DESERT

DESERT
Online at http://jdesert.ut.ac.ir

DESERT 12 (2008) 121-128

Effects of various super absorbent concentrations on runoff volume in slopes and various intensity of simulated rainfall in Shahrekord plain

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Received 2 November 2005; received in revised form 5 November 2007; accepted 23 March 2008

Abstract

In order to study the effect of super absorbent on runoff volume in slopes and various intensity of rainfall research was accomplish according to split – factorial blocks method with main treatment and two accessory treatments in three replicate . the main treatment consist of three dominant slopes (10 , 20 , 30 percent) and accessory treatments consist of five levels of substance super absorbent (instance , 20 , 40 , 60 , 80 kg/ha) and three levels of various rainfall intensity (25, 30,40 mm/hr). the rain simulator set was used and the rainfall duration intervals was 30 minutes. To establish hydraulic pressure complementary water volume added to reservoir tank in each 5 minutes. Then runoff was gathered to measure output runoff volume. Finally statistical analysis was done on the collected data. Results shows that substance super absorbent treatments of various rainfall intensity in comparison with control plate has significant effect in decrease of output runoff volume to 5 level percent.

Keywords: Soil erosion;, Super absorbent; Rain simulation; Volume runoff; Slope

1. Introduction

Soil erosion is one of the prejudicial phenomena of human civilization, especially with increasing population in the recent century and exorbitant and irregular exploitation of fields, it represents as a critical problem (Rafahi H.GH, 1997).

With attendance to loss marking effects of erosion it require struggles for prohibit of erosion, runoff and penetrate surface water for maintain water ground resources. There are various methods for increase penetration surface runoff from raining and irrigation of gradient fields. One of them is using surface Mulch on surface soil and establishment vegetable coating in slanting fields. Vegetable cover prohibit runoff on surface soil and in other wise with creating desirable structure in soil cause increasing water penetration in to soil. In some countries a new method was created. In this method poly acryl amid is used for creating structure in soil. Initial scientific researching about consumption of products accomplished at the beginning of 1980s. After recognize the effect of supper absorbents on soil characteristics and growing vegetables , in some countries clump and commercial production starts at late 1980's and early 1990's. Also, recently in Iran Polymer search place take action to produce new materials as freshness supper absorbent or supper water which it is modified poly acryl amid materials. Use up these materials has positive effects that include:

1. Enhancement cohesion of soil granulation and therefore reform of soil structure.

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2. Enhancement water capacity retention in soil.
3. Enhancement irrigation revolution for most vegetables.
4. Countercheck of intense moisture fluctuation in soil.
5. Reduce volume of running water.
6. Reduce irrigation cost.

Ben Hour (1989) used 25, 50, 150 mg/lit densities of poly acryl amid for spit irrigation in clay loam soil and reported that penetrated irrigation water for 4 first hours enhanced 30 to 75 percent.

Lentz and Sojka (1994) worked on severely erosion silty loam soil in Idaho and to take notice that poly acryl amid cause reduce lose able soil to 75 percent for strew supper absorbent material from rills.

Helalia and Letey (1988) investigated the effect of various concentration of poly acryl amid that strew as solution materials on three kind of soils and used rain simulator set. They observed that in various soils, supper absorbent can decrease output runoff volume and increase soil penetration.

EL-Murci et al. (1991) measured hydraulic conduction of sandy loam soil with use up various intensity electrolyte water and various portion of ratio sodium absorbent with or without poly acryl amid and therefore reported that with consumption of poly acryl amid enhance hydraulic conduction in sandy loam.

Michel (1986) researched on two kinds soil with ESP 8 and 25 percent that had heavy texture and swelling clay and find out that enhancement values of polymer increase hydraulic conduction and movement of salts in soils with excessive crack significantly.

In general, the purpose of this research is labor various concentrations of supper absorbent and study runoff volume in slopes and various intensity of rainfall with rain simulator set.

2. Materials and Methods

This study accomplished in research fields of Shahrekord University. Figure (Khoram Del, N. 2002) shows situation of the region that is in 50^0 51' 4" longitude and 32^0 19' 17" latitude coordinates.

Average elevation of the Iran is 2078 ma.s.l. Average annual temperature region is 12.5°C (maximum in July 34.1°C and minimum in December -8°C). Average annual rainfall is 320.9 mm and average relative moisture is 31 percent in August while 67 percent in December.

Fig. 1. Situation of the region

Soil thermal regime is mesic and soil moisture regime is xeric. Soils of this region on the basis of American classification are Inceptisol. In researching farm of Shahrekord University choose three dominant slopes of the region (10, 20, 30 percent) and related researching design accomplish in split-factorial blocks frame. Slopes selected as a main treatment and sampling zig-zag form of related soil in each slope (Figure2) and samples transferred to laboratory to calculate physicochemical characteristics, the results of these experiments are shown in Table 1.

Slope 10 percent

I=30mm/h C=4kg/ha	I=40mm/h C=8kg/ha	I=30mm/h C=0kg/ha	I=30mm/h C=2kg/ha	I=25mm/h C=8kg/ha	I=40mm/h C=0kg/ha	I=25mm/h C=4kg/ha	I=25mm/h C=6kg/ha	I=25mm/h C=0kg/ha
I=40mm/h C=0kg/ha	I=30mm/h C=8kg/ha	I=40mm/h C=4kg/ha	I=25mm/h C=2kg/ha	I=30mm/h C=2kg/ha	I=25mm/h C=0kg/ha	I=40mm/h C=6kg/ha	I=25mm/h C=6kg/ha	I=40mm/h C=2kg/ha
I=30mm/h C=6kg/ha	I=25mm/h C=4kg/ha	I=30mm/h C=0kg/ha	I=25mm/h C=8kg/ha	I=30mm/h C=8kg/ha	I=30mm/h C=6kg/ha	I=25mm/h C=2kg/ha	I=30mm/h C=4kg/ha	I=40mm/h C=8kg/ha
I=40mm/h C=4kg/ha	I=25mm/h C=0kg/ha	I=40mm/h C=2kg/ha	I=40mm/h C=0kg/ha	I=30mm/h C=2kg/ha	I=25mm/h C=2kg/ha	I=40mm/h C=6kg/ha	I=40mm/h C=8kg/ha	I=25mm/h C=4kg/ha
I=25mm/h C=6kg/ha	I=30mm/h C=6kg/ha	I=30mm/h C=4kg/ha	I=40mm/h C=2kg/ha	I=30mm/h C=0kg/ha	I=40mm/h C=4kg/ha	I=30mm/h C=8kg/ha	I=25mm/h C=8kg/ha	I=40mm/h C=6kg/ha

5m

Slope 20 percent

I=30mm/h C=4kg/ha	I=40mm/h C=8kg/ha	I=30mm/h C=0kg/ha	I=30mm/h C=2kg/ha	I=25mm/h C=8kg/ha	I=40mm/h C=0kg/ha	I=25mm/h C=4kg/ha	I=25mm/h C=8kg/ha	I=30mm/h C=0kg/ha
I=40mm/h C=0kg/ha	I=30mm/h C=8kg/ha	I=40mm/h C=2kg/ha	I=25mm/h C=2kg/ha	I=30mm/h C=2kg/ha	I=25mm/h C=0kg/ha	I=40mm/h C=6kg/ha	I=25mm/h C=8kg/ha	I=40mm/h C=4kg/ha
I=30mm/h C=6kg/ha	I=25mm/h C=4kg/ha	I=25mm/h C=0kg/ha	I=25mm/h C=8kg/ha	I=30mm/h C=8kg/ha	I=30mm/h C=6kg/ha	I=25mm/h C=2kg/ha	I=30mm/h C=4kg/ha	I=40mm/h C=8kg/ha
I=40mm/h C=4kg/ha	I=25mm/h C=0kg/ha	I=40mm/h C=2kg/ha	I=40mm/h C=0kg/ha	I=30mm/h C=2kg/ha	I=25mm/h C=2kg/ha	I=40mm/h C=6kg/ha	I=40mm/h C=8kg/ha	I=25mm/h C=4kg/ha
I=25mm/h C=6kg/ha	I=30mm/h C=6kg/ha	I=30mm/h C=4kg/ha	I=40mm/h C=2kg/ha	I=30mm/h C=0kg/ha	I=40mm/h C=4kg/ha	I=30mm/h C=8kg/ha	I=25mm/h C=8kg/ha	I=40mm/h C=6kg/ha

5m

Slope 30 percent

I=30mm/h C=4kg/ha	I=40mm/h C=0kg/ha	I=30mm/h C=0kg/ha	I=40mm/h C=4kg/ha	I=25mm/h C=8kg/ha	I=25mm/h C=6kg/ha	I=30mm/h C=0kg/ha	I=25mm/h C=8kg/ha	I=25mm/h C=4kg/ha
I=40mm/h C=0kg/ha	I=30mm/h C=8kg/ha	I=40mm/h C=2kg/ha	I=25mm/h C=2kg/ha	I=30mm/h C=2kg/ha	I=25mm/h C=0kg/ha	I=40mm/h C=6kg/ha	I=30mm/h C=6kg/ha	I=40mm/h C=0kg/ha
I=30mm/h C=6kg/ha	I=25mm/h C=4kg/ha	I=25mm/h C=0kg/ha	I=30mm/h C=2kg/ha	I=30mm/h C=8kg/ha	I=25mm/h C=8kg/ha	I=25mm/h C=2kg/ha	I=40mm/h C=8kg/ha	I=30mm/h C=4kg/ha
I=40mm/h C=4kg/ha	I=25mm/h C=0kg/ha	I=40mm/h C=2kg/ha	I=40mm/h C=8kg/ha	I=30mm/h C=2kg/ha	I=25mm/h C=2kg/ha	I=40mm/h C=6kg/ha	I=40mm/h C=8kg/ha	I=25mm/h C=4kg/ha
I=25mm/h C=6kg/ha	I=40mm/h C=2kg/ha	I=30mm/h C=4kg/ha	I=30mm/h C=6kg/ha	I=30mm/h C=0kg/ha	I=40mm/h C=4kg/ha	I=30mm/h C=8kg/ha	I=25mm/h C=6kg/ha	I=40mm/h C=6kg/ha

5m

9m

Fig. 2. Experimental blocks plan on three various slopes

Table1. Soil physicochemical characteristics on three various slopes

Slope (%)	Texture	B.D (gr/cm^3)	$CaCo_3$ (%)	EC (ds/m)	pH	O.C (%)	Na (meq/lit)	Ca (meq/lit)	Mg (meq/lit)
10	SC-SCL	1.4	53	0.61	7.7	0.08	5.7	6.1	1.5
20	SCL	1.5	57	0.30	7.8	0.05	5.1	2.7	2.0
30	SCL	1.6	57	0.33	7.5	0.04	4.5	3.0	2.2

Create plots with dimensions $1*1m^2$ and added super absorbent with various intensities (0, 20, 40, 60, 80 Kg/ha) to each plot, for use up of rain simulator set These materials were added to soil as mixture with water before 24 hours raining for having enough time to cohesion within practice of soil .

In each slope for measure effect of these materials on surface soil, limit of possible, remove vegetable covering and mulch and gravel in soil. Raining accomplish with use up artificial rain simulator set on various intensity 25, 30, 40 mm/hr. At the end of each rain event, collected output runoff of each plot with installed encasement in the end of plot to assess its volume with graduation plates.

Collected data were analyzed using statistical methods with use up Statgraph, Mstatc, SAS, Excel softwares. The results analysis of variance treatment effects slopes, intensity of rainfall and concentration of supper absorbent and average compare each of them on runoff volume show in Tables 2, 3, 4 and 5 and Figures 2, 3 and 4.

Table 2.Variance analysis of concentrations of supper absorbent, intensity of rainfall and slope on output runoff volume

Resource	df	SS	MS	F	P-value
R	2	52.41	26.20	$1.55^{n.s}$	0.31
S	2	6818.5	340.09	202.25^{**}	0.0001
C	4	1241.74	310.43	29.49^{**}	0.0001
I	2	2082.37	1041.18	98.9^{**}	0.0001
Error A	4	67.42	16.85	---------	-------
S* C	8	138.19	172.74	29.49^{**}	0.0001
S* I	4	934.02	233.50	22.18^{**}	0.0001
I*C	8	1158.93	144.86	16.41^{**}	0.0001
S*I*C	16	1601.78	100.11	9.51^{**}	0.0001
Error B	84	884.37	10.52	--------	--------

S: Slope C: Concentration of super absorbent
I: Intensity of rainfall R: Replication

Table 3. Average comparison of super absorbent effect on output runoff volume

Output runoff volume(mm/m^2) Average comparison via Donken (5%)	Concentration of super absorbent(kg/ha)
5368.7_a	0
4160.6_b	20
3210.8_c	40
2901.2_d	60
2758.9_e	80

Table 4. Average comparison intensity of rainfall effect on output runoff volume

Output runoff volume(mm/m^2) Average comparison via Donken (5%)	Intensity of rainfall(mm/h)
5413_a	40
3988.3_b	30
2372.8_c	25

3. Results

3.1. Effect of concentration Supper absorbent

Results of variance analysis (Table 2) shows that concentration of supper absorbent on output runoff volume is significant in level 5 percent. Also, compare average via Donken shows that all levels of supper absorbent ratio control plot have significant difference. (Table 3). It means that with increase supper absorbent, reduce output runoff volume ratio in control plot significantly and maximum of decreasing of runoff when supper absorbent adding to plot in concentration of 80 Kg/hectare.

3.2. Effect of rainfall Intensity

The results of variance analysis (Table 2) show that rainfall intensity effect on output runoff volume was significant on level 5 percent.

In Table 4, average comparison intensity of rainfall effects shows significant difference on output runoff volume. Also, this table shows that maximum amount of output runoff was reached to 40 mm/h but minimum of amount

output runoff was accomplished in 25 mm/h in intensity of rainfall.

3.3. Slope effect

The results of variance analysis (Table 2) show that slope effect on output runoff volume was significant on 5 percent. Also Table 5, average comparison shows slope effect on output runoff volume with Donken method, maximum amount of output runoff volume was accomplished in slope 30 percent and minimum amount of output runoff volume was accomplished in slope 10 percent.

Table- 5 Average comparison of slope effect on output runoff volume

output runoff volume(mm/m^2) Average comparison via Donken (5%)	Slope (%)
6473.9_a	30
4293.9_b	20
1006.2_c	10

Composing effects of super absorbent substance and intensity of rainfall on output runoff volume from 3 various slopes was shown in 3, 4, 5 Figures.

In figure 3, in control treatment output runoff volume increase with intensity of rainfall enhancement and maximum of output runoff was accomplished in intensity of rainfall 40 mm/h. With adding super absorbent substance in 20, 40, 60, 80 kg / ha, concentrations begin to decrease output runoff volume in various intensity of rainfall.

In intensity of rainfall 40 mm/h, super absorbent substance can neutralize high intensity of rainfall effect. In intensity of rainfall 30 mm/h observe significant difference between all treatments and control plot. But in 20, 40, 60 kg/ha, concentration of super absorbent substances did not show significant difference.

Concentration with 80Kg/Hectare with remainders of supper absorbent concentration has a significant difference. In intensity of rainfall 25 mm/h doesn't observe significant difference between control plot runoff and concentration with super absorbent substance 80 kg/ha because of descend intensity of rainfall.

Figure 4 shows composing effects of super absorbent substance and intensity of rainfall on output runoff volume in slope 20 percent. In control plot with intensity of rainfall enhancement, increase runoff volume. In this plot runoff volume has a significant difference in 3 various intensities of rainfall.

With adding super absorbent substance decrease runoff volume and in concentration 80 kg/ha super absorbent substance become to minimum amount. In this concentration between 3 various intensity of rainfall there isn't significant difference in output runoff volume. Also, in density 60 kg/ha super absorbent between 3 various intensities didn't show significant difference in runoff volume.

Therefore super absorbent substance can keep runoff volume in 3 intensity of rainfall in same extent, and neutralize various intensity of rainfall effect.

In this slope, output runoff volume is higher than as compared with slope 10 percent, that because of rapid water flow on gradient surface and there wasn't enough time to penetrate into the soil.

Figure 5, shows composing effects of super absorbent substance and intensity of rainfall on output runoff volume in slope 30 percent. We observe that in control plot with intensity of rainfall enhancement from 25 to 40 mm/h, increase runoff volume, and this is more than as compared with slopes 10, 20 percent, that because of dominant slope effect in this plot.

In intensity of rainfall 25 mm/h with adding super absorbent substance to soil , decrease output runoff volume slowly until available constant amounting in concentrations 60 , 80 kg/ha .

That means, there is not significant difference between two concentrations, but significant difference was observed from output runoff volume between various concentrations of super absorbent substance and control plot.

In intensity of rainfall 30 mm/h, with adding super absorbent substance, runoff volume decrease significantly as compared with control plot. Significant difference from runoff volume between super absorbent 20, 40 , 60 kg/ha were not observed but significant difference in concentration 80 Kg/Hectare super absorbent with other concentrations were measured.

In intensity of rainfall 40 mm/hr, effect of high intensity rainfall and steep slope, time of infiltration of water in to the soil was too short, because of high intensity of rainfall and high slope. Therefore we didn't observe significant difference from output runoff volume with control plot until concentration 40 kg/ha, but in super absorbent substance concentration 60 kg/ha observe significant difference with less concentration.

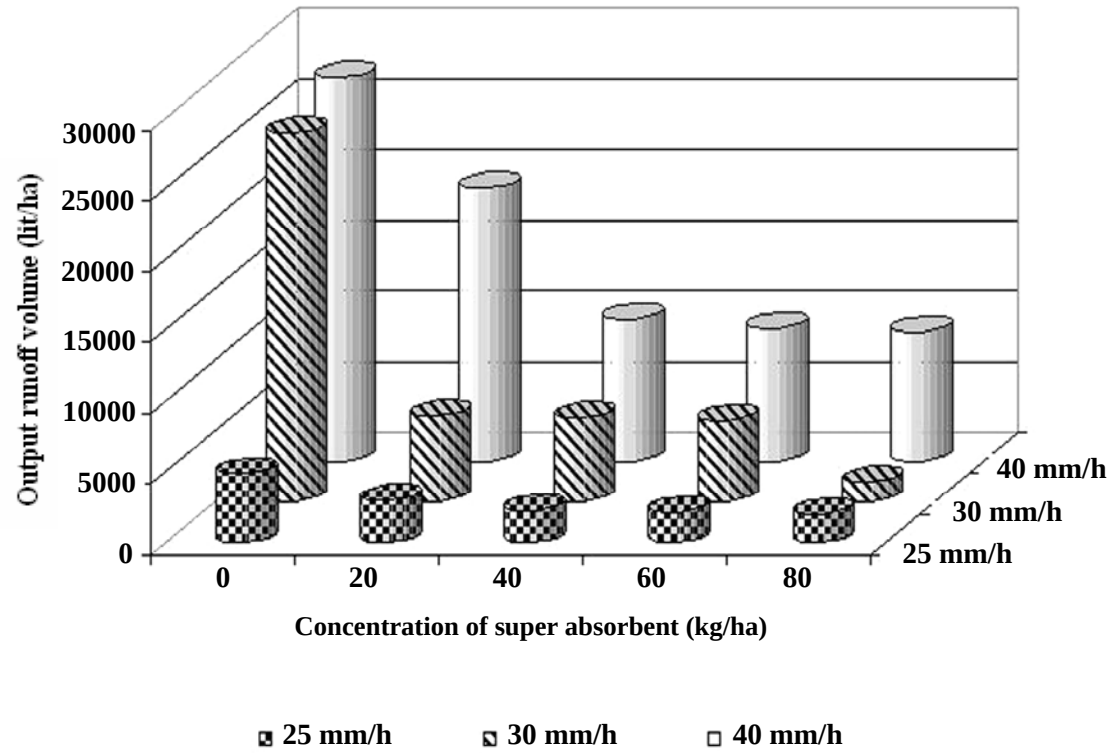

Fig. 3. Effect of super absorbent and intensity rainfall on runoff volume from slop 20 percent

In super absorbent substance concentration 80 kg/ha, runoff volume has a minimum amount but has not significant difference with concentration 60 kg/ha.

Therefore super absorbent substance concentration 60, 80 kg/ha can decrease slope effect still much extent.

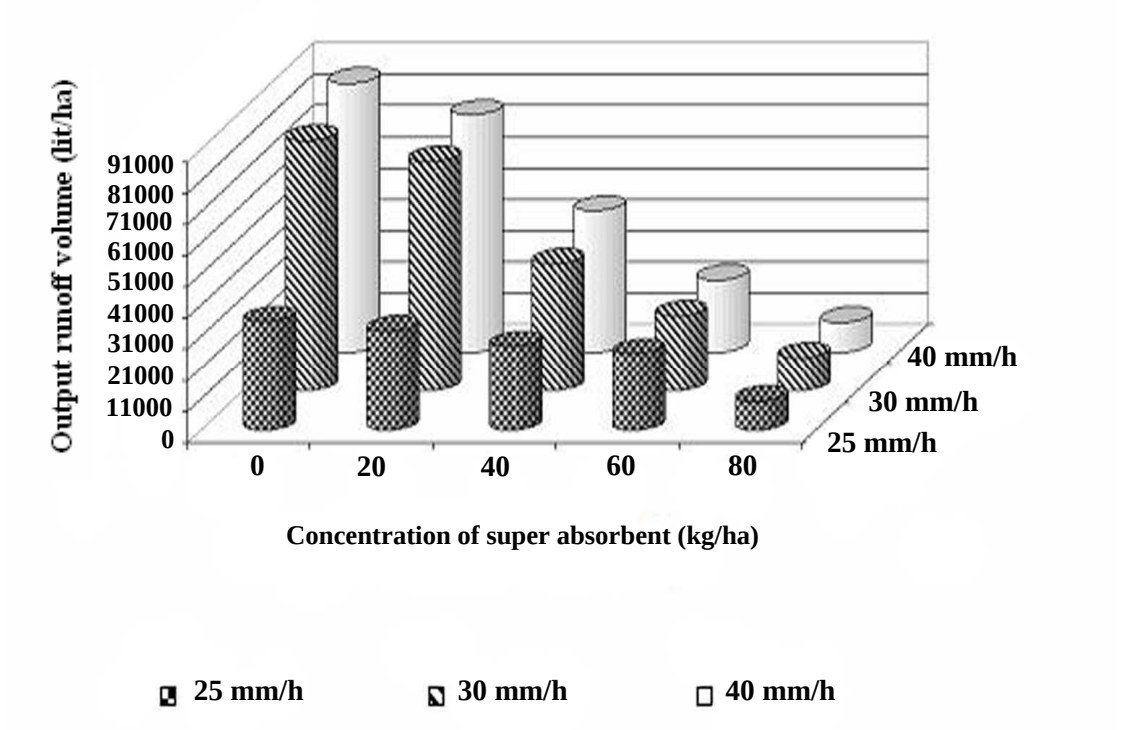

Fig. 4. Effect of super absorbent and intensity rainfall on runoff volume from slop 20 percent

4. Discussion and conclusion

On the whole, according to the results, amounts of below were considered for different slopes with intending of relative cost of these materials:

In slope 10 percent and intensity of rainfall 25 millimeters per hour, and slopes 20 and 30 percent and intensities of rainfall 25 and 30 mm/hr, using of super absorbent 40 kg/ha is suitable. In slope 10 percent and intensity of rainfall 30 mm/hr, and slope 20 percent and intensity of rainfall 40 mm/hr, using of super absorbent 60 kg/ha is suitable. In slope of 30 percent and intensity of rainfall 40 mm/hr, using of super absorbent 60-80 kg/ha is suitable.

In slope 10 percent due to previous cultivated land, soil compactness and elimination of macro pore of soil, runoff volume has increased and needs relatively tsuper absorbent for improvement of soil surface structure.

As results of data analysis shows, increasing of rainfall intensity have a positive effects on output runoff volume and these effects is significantly in level of 5 percent .But various treatments of super absorbent have shown negative effects on output runoff volume. Khalil pour (2002) suggested using of these materials on low slope. Also Ganji Khorramdel (2002) showed that poly acryl amide because of increased infiltration to surface, has favorable effects on soil structure and decrease of soil losses.

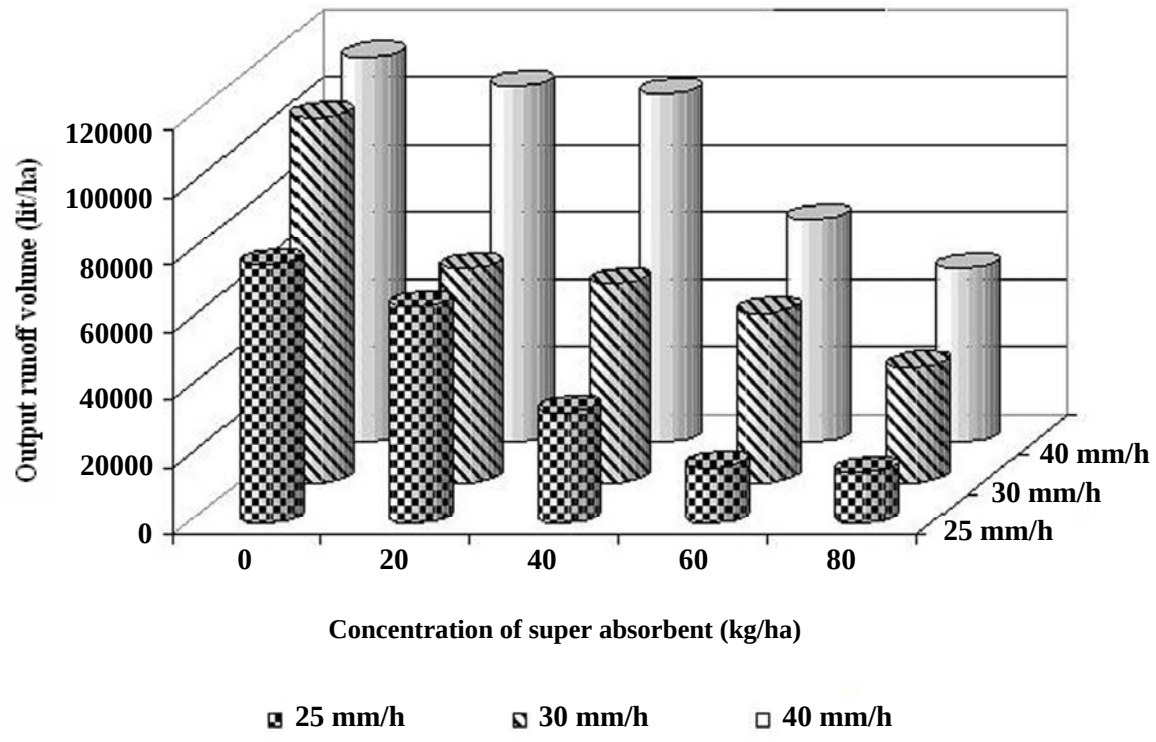

Fig. 5. Effect of super absorbent and intensity rainfall on runoff volume from slop 30 percent

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