (V_{max} and K_m) characterizing high-affinity uptake system, can be used for assessment of intra and inter species differences in effectiveness of nitrate and ammonium uptake. In both studied species of wheat (*T.aestivum* and *T.durum*) a higher capacity (V_{max}) for the uptake of ammonium ions when compared to nitrates, but simultaneously a better affinity for nitrate (lower K_m) was found. In all studied cultivars development of root system as a reaction to the form of supplied nitrogen was more or less influenced. There was a higher R/S ratio in plants growing under NO_3^- than in NH_4^+-fed plants. The capacity for uptake of both ions was substantially modified by size of root system. Intra and inter species comparison shown significant differences in the ability to nitrate uptake; in case of ammonium ions the differences were less distinctive. Evaluation of intra- and inter species differences of uptake efficiency from the outer environment by means the determination of kinetic parameters of uptake systems could be used as a marker for selection of breeding material.

The rate of uptake of both nitrogen forms (NO_3^- and NH_4^+) is influenced by the current state of the plant and is substantially regulated by the rate of their assimilation and translocation to shoot. The necessity

of fast ammonium assimilation in roots lead subsequently to substantial inhibition of its uptake. Assimilated nitrogen was then translocated to young growing leaves. More slowly taken up nitrate were rapidly translocated to the mature leaf where they were assimilated so that no substantial limitation of their uptake occurred.

If both ions are available in medium in the same concentration, uptake of ammonium ion is higher than nitrate. The rate of nitrate uptake in wheat was negatively influenced by the presence of ammonium ions – their uptake was decreased to one fourth compared to their uptake from nitrate medium only. The uptake of ammonium wasn't influenced at all. Plants taking up nitrogen from the mixture of both ions thus acquired aproximately by 20 % of nitrogen more than plants growing only on one of N forms.

The rate of uptake of all nitrogen forms is linearly dependent on temperature. In temperature ranges 2 °C – 20 °C, the rate of ammonium uptake is highest among N sources. In higher temperature, regulation of their uptake by insufficient rate of assimilation and thus their accumulation in roots was observed. The rate of nitrate uptake is two-time smaller than the rate of ammonium uptake. The maximum rate of nitrate uptake is already at 15 °C Urea uptake was the slowest from all forms. With respect to its rapid degradation in soil, importance of its uptake by plants is only slight.

Penetration of various forms of nitrogen through the cuticle and subsequent uptake into epidermis and mesophyll cells depends on their chemical nature. Ammonium (cation form) was the most easily taken up form by wheat leaves. The ammonium uptake into the cells of leaves was not so significantly limited by their assimilation rate, and that is why the ammonium nitrogen was the best-utilized form of nitrogen. The nitrate uptake (the anion form) was slower and moreover the high amounts of nitrate were accumulated in the exposed leaf, probably as a storage form in vacuoles. Urea (non-polar molecule) probably penetrated easily through the cuticle, but its uptake into cells was such as in roots, slower. Urea, like ammonium ions, was metabolized rapidly and subsequently was used as a nitrogen source in growing tissues.

Wheat leaves are able to uptake foliarly applied urea even during the generative phase of its development and urea can be subsequently fully utilized during the grain formation process. Under favourable conditions plants acquire almost 90 % of the applied amount at start of heading and 95 % of this amount was found in the harvested grain. Foliar application of urea together with plant protection products (Tango Super) positively influenced the initial rate of its uptake which could improve the efficiency of utilization of the applied fertilizer under unfavourable environmental conditions.