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Research Paper

Monitoring soil nutrient balances using participatory research

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Abstract
A participatory program was conducted in western Iran to calculate nutrient balances. Information on farmer's resources and soil characteristics were collected in two watersheds (Honam and Merek). Results showed a positive and negative balance for some crops in two studied areas.

Introduction
Soil nutrient balances are defined as the difference between the sum of nutrient input flows and the sum of nutrient output flows within a field, farm or nation over a period of time (Elias, 2002). Nutrient-balance studies can be done at different levels including plot, farm, regional, national and continental. Van Beek *et al* (2016) calculated soil nutrient balances at plot level for 350 farms of Ethiopia and they concluded that average nitrogen, phosphorus, and potassium balances are -23 ± 73, 9 ± 29 and -7 ± 64 kgha-1 respectively. Haileslassie *et al* (2006) studied the differences of soil fertility management between two farming systems using participatory research in the central highlands of Ethiopia. They found that farmer's management in two studied farming systems is different and nutrient inputs were positively related to farmers' wealth status. The objective of this research was to gain a quantitative overview of annual nutrient balances at field scale for the most prevalent crops in upper Karkheh river basin using a participatory program.
Key words: Honam, Merek, Karkheh river basin

Material and methods
Studied sites
This study operated in Honam and Merek watersheds that are located in the upper catchment of Karkheh River Basin (KRB) in Lorestan and Kermanshah provinces, western Iran (Figure 1).

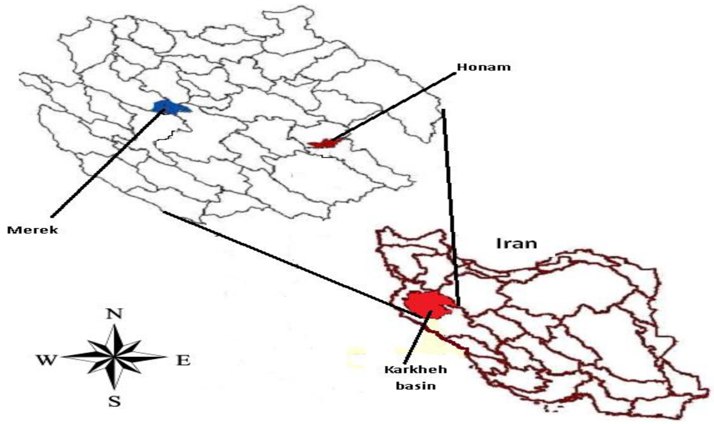

Figure 1: location of studied sites (Own work)

Number of observation fields and field's area

Tables 1 and 2 display the crops, the number and percentage of observations fields, as well as acreage percentage ratio of each crops in the study area of Lorestan (Honam watershed) and Kermanshah (Merek watershed) respectively.

Table 1: The observations fields and acreage percentage ratio of crops in Honam watershed (Lorestan)

crop	Observation fields	%	Acreage (hectares)	%
Wheat	122	51.5	242.6	60.2
Barley	44	18.6	95.1	23.6
Trifolium	28	11.8	26.3	6.5
Alfalfa	15	6.3	10.9	2.7
Chick pea	15	6.3	23.2	5.8
Lentil	8	3.4	4.9	1.2
Beans	5	2.1	6.5	1.6
Total	237	100	403	100

Table 2: The observations fields and acreage percentage ratio of crops in Merek watershed (Kermanshah)

crop	Observation fields	%	Acreage (hectares)	%
Wheat	86	49.6	422	53.5
Lentil	32	18.4	202.5	25.7
Sugar beet	26	14.8	86	10.9
Barley	21	12.1	58.5	7.4
Chick pea	6	3.4	14	1.8
Corn	3	1.7	6	0.8
Total	174	100	789	100

Tables 3 and 4 display the percentage of field area accurately.

Table 3: The observations fields and acreage percentage ratio of crops in Honam watershed (Lorestan)

Field area (ha.)	Observation fields	%
< 1	97	40.9
1 – 2	95	40.1
2.1 – 4	24	10.1
4.1 – 10	17	7.2
> 10	4	1.7
Total	237	100

Table 4: The observations fields and acreage percentage ratio of crops in Merek watershed (Kermanshah)

Field area (ha.)	Observation fields	%
< 1	1	0.6
1 – 2	67	38.5
2.1 – 4	54	31.0
4.1 – 10	45	25.9
> 10	7	4.0
	174	100

Soil sampling and laboratory analysis

In order to get an overview of soil properties in studied sites, soil samples were collected randomly and a composite sample was created for each farm. After air drying of soil samples and passing through a 2 mm sieve, all samples were analyzed in laboratory.

Nutrients Balances

Major inputs and outputs fluxes that we considered for calculating N, P and K balances and their respective units are shown in table 5. Consumption of chemical fertilizers and manure, crop residue, atmospheric fixation rate and biological nitrogen fixation were considered as inputs. The main outputs were grains, tubers, stubbles and crops residues which removed out of fields and grazed by animals and volatile losses of nitrogen.

Table 5: Balance entries for soil nutrient balances as used in research

quantity	unit	source
field area	ha	survey
crop	-	survey
yield	kg, bag, tonnes, truckload	survey
nutrient concentrations (N, P, K)	kg kg^{-1}	laboratory analysis
residue	kg, bag, tonnes, truckload	survey
fertilizer	kg, bag	survey
manure	kg, bag, truckload	survey
gaseous losses	kg kg^{-1} y^{-1}	secondary literature
atmospheric fixation rate	kg ha^{-1} y^{-1}	secondary literature

Atmospheric deposition was estimated (in kg ha^{-1} y^{-1}) according to Smaling and Fresco (1993) model that have used mean annual rainfall and coefficients of 0.14, 0.023 and 0.092 for N, P and K, respectively. Symbiotic nitrogen fixation was estimated by assuming that legumes fix 60% of total N uptake. Regression model of FAO (2005) was used to estimate nitrogen fixation by free-living bacteria. We estimated gaseous losses of nitrogen using the regression model of FAO (2005).

A total number of 119 farmers in the Lorestan and Kermanshah provinces (59 and 60 farmers from 11 and 22 villages respectively) were interviewed. Basic information about farmers' social and economic situations was recorded. Farmer's income (low, medium, high) was assessed to evaluate the effect of household capital availability on the field nutrient balance. Once the data were gathered, sample averages, percentage and count were calculated for each crop, irrigation regime, size of fields and nutrient balance. The N, P, and K balances were performed for each field and converted the numeric results to kg.ha-1 of positive balance (loading) or negative balance (offloading) of nutrients N, P, and K. In order to determine the N, P, and K balances, it assumed that the fields with + / - 5 kg.ha-1 variation of positive or negative balance were in balanced. However calculations were also performed without this assumption.

Results and discussion

Soil properties of two studied watersheds

An overview of soil properties are presented in table 6.

Table 6: Average soil properties of two studied watersheds

Watershed	N (%)	P(mg kg^{-1})	K(mg kg^{-1})	CEC(meq $100g^{-1}$)	Organic carbon (%)
Honam	**0.15**	**10**	**330**	**22**	**1.8**
Merek	**0.2**	**13**	**380**	**25**	**2**

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Nutrient balance

The result of nutrient balance (nitrogen, phosphorous and potassium) calculation for different crops in Honam watershed is displayed in table 7. As can be seen the positive balance of nitrogen (12-67 kg.ha-1) and phosphorous (40-72) kg.ha-1 was occurred in 167 observation fields for wheat and barley while the negative balance (35-56 kg.ha-1)was occurred for potassium. The result of nutrient (nitrogen, phosphorous and potassium) balance calculation for different crops in Merek watershed is displayed in table 8.

Table 7: The observations fields and nitrogen, phosphorous and potassium flow in Honam watershed (Lorestan)

						% of involved fields			% of balanced fields		
Crop		observation fields	N	P	K	N	P	K	N	P	K
barley	rain fed	41	46	57	-36	80	93	80	5	2	0
chick pea	rain fed	15	13	18	-13	60	27	93	20	40	7
alfalfa	irrigated	15	-1752	-121	-1137	93	60	93	0	7	0
lentil	rain fed	8	11	27	-60	38	25	100	0	25	0
beans	irrigated	5	246	155	68	100	100	100	0	0	60
wheat	irrigated	97	37	72	-56	55	89	77	9	3	1
wheat	rain fed	25	12	40	-35	52	84	88	4	8	0
barley	irrigated	4	67	64	-50	50	100	75	0	0	0
trifolium	irrigated	28	-519	14	-493	93	43	96	0	29	0

Table 8: The observations fields and nitrogen, phosphorous and potassium flow in Merek watershed (Kermanshah)

						% of involved fields			% of balanced fields		
Crop		observation fields	N	P	K	N	P	K	N	P	K
barley	rain fed	20	-36	5	-31	90	65	95	0	40	0
chickpea	rain fed	6	10	-3	-8	100	100	100	17	100	17
corn	irrigated	3	141	102	104	100	100	100	0	0	33
lentil	rain fed	31	-15	-3	-19	84	94	100	16	94	6
sugar beets	irrigated	28	-798	-17	-1571	100	61	100	0	4	0
wheat	irrigated	37	-41	21	-19	81	70	73	3	19	0
wheat	rain fed	49	-27	9	-21	94	73	98	8	41	2

The study on Honam farmer's economic situations revealed that the farmers with medium income category applied more nitrogen and potassium fertilizer than the high and low income farmers. The phosphorous was more positive balance in low income farmer's fields than the others (fig. 2). The study on Kermanshah farmer's economic situations revealed that the farmers with high and medium income categories had more negative nitrogen and potassium balance than the low income farmers. It might be because of higher yield along with fewer inputs. The phosphorous was more or less in balance especially in low income farmer fields (Fig. 3).

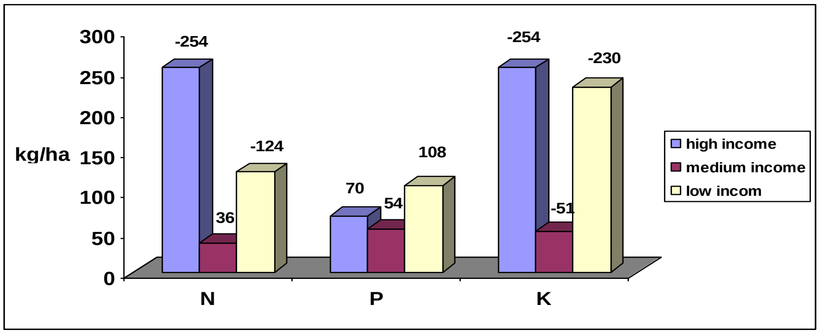

Fig. 2: The relation between Honam farmer's income and N, P, K balance of their fields

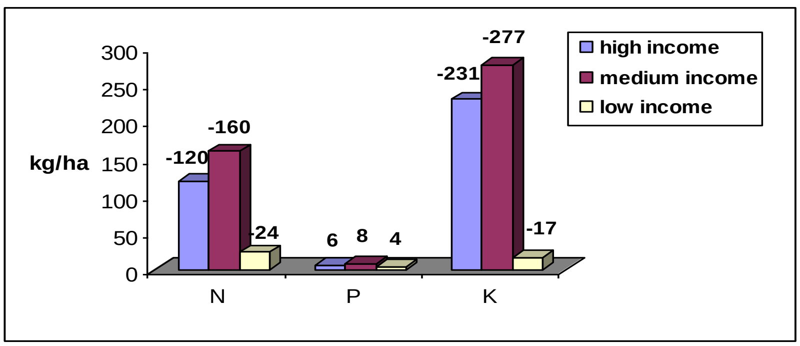

Fig.3: The relation between Merek farmer's income and N, P, K balance of their fields

Conclusion

The results revealed that the average nitrogen positive balance in Lorestan is due to applying animal manure and ability of farmers for buying chemical nitrogen fertilizers from free market. The average negative nitrogen balance in Kermanshah is due to applying less animal manure and nitrogen chemical fertilizers. Evaluation of nutrient balance of each field can be performed each year through filling the simple data sheet by educated farmers or cooperation and solving the data by a fast computer program.

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