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Study of Nitrogen and intercropping effect on maize and vetch in region of Sistan

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ABSTRACT: In order to analyze the effect of nitrogen and different ratios of planting on some of the yield components and yield in intercropping of maize and vetch, a research is done as once-split field which is in the form of completely random blocks with three repetitions in research farm of Sistan Nature and Agricultural Research Center in the year 2014. The treatments are including different amounts of nitrogen in three levels (0, 100 and 150 kg.nitrogen per hectare of urea source) which are considered as main fields, and ratios of maize and vetch intercropping are considered as the secondary fields. Ratios of intercropping were consisted of S_1 (100% mazie), S_2 (75% maize and 25% vetch), S_3 (50% maize and 50% vetch), S_4 (25% maize and 75% vetch) and S_5 (100% vetch). Number of seeds per row features, seed weight, seed yield, harvest index from the maize plant and number of seeds per pod, seed weight, seed yield and harvest index from the vetch plant were measured and studied. Experiment results showed that fertilizer levels and planting pattern have significant effect on maize and vetch economic performance. With increase in nitrogen levels from 0 to 150kg per hectare, seed yield increased in both plants. The maximum economic performance in level unit of maize and vetch are obtained at highest fertilizer and net cultivation level. The land equivalence ratio (LER) related to 25% care-combination of vetch and 75% of maize was 1.40. According to the results obtained from the yield and its components in different additive intercropping of maize with vetch and concerning the obtained values of various parameters to evaluate intercropping, it can be concluded that intercropping in all of cultivated ratios can decrease Biomass and seed yield compared to net cultivation. Among all these, additive intercropping of 75% maize and 25% had the most economic profitability in comparison with other intercropping.

***Keywords*:** Intercropping, nitrogen, maize, vetch.

INTRODUCTION

In 2030, the global demand for food will probably be close to double the current level. However, in some countries farmers are restricted due to land constraints and products low yield. Preliminary researches have shown that a feasible way to increase agricultural products while preserving and enhancing performance in the fields is mixed agriculture (intercropping), (Pinedo-Vasquez, *et al.,* 2000). This system which is described as cultivation of more than one plant in a field in a farming year, is considered as one of the stable agriculture ways which with taking advantage of plant diversity in the farm can increase production, increase and maintain soil fertility, control erosion and totally, it can bring the optimal and efficient utilization of production entities, food exchanging, reducing of weeds competition and pathogenic factors (Park *et al.,* 2002). As an example, cultivation of maize and cotton in India, Brazil and Nigeria, maize with beans and castor bean in Brazil and Mexico and finally, cultivation of maize with different kinds of beans are of the most common intercropping methods in North and South America. In intercropping, maize is normally cultivated as the main crop and legumes are cultivated as the secondary ones. Because of having nitrogen stabilizing feature, legumes are kind of plants which are suitable to be cultivated with other plants in order to supply their need

of nutrients. Vetch is one of most important plants of the legumes family that many farming evidences for its performance in legumes and maize mixture systems have been reported (Walker and Ogindo, 2003). Among nutrient elements, nitrogen is considered as a high-consumption element and also it is considered the most important and essential element for plants nutrition because of its role in making amino acids, amides, nucleotides, nucleoprotein, enzymes and cell division, increasing chlorophyll growth, balanced growth and development of plant, growth of leaves green color intensity, increasing of plant proteins, fruit and seed production increase and so forth. In order that plant uses the light to produce biomass and subsequently the seed, it needs a sufficient supply of nitrogen in its leaves and therefore, it requires provision of nitrogen in the farm (Salvagiotti *et al.,* 2008). On the other hand, the concern about nitrate toxicity justifies the need for optimal amount of nitrogen. According to the studies, it can be said that nitrogen fertilizer is one of the most important farming factors which has a significant effect on growth barometers that if you choose appropriate amount of nitrogen, you can improve the performance. It seems concerning the importance of stable agriculture systems as well as high importance of maize and legumes (including vetch) in supplying food for humans and animals, studying of these two plants' intercropping and also the effect of managing factors such as nitrogen fertilizer is of a particular importance (Mosian *et al., 2014).* In most parts of the world, monoculture of cucurbits, winter and summer cereal or summer-winter double culture (like double culture of maize and barley with silage corn) is common. This reduces plants diversity, soil fertility and increases diseases, pests and economic risk and therefore, it reduces the stability. Intercropping, **simultaneous culture** of two or several crops in different regions and climates, have managed to increase the total yield in surface unit in comparison with monoculture. This system, in addition to maintaining the ecological balance and system stability, pursues different objectives (Javanshir et al., 2001). More performance without increasing agricultural inputs, natural control of weeds, creating a suitable microclimate and reducing the risk of pests and diseases, are including in the benefits to confirm the stability of intercropping (Maingi *et al.,* 2001). In developing countries, intercropping plays an important role in food production and people's livelihoods. In these countries, intercropping systems are usually conventionally managed by farmers in small farms (Walker and Ogindo, 2003). Higher efficiency of land using and worker force and increasing of competitive ability in intercropping's weed controlling is one of integrated weed management strategies with lower effect on environment in comparison with chemical herbicides. In intercropping rather than net cultivation, due to higher external competition beside species completing effects, can improve capability of mixed canopy against weeds and therefore, can reduce the congestion and weed biomass and increase the yield of mixed plants. Due to good controlling of weeds in intercropping, this method can bring the use of herbicides toxins to minimum (Banink*, et, al. 2006).*

MATERIALS AND METHODS

This research was done in the farm of Zahak's Agricultural and Natural Resources Research Station. Weather conditions for the months of this experiment are reported in the table below.

Table 1. Climatic characteristics of the experiment region in index periods in the year of the test.

December	November	October	September	August	*Month* / Climatic Characteristics
12/6	17/8	27/1	31/7	34/7	Average temperature
6/3	0	0	0	0	Average rainfall
53	36	20	13	18	Average relative humidity

Resources: Zahak Agricultural Meteorology Research Center

In order to determine the physical and chemical characteristics of soil, before performing the tillage operations from the depth of 0-30 cm samples are taken from several points of the farm and after providing a composite sample and sending it to the laboratory, the following results were obtained.

Table 2. The results of physical and chemical decomposition of experiment region soil

Unit	Value	Index
-	7/82	pH
Ms/cm	3/28	EC
Meq/litr	43/75	Ca + Mg
Meq/litr	56/58	Na
Meq/litr	6/42	HCO_3
Meq/litr	80/48	Cl
Meq/litr	13/84	SO_4
Meq/litr	*100/74*	Sum of Anions

The water needed for the experiment farm was supplied from station's internal water resources which were semi-deep wells and lakes. The laboratory results are as presented in the below table.

Table 3. Chemical decomposition of the experiment region's water

mEq/Lit					Acidity	Conductivity
Sodium Na^{+}	Magnesium Mg_2^{++}	Calcium Ca_2^{++}	Bicarbonate HCo_3^{-}	Carbonate Co_3^{--}	pH	(µ mho/cm)
2/8	2/7	1/9	3/5	–	8/3	0/95

The experiment was as once-split in form of completely random block designs with experimental treatments contained the different levels of nitrogen fertilizer from the source of urea in three levels of 0, 100 and 150 kg per hectare as the main field and also contained mixing ratios with replacing method as row mixture of maize and vetch containing S_1 (100% maize), S_2 (75% maize and 25% vetch), S_3 (50%maize and 50% vetch), S_4 (25% maize and 75% vetch) and S_5 (100% vetch). Every secondary field contained 6 cultivation lines with length of 4 meter. In maize, the distance among rows were 60cm and on the row was 20cm, whereas in vetch, the distance among the lines were 30cm and it was 10cm between two bushes. And also the optimal bush congestion of the two plants was considered as 8 bush per square meter for maize and 33 bush per square meter for vetch. The used maize was 704 single-cross with growth period of 105 to 115 days and the vetch used was MN94 with growth period of 65 to 75 days. The resulted data were statically analyzed with SAS software and the averages comparisons were done using Duncan's test at 5% level. In order to write and draw the charts, Word and Excel software were used.

RESULTS AND DISCUSSION

Variance analysis showed a significant effect of nitrogen fertilizer on seed yield which was 1% at probability level and 5% at biological yield. Furthermore, results showed that except the harvest index, other ratios of intercropping had significant effects on measured characteristics at the level of 1%. Mutual effects of nitrogen fertilizer and mixing ratios did not become significant on other traits among experimenting treatments.

Table 4. Variance analysis of yield traits and yield components of 704 single-cross maize influenced by mixing ratios and different levels of nitrogen fertilizer in intercropping.

Measured traits					Freedom degree	Variation sources
Harvest index	Biological function	Seed yield	Weight of thousand seeds	Number of seeds per row		
230/138*	^{ns}6616419/138	^{ns}3679296/022	^{ns}6917/028	^{ns}52/694	2	Repetition
^{ns}37/796	50919259/161*	10965794/982**	^{ns}7998/694	73/361**	2	Nitrogen fertilizer
29/425	4225921/223	552717/902	3562/861	32/528	4	First fault
^{ns}23/533	336411595/761**	47956734/664**	3953/657**	175/880**	3	Mixing ratios
^{ns}24/510	^{ns}9476072/332	^{ns}2043810/209	^{ns}1672/769	^{ns}15/324	6	Nitrogen fertilizer * Mixing ratios
50/913	3608782/084	810274/751	665/509	21/287	18	Second fault
20/86	11/59	15/97	11/13	15/11	–	Variation ratio (%CV)

**, *and ^{ns} are significant in probability level of 1%, 5% and non-significant, respectively.

Table 5. Average comparison of nitrogen fertilizer different levels and mixing ratios of maize and vetch on yield traits and components of 704 single-cross maize.

Measured traits				Experimental factors	
Biological function (kg per hectare)	Seed yield (kg per hectare)	Weight of thousand seeds (g)	Number of seeds per row		
				Levels of nitrogen fertilizer (Kg/ha)	
14160/00	4700/42	*a*202/08	*c*27/92	Zero	
16795/90	5600/31	*a*244/67	*b*30/83	100	
18220/00	6611/22	*a*248/67	*a*32/83	150	
				Mixing ratios	
				Vetch	Maize
23278/78	8244/26	214/22	27/11	%0	%100
19632/22	6828/31	261/33	34/78	%25	%75
12544/44	4266/92	220/11	33/89	%50	%50
10113/42	3209/77	231/56	26/33	%75	%25

Averages in columns with letters in common, do not have significant difference.

The effect of nitrogen amount and different ratios of intercropping on number of seeds in maize row in probability level of 1% became significant. It is as the maximum number of seeds in row was from using nitrogen fertilizer highest treatment with the average of 32.83 which had a 17.59 % increase in comparison with the witness. In addition, the treatment of 75% maize + 25% vetch with the average of 34.78 had the maximum number of treatments and the minimum number was resulted from the treatment of 25% maize + 75% vetch with the average of 26.33 which showed a 32.09 % increase in number of seeds per row in this treatment. Number of seeds is one of the main components of seed yield. The positive effect of nitrogen increasing in seed yield improvement is by increasing the number of seeds in rows (Hanway, 1979). Number of seeds characteristics per row was influenced by the amounts of nitrogen in the probability level of 1% (Rezayi Sokht Abandani, 2009). Lack of nitrogen brought reducing in number and the weight of seed (Alizadeh et al., 2007). Furthermore, positive effect of nitrogen on increasing the number of seeds in corn, seed weight and the yield of maize different hybrids were reported (Osborne *et al.*, 2002). Qadiri and Majidian in the year 2003 and Sadeqi and Bohrani the year 2001, reported the significant increase in number of seeds in maize with increase in nitrogen. **Using greater amounts of nitrogen can increase the leaf area index (LAI) as well as increasing the availability of assimilated materials for maize using photosynthesized durability and therefore, increases number of seeds in maize.**

Mutual effect of nitrogen fertilizer levels with different ratios of vetch and maize intercropping on the number of seeds per row, was not significant. The weight of one thousand seeds was not influenced by nitrogen fertilizer level, however; the different ratios of intercropping in the probability level of 1% became significant. The maximum weight of one thousand seeds in treatment was related to the ratios of 75% maize and 25% vetch and the minimum was related to net cultivation treatment. The weight of one thousand seeds in ratios of 75% maize and 25% vetch in comparison with treatments of 50% maize and 50% vetch , 25% maize and 75% vetch and also maize net cultivation is 40%, 6% and 6% higher respectively. It seems among different treatments of the experiment, intercropping of 75% maize and 25% vetch has got the best canopy arrangement to absorb light. Thus, the weight of thousand maize seeds which is one the most important seed yield indexes has the highest amount in the above intercropping. In evaluation of maize and bean intercropping, with maize congestion increase in the mixture, the weight of one thousand seeds increased (Kouchaki et al. 2009). In another study, seed weight characteristic was adapted with the nitrogen effect on it, however; it was in contrast with current study (Rezayi Sookht Bandani, 2009). Result analysis emphasized the positive effect of nitrogen on increasing the weight of maize seed (Osborne *et al.*, 2002). Interaction of nitrogen fertilizer levels with various ratios of maize and vetch intercropping did not have siginificant effect on charactrisitc of one thousand maize seed weight. Effect of nitrogen fretilzer amount and intercropping different ratios became siginificant on maize yield at 1% probability level. The maxiumum maize yield was obtained from the quantity of 150kg per hectare of nitrogen fertilizer with the average of 6611.22 kg per hectare and the minimum was obtained from witness treatment (Without using nitrogen fertilizer) and showed a 40.65 increase. But, the maximum seed yield was related to the treatment of net cultivation of maize with 8244.26kg per hectare. The obtained ratio of 75 % maize and 25% vetch with the average of 3209.77 kg per hectare indicated that the more maize ratios reduces in intercropping , the less would be the seed yield in unit level. In other words, the maize plant does not gain any benefits from the system of intercropping with maize (Jehan Bakht *et al.,* 1989). Due to the role of nitrogen in plant chlorophyll growth and its importance in the sustainability of the photosynthetic organs, this element in the currents experiment caused the photosynthesis to be maintained in a suitable level during seeds filling. Therefore, seeds filling was done faster and subsequently, the maximum seed yield in the amount of 150 kg nitrogen per hectare was seen. This seed yield weight, showed a 40.65% increase in comparison with minimum seed yield in witness treatment (Without using nitrogen), table 6-4. Increasing in nitrogen maximum ratios can be related to nitrogen availability during the month and physical and biological characteristics of soil. Concerning the issue, it is reported that seed yield has a direct relationship with storing and transferring of photosynthesis materials in plant's growing tissues, (Jun-Hua et al., 2010). Concerning more suitability of photosynthis during the growth season beacause of nitrogen and its storing in plants tissues, this factor is considered as one of the yield increase factors. Mutual effect of nitrogen fertilizer levels with various ratios of maize and vetch intercropping did not have significant effect on maize seed. However, nitrogrn amounts at 5% probability level and different ratios of intercropping at 1% probability level had a siginificant effect on maize biological yield, Table 5. The percentage and intercropping different ratios in the probability level of 1% had a siginificant effect on biologic yield of maize which in this case, the maximum biological yield was obtained from 150 kg nitrogen fertilizer per hectare with the average of 18220.00 g per plot and as a result, rather than witness treatment (Without using nitrogen) it showed a 28.67% increase. However, the maximum and minimum biological yield were related to the maize net cultivation treatment with 23278.78g per plot and the ratio of 75% maize + 25% vetch with the average of 10113.42g per plot which probably in the above fertilizer level, supplying of suitable using nitrogen improved the soil physical conditions and caused the availability of elements during the growth. Furthermore, the amount of nitrogen in the system has fulfilled the plant need and no nitrogen over using poisoning has been seen in

the grain and barely plants. Accorrding to the reports of (Albrizio *et al.,* 2010) on maize and barely plants, (Gheysari *et al.,* 2009) on maize plant and (Ehdaei and Waines, 2009) on Durum wheat, the farming plants biological yield increase is more, parallel to nitrogen using. Variance analysis showed the significant effect of nitrogen fertilizer levels on seed yield at 1% probability level. In addition, results showed the surveying mixture ratios had significant effect on all measured characteristics at 1% probability level. Mutual effect of nitrogen fertilizer and mixture ratios became significant on none of the characteristics.

Table 6. Variance analysis of different amounts nitrogen fertilizer for examined characteristics of MN-94 vetch influenced by intercropping and their mixture ratios.

Measured Traits					Freedom Degree	Variation Sources
Harvest Index	Biological Yield	Seed Yield	Weight of one thousand seeds	Number of seeds per pod		
^{ns}203/029	^{ns}45649/333	164942/194**	41/093**	^{ns}0/361	2	Repetition
^{ns}52/647	^{ns}129936/000	67293/778**	^{ns}0/470	^{ns}0/528	2	Nitrogen Fertilizer
52/071	36364/583	2205/153	0/361	0/444	4	First Fault
313/621**	785621/065**	572167/407**	129/447**	9/111**	3	Mixing ratios
^{ns}46/816	^{ns}15614/037	^{ns}1579/407	^{ns}2/520	^{ns}0/194	6	Fertilizer * Mixing ratio
38/708	20427/796	4748/352	5/090	0/306	18	Second Fault
10/81	8/64	7/07	8/35	7/77	-	Variation ratio (%CV)

**, *and ^{ns} are significant in probability level of 1%, 5% and non-significant, respectively.

Table 7. Average comparison of nitrogen fertilizer different levels and mixing ratios of maize and vetch on surveying characteristics of MN-94 vetch.

Measured Characteristics					Experimenting Factors	
Harvest Index	Biological Yield	Seed Yield	Weight of one thousand seeds	Number of seeds per pod		
					Levels of nitrogen fertilizer (Kg/ha)	
*a*55/733	*a*1548/583	909/667	*a*27/189	*a*6/917	Zero	
*a*57/132	*a*1658/583	958/333	*a*27/052	*a* 7/083	100	
*a*59/852	*a*1756/583	1056/667	*a*26/799	*a*7/333	150	
					Mixing Ratios	
					Maize	Vetch
64/360	2013/778	1281/778	32/099	8/333	%0	%100
50/237	1348/111	690/000	23/068	6/000	%75	%25
56/344	1491/222	876/889	25/712	7/444	%50	%50
59/347	1765/222	1050/889	27/174	6/667	%25	%75

Averages in columns with letters in common, do not have significant difference.

Variance analysis results in this experiment show the significant difference of number of seeds per vetch pod influenced by different mixing ratios in intercropping in 1% level of probability as well as non-significance of different nitrogen amounts on this attribute. As it can be understood from average comparisons table, vetch net cultivation treatment increased the number of seeds per pod by 38.83% compared with treatment of 25% vetch and 75% maize. The results of number of seeds per pot influenced by intercropping, adapt to the results of Mousian, et al, in the year *2010* and Urhart and Andrade in the year 1995. They announced that the maximum and minimum number of seeds in maize in different mixing ratios respectively, were dedicated to maize net cultivation with 754 seeds in corn and mixing ratios of 25% maize and 75% sunflower with 561 seeds. Variance analysis showed that different ratios of intercropping in 1% probability level were significant in weight of one thousand seeds. The maximum weight of one thousand seeds was related 100% vetch cultivation treatment with the average of 32.10g and the minimum was related to ratio of 50% vetch and 50% maize in their intercropping with average of 23.07g which showed a 35.40% increase. In the study of Mosian et al, 2010, the maximum and minimum weights of one thousand seeds respectively, were related to net cultivation and mixing ratio of 50% maize and 50% sunflower. As it can be seen in 7-4 table, Mutual effects of nitrogen fertilizer levels and plants mixing ratios did not become significant in intercropping which was the parallel effect concept of nitrogen fertilizer and intercropping different ratios functionalities in increasing the weight of one thousand vetch seeds. Vetch yield influenced by nitrogen fertilizer different levels and intercropping mixing ratios, was placed at 1% probability level which among different levels of nitrogen fertilizer, the amount of 150kg nitrogen fertilizer per hercater had the maximum yield with production average of 1056.67 and also, the minimum yield was obtained from witness treatment (Without using nitrogen) about 909.67kg per hectare. However,

in vetch net cultivation, the maximum seed yield was 1281.78kg per hectare and in treatment of 25% vetch and 75% maize, the minimum yield was achieved about 690.000kg per hectare which showed the 85.76 increase of seed yield. (Table 8-4). The results obtained by Nabavi *et al,* in the year1998 adapt the ones obtained by Tve itnes and Mcphilips, in the year 1989. It seems the vetch yield reduction in intercropping was due to maize capability and its shadowing on vetch which reduce the growth and the number of pods, and cause pod loss and eventually reduce the vetch yield. In fact, with increasing the maize rows, light penetration in vetch canopy and crop growth has been reduced and eventually the yield has been decreased. Based on findings, nitrogen fertilizer different levels mutual effects and plants mixing ratios in intercropping did not become significant on the seed yield. Results of data variance analysis in this experiment showed a significant difference in vetch biological yield influenced by intercropping different ratios at 1% probability level whereas nitrogen fertilizer different levels did not have a significant effect on this characteristic. As comprehended from the comparisons table, vetch maximum biological yield was obtained from vetch net cultivation with the average of 2013.78kg per hectare and the minimum was obtained from the treatment of 25% vetch and 75% maize. In other words, compared with treatment of 25% vetch and 75% maize, vetch net cultivation increased the biological yield by 49.38%. Results showed with changing from net cultivation towards intercropping, biological yield was reduced and it can be concluded that between-species competition increasing resulted in higher competition for water and nutrients and therefore, biological yield has been reduced. Mutual effects of nitrogen fertilizer levels and plants mixing ratios did not become significant on the above trait. Nitrogen amounts did not have significant on vetch harvest index, however; mixing ratios of maize and vetch plants are significant at 1% probability level. Based on averages comparison among various ratios of intercropping, vetch net cultivation treatment created the maximum harvest index (64.36%) for vetch which in comparison with treatments of 25% vetch and 75% maize, 50% vetch and 50% maize and 75% vetch and 25% maize respectively, had the excellence percentages of 25.11, 14.23, 8.44. Results of their survey showed the significance effect of cultivation different ratios on grass pea index, and the maximum amount of this characteristic was gained in the cultivation of 25% maize and 75% grass pea. Concerning the concept of harvest index, any factor that increases seed yield in terms of plant total dry weight, increases this index which represents a more appropriate allocation of photosynthesis materials and nutrients to the seed. This is probably reduced by increasing maize portion in vetch cropping pattern which can be due to more severe competition of maize and vetch in their mixture and above maize systems. This issue causes inappropriate growth and reduction of seed yield in comparison with plant dry weight and therefore, harvest index is reduced and also, mutual effects of nitrogen fertilizer levels and plants mixing ratios in intercropping did not become significant on vetch harvest index. The LER calculated values were more than 1 in all of the intercropping systems. Which shows the dominance of intercropping over net cropping. Its maximum value (1.40) was obtained in mixture of 25% vetch and 75% maize (table 9-4). Similar results are also been reported by Naqizadeh et al, 2013. When the value is higher than 1 then, intercropping is dominant on net cropping. Vetch net cropping seed yield was higher than all the mixing ratios which can be related to higher plant external-species competition in comparison with internal-species competition. However, seed production in both crops at different levels of nitrogen had critical changes. For this reason, the highest total of seed yield was related to fertilizer amounts of 150kg nitrogen per hectare.

Table 8. The effect of nitrogen different levels and cropping ratios of vetch and maize on filed equality ratio

LER average in harvest different ratios	*150* (Kg/ha)	*100* (Kg/ha)	*0* (Kg/ha)	Nitrogen Fertilizer Mixing Ratios
1/40	1/65	1/30	1/23	Mixture of 25% vetch and 75% maize
1.21	1/32	1/26	1/06	Mixture of 50% vetch and 50% maize
1/24	1/35	1/20	1/15	Mixture of 75% vetch and 25% maize
	1/44	1/26	1/14	LER average in different amounts of nitrogen fertilizer

Nitrogen fertilizer levels showed a significant effect on number of seeds per row charactristics, seed yield and biological yield for maize plant and seed yield for vetch plant. The highest seed yield of maize and vetch was obtained from the treatment of using 150kg nitrogen fertilizer per hectare and net cropping of these two. Various ratios of intercropping had a significant effect on number of seeds per row, weight of one thousand seeds, seed and biological yield of maize and in the vetch plant had a significant effect on all the surveying characteristics and finally, the maximum seed yield was gained from the net cropping of each surveying plants. In other words, net cropping seed yield of maize and vetch plants was higher than all the mixing ratios which can be related to higher plant external-species competition in comparison with internal-species competition. However, seed production in both crops at

different levels of nitrogen had critical variations. The interaction of nitrogen fertilizer levels and intercropping various ratios was not significant on none of the features.

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