UDC 631.82/.85:635.657:631.445.4(477.46)

IMPACT OF FERTILIZATION AND INOCULATION ON INDICATORS OF QUALITY OF CHICKPEA GRAIN

G.M. GOSPODARENKO, Doctor of Agricultural Sciences
S.V. PROKOPCHUK, Postgraduate Student
Uman National University of Horticulture

The results of research with determining the optimal application rate of mineral fertilizers and application of microbiological preparation Ryzobofit on the formation of physical quality of grain and productivity of chickpea are given.

Key words: *chickpeas, Bacterization seed, quality indicators seeds, fertilizers, crop yields.*

Growing of environmentally friendly products by relevant export price is attractive for farmers. Nowadays selectionists grow varieties of chickpea that combine high mass of 1000 seeds exceeding 345 g with saber shape of bean and better quality of grain [1].

Chickpea has a great agro-technological and food value. It exceeds all other leguminous plants with nutritional value. The root system of chickpea is rod and penetrates deeply into soil – up to 1.5 – 2 meters. There are poorly developed root hairs that cover a small amount of soil on main roots. These roots do not use a lot of water from soil, so the part of it is available for the crop that will be grown after chickpea, that improves its sufficiency of moisture-supply [2].

Protein of chickpea is close to ideal protein with amino acid composition. The biological value of protein is 52-78%, and the coefficient of digestibility is 80-83% [3]. Therefore chickpea is used as a recipe ingredient in baking and flour containing confectionery [4].

Mineral fertilizer is one of the fastest acting factors of environment that affects not only yield but also the quality of products. Creation due to fertilizers of optimal conditions for mineral nutrition for growth and development of plants is essential for the formation of high productive agrophytocenoses with corresponding indicators of grain quality of chickpeas. Perfection of methods of application of fertilizers and determination of reasonable doses is possible by examining not only the properties of soil and fertilizers, but also the needs of plants in the macro- and micronutrients to form a high yield with adequate quality of grain.

As far as the issue of seeds quality of chickpea under different fertilization and inoculation on the podzolized chornozem of Right-Bank Forest-Steppe is poorly understood, and therefore there was a need for a research in this area.

The purpose of the research. Improvement of fertilizing system of chickpeas to increase productivity and quality of grain on the podzolized chornozem of Right-Bank Forest-Steppe by choosing the optimal combination of fertilization and bacterial specimen.

Methodology of the research. Field research was held in the temporary experiment on the experimental field of Uman NUH. Soil on the tested plots is podzolized heavy loamy chornozem in accordance with ISO 4362:2004 of Soil quality. Indicators of soil quality: it had high content of humus, nitrogen alkali hydrolytic compounds – low, medium – mobile phosphorus and potassium, the reaction of soil solution is slightly acidic. Allocation of plots is consistent, the repetition of the experiment is three times. The area of the researched plot is 54 m^2; accounting plot – 30 m^2. Establishment of field experiments was carried out according to conventional methods. The action and interaction of two factors: A – fertilization, B – inoculation – were studied. Phosphate, potash fertilizer and defecate were applied during autumn ploughing, nitrogen fertilizers – during pre-sowing cultivation and leaf nutrition – in the phase of bean formation of chickpeas. Before sowing the seeds were treated with suspension of Ryzobofit (preparation of nodule bacteria *Mesorhizobium ciceri* made from strain H-12 at the rate of 10^6 bacteria for a seed).

Variety of chickpea Rosanna was sowed after winter wheat. The scheme of the experiment consisted of the following options: 1. Without fertilizer (control), 2. $N_{60}K_{60}$; 3. $N_{60}P_{60}$; 4. $P_{60}K_{60}$ – Background 5. Background + N_{30}; 6. Background + N_{30} + S_{35}; 7. Background + N_{60}; 8. Background + N_{90}; 9. Background Mo + N_{30}; 10. $CaCO_3$ + background + N_{30}; 11. $CaCO_3$ + background + Mo + N_{30}; 12. $CaCO_3$ + background + Mo + N_{30} + N_{30} out of root system. Forms of fertilizers – ammonium nitrate, urea, double superphosphate, potassium chloride, ammonium molybdate, ammonium sulphate. Limestone material – defecate, which application rate is calculated by hydrolytic acidity.

Harvesting and accounting of crops of chickpea was carried on each plot by means of direct combine harvesting. Straw yield was determined by method of trial sheaf. Processing and summarizing the results of experiments were conducted using the method of mathematical statistics [5].

Results of the research. Getting of high yields of agricultural crops with an appropriate high grain quality depends a lot on soil and climatic conditions of their production, as well as fertilizing and varietal characteristics. Pre-planting inoculation of legume seeds is also an important agricultural procedure. In general, all these factors affect the performance of grain quality of chickpea plants.

During the research, it was established that fertilization combined with inoculated seeds affects indexes of grain quality of chickpea significantly (Table 1).

Grain weight is an important indicator of its quality, which depends on the genetic characteristics of the variety and impact of external factors. Thus, under the influence of weather conditions and fertilizing in 2011, it was significantly lower compared with 2012, due to large amount of precipitations in the second half of vegetation, as the result seeds are frail to some extent.

In 2011 the highest weight of 1000 grains was obtained in the variant of $CaCO_3$ +background+ Mo + N_{30} + N_{30} without inoculation – 240 g, and on the background of inoculation 259 g, that was respectively for 13% and 21% more compared with the control variant.

1. Physical parameters of grain quality of chickpea according to the fertilization and inoculation

Variant of the experiment	Weight of 1000 grains, g		Full-scale weight, g/l		Fineness, mm		Uniformity of grains, %	
	2011	2012	2011	2012	2011	2012	2011	2012
Without fertilizer (control)	212 215	241 247	753 757	757 760	5,4 5,5	5,8 5,9	92 92	93 93
$N_{60}K_{60}$	222 221	244 251	763 767	767 767	5,8 5,9	6,0 6,2	93 93	94 94
$N_{60}P_{60}$	230 237	245 252	760 763	763 767	5,8 5,9	6,0 6,2	93 93	94 94
$P_{60}K_{60}$ – background	234 242	247 251	760 767	760 767	5,7 5,8	6,1 6,3	94 94	93 94
Background + N_{30}	232 241	251 253	763 767	763 763	6,0 6,1	6,0 6,2	93 94	94 95
Background + N_{30} S_{35}	233 249	253 256	767 763	760 767	6,1 6,4	6,2 6,4	94 95	94 95
Background + N_{60}	226 246	249 257	763 770	763 770	6,8 6,9	7,1 7,3	95 96	95 96
Background + N_{90}	239 243	251 262	767 773	770 773	6,7 6,8	7,0 7,2	94 95	94 95
Background + Mo + N_{30}	237 258	250 263	766 767	763 767	6,8 6,9	7,0 7,1	94 95	95 96
$CaCO_3$+ background +N_{30}	239 253	255 267	767 773	767 770	7,0 7,2	7,3 7,5	95 95	95 96
$CaCO_3$+ background +Mo+N_{30}	243 250	254 264	767 770	763 770	7,1 7,4	7,3 7,5	95 96	95 96
$CaCO_3$+ background +Mo+N_{30}+N_{30}	240 259	255 265	767 770	767 773	7,3 7,5	7,4 7,7	95 97	96 97

Note. Above the dash – without inoculation, under dash – with inoculation.

In 2012 weather conditions contributed to the formation of larger grains. The highest weight of 1000 grains was obtained in the variant $CaCO_3$ + background + N_{30} without inoculation – 255 g, and with inoculation – 267 g, that was respectively for 6 and 7% more compared with the control variant.

Weak correlation dependence (r = 0,33 and 0,46) was found based on two-year data between this indicator and yield of chickpea and protein yield per unit of the sown area, while with other indicators it was average (r = 0,58 and 0, 75).

Full-scale weight of chickpea grains is also an important indicator of its quality. This indicator in 2011 and 2012 was the best in the variant $CaCO_3$ + background + Mo + N_{30} + N_{30} and was accordingly 770 and 773 g/l, that was only 17 and 16 g less compared to the control (753 and 757 g/l). Thus, in 2012 this index was better compared to 2011, due to optimal weather conditions prevailing during the

growing season. Average correlation dependence (r = 0,55-0,71) was set between full-scale weight of grains and other indicators of quality.

The integral indicator of quality is the full-scale size and uniformity of chickpea grains. In 2011 grain data rates varied within 5.7 mm and 93% to 7.5 mm and 97%, depending on the variant of the experiment, which is 2.1 mm and 4% more than control. In 2012 this index was slightly better and varied within 6,0 – 7,7 mm. In conducting inoculation averagely for two years of study the index of grain fineness was better especially against the background of applying defecate or ammonium molybdate. Fineness and uniformity of grain are correlated indirectly with other indicators of quality (r = 0,56 and 0,88).

Index of grain uniformity for two years of study with increasing doses of nitrogen and molybdenum fertilizers and defecate improved and reached 95%. Conducting of inoculation did not significantly affect the uniformity of chickpea grain. Parameters of this index increased only for 1 – 2%.

The content of protein, fibber and fat in chickpea grains are the main technological indicators for the food industry. As it can be seen from Table 2, the content of protein and fat in chickpea depends greatly on the mineral nutrition of plants, and weather conditions for its cultivation. Thus, in 2011 the contents of protein and fat in chickpea in areas with no fertilizer and no inoculation were respectively 19,2 and 4,10%. In variants of the experiment the content of fat increased from 4.17% (variant $N_{60}K_{60}$) to 5.20%, and the rate of protein varied in the range from 20.6% (variant $P_{60}K_{60}$) to 24.1% (variant $CaCO_3$ + background + Mo + N_{30} + N_{30}). Average correlation dependence (r = 0,56 and 0,83) was set between the content of protein and fat in grains and other indicators of its quality.

Analyzing the data content of protein and fat in 2012, we can say that weather conditions prevailing during the growing season were favourable for their accumulation in grains of chickpea compared to 2011.

The research also found out that nitrogen fertilizers and applying of defecate have the greatest influence on the content of protein and fat in grains of chickpea among main elements of nutrition. It should be indicated that increasing doses of nitrogen fertilizers and applying of defecate contributed to increasing values of these indexes are respectively 1.25 and 5.20% compared to the control variant (4.38 and 19.4%).

In terms of fat and protein content in grains of chickpea for two years of research the best variant was with inoculated seeds of Ryzobofit on the background of fertilization in the dose $N_{30}P_{60}K_{60}$. Also the effective variant was $CaCO_3$ + background + Mo + N_{30} + N_{30}, that contributed to the intensive increase of biomass of plants, protein and fat accumulation in grains that determine the future of their individual productivity, total yield agrocenosis and quality of grains of chickpea.

The important measure of crop productivity is protein yield per unit of the sown area. This index for years of research was the highest in the variant with inoculation and lime treatment of soil on the background with mineral fertilization and was 0,92-0,81 t / ha, which was higher compared to the control with 0,43-0,35 t / ha. In variants without inoculation of applying of fertilizer on the background after liming treatment the rate of growth varied within 0.21 t / ha. Therefore,

inoculation combined with liming treatment of soil is an effective method of increasing of protein yield.

2. Technological indicators of grain quality of chickpea depending on fertilization and inoculation, 2011-2012

Variant of the experiment	Content in dry substance, %					
	protein		fat		fibber	
	2011	2012	2011	2012	2011	2012
Without fertilizer (control)	18,9 19,4	19,1 19,7	4,09 4,11	4,37 4,39	4,94 5,01	5,03 5,07
$N_{60}K_{60}$	22,5 22,7	23,1 23,5	4,17 4,18	4,42 4,44	4,98 5,03	5,09 5,13
$N_{60}P_{60}$	22,6 22,9	23,2 23,4	4,18 4,21	4,44 4,45	4,99 5,03	5,12 5,15
$P_{60}K_{60}$ – background	20,6 20,9	21,2 21,8	4,19 4,21	4,47 4,49	5,04 5,06	5,16 5,19
Background + N_{30}	22,3 22,6	22,8 23,2	4,31 4,38	4,74 4,76	5,05 5,08	5,19 5,22
Background + N_{30} S_{35}	22,2 22,4	23,1 23,3	4,27 4,31	4,50 4,53	5,05 5,12	5,51 5,59
Background + N_{60}	23,1 23,3	23,7 23,9	4,39 4,41	4,46 4,49	5,07 5,10	5,54 5,57
Background + N_{90}	23,2 23,4	23,2 23,5	4,86 4,92	5,59 5,62	5,21 5,25	5,60 5,64
Background + Mo + N_{30}	22,9 22,9	23,9 24,1	4,57 4,58	4,71 4,72	5,19 5,27	5,43 5,48
$CaCO_3$+ background +N_{30}	23,2 23,3	24,4 24,5	4,43 4,48	4,82 4,84	5,31 5,33	5,66 5,74
$CaCO_3$+ background +Mo+N_{30}	23,6 23,8	24,3 24,5	5,17 5,21	5,44 5,51	5,52 5,50	5,67 5,77
$CaCO_3$+ background +Mo+N_{30}+N_{30}	24,1 24,2	24,5 24,7	5,20 5,25	5,61 5,64	5,54 5,55	5,67 5,81
HIP_{05}	0,27	0,28	0,05	0,06	0,06	0,07

Note. Above the dash – without inoculation, under dash – with inoculation.

Fibber content in grains of chickpea depends significantly on the mineral nutrition of plants and weather conditions for its cultivation. Thus, in 2011 it was 4.94% on plots without fertilization and without inoculation. In the variant of the experiment, ($CaCO_3$ + background + Mo + N_{30} + N_{30}) fibber content increased to 5.55%.

Analyzing the data content of fibber in 2012 the weather conditions prevailing during the growing season were favourable respectively to this indicator. Variant $CaCO_3$ + background + Mo + N_{30} + N_{30} which contributed to the intensity of

accumulation of protein and fibber in grains, which determines individual productivity, the overall yield and quality of grain agrocenosis of chickpea plants, was effective.

Yield of chickpea in the experiment depended significantly on the weather conditions of growing season and agro-technical measures studied in the experiment and varied from 2.01 to 3.80 t/ha (Table 3). First of all, it should be noted that inoculation of seeds allowed obtaining reliable increase yield in all variants of the experiment. Its value was different and varied on average two years of research by 15% on the plots without fertilizers and on the background of applying of high doses of nitrogen fertilizers (variant background + N_{90}) up to 21% on the background of liming treatment and applying starting dose of nitrogen fertilizers (30 kg/ha).

3. Crop capacity of chickpea depending on fertilization and inoculation, t/ha

Variant of the experiment (factor A)	Without inoculation			With inoculation		
	Factor B					
	2011	2012	Average for two years	2011	2012	Average for two years
Without fertilizer (control)	2,17	2,01	2,09	2,52	2,29	2,41
$N_{60}K_{60}$	2,70	2,35	2,53	3,23	2,79	3,01
$N_{60}P_{60}$	2,85	2,50	2,68	3,41	2,99	3,20
$P_{60}K_{60}$–background	2,44	2,17	2,31	2,87	2,58	2,73
Background+N_{30}	2,75	2,46	2,61	3,31	2,96	3,14
Background +$N_{30}S_{35}$	2,92	2,56	2,74	3,59	3,15	3,37
Background +N_{60}	2,93	2,65	2,79	3,51	3,13	3,32
Background +N_{90}	3,09	2,75	2,92	3,56	3,17	3,37
Background +Mo+N_{30}	2,97	2,66	2,82	3,57	3,20	3,39
$CaCO_3$+ background +N_{30}	3,01	2,75	2,88	3,71	3,20	3,46
$CaCO_3$+ background +Mo+N_{30}	3,04	2,74	2,89	3,75	3,24	3,50
$CaCO_3$+ background +Mo+N_{30}+N_{30}	3,18	2,84	3,01	3,80	3,26	3,53
HIP_{05} *factor A*	0,19	0,11				
HIP_{05} *factor B*	0,08	0,05				
HIP_{05} *Interaction AB*	0,27	0,16				

On average for two years of research on the background of inoculation nitrogen component of a complete mineral fertilizer increased the yield of chickpea to 0.59 t / ha, phosphorus – to 0.31, and potassium – only to 0.12 t / ha.

Replacement of ammonium nitrate, ammonium sulphate (variant background + N_{30} + S_{35}) contributed to the increase of chickpea yield by 0.23 t / ha. Increasing of application rate of nitrogen fertilizer from 60 to 90 kg / ha did not give significant increase in yield.

The application of molybdenum was also an effective measure and contributed to increasing yield by 0.25 t/ha on the background of start application of nitrogen fertilizer dose of 30 kg/ha. This can be explained by increased mobility of molybdenum compounds with displacement reaction of soil solution in a neutral way. Leaf-feeding of chickpea with carbamide in the dose of 30 kg/ha had almost no effect on the yield of chickpea. Calculation of correlation showed that the yield hardly depends on the mass of 1000 grains (r = 0,33). Contents of fat and fibber in grain also hardly depends on its yield (r = 0,30 and 0,32).

Grain yield (r = 0,97) depends greatly on the output of protein per a unit of the sown area, whereas average grain correlation (r = 0,75) is with protein in grains.

Conclusions

1. Application of mineral fertilizer and seed inoculation of chickpea by nitrogen-assimilating bacteria affected significantly the physical parameters of grain quality – full-scale weight, fineness, uniformity.

2. Index of chickpea grain quality depends on the genetic characteristics of the variety and the effect of external factors. Physical and technological parameters of grain quality of chickpea significantly changed depending on the impact of weather conditions and fertilization.

3. Nitrogen fertilizers made the greatest influence on the content of protein and fat in grains of chickpea, as well as applying of defecate and inoculation of seeds.

4. Nitrogen component – 0.59 t / ha provides the highest increase of the yield of chickpea on the inoculation in the background of a complete mineral fertilizer, whereas phosphorus – 0.31, and potassium – only 0.12 t / ha. However, raising standards of the nitrogen fertilizer up to 90 kg / ha is inefficient. Replacement of ammonium nitrate fertilizer in the starting fertilizer (N_{30}) by ammonium sulphate in the conditions of inoculation increases chickpea yield by 0.23 t / ha.

5. Liming treatment of soil or applying of molybdenum fertilizer in combination with the application of phosphate and potash fertilizers during autumn tillage normally to 60 kg / ha and the starting dose of nitrogen fertilizer (N30) during pre-sowing cultivation provides the best quality of chickpea grains.