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WHEAT YIELD AS INFLUENCED BY MOISTURE CONSERVATION PRACTICE THROUGH PLOUGHING AND PLANKING AFTER MAIZE HARVEST UNDER RAINFED CONDITIONS

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Abstract: To evaluate the response of rainfed wheat (*Triticum aestivum* L.) to moisture conservation after harvest of preceding maize, a field experiment was conducted for four consecutive years at Zonal Research Station for *Kandi* area, Ballowal Saunkhri in Shaheed Bhagat Singh Nagar district of Punjab. Moisture conservation at physiological maturity of maize recorded highest yield of wheat during all the growing seasons. The treatment of moisture conservation at physiological maturity registered highest wheat yield (41.2 q ha^{-1}) during fourth year while in third year, lowest wheat yield (18.3 q ha^{-1}) was obtained. Lowest yield was recorded in all the treatments during third year due to poor and erratic distributed rainfall during the growing season. This reduction in yield of wheat was also due to less stored moisture in the profile as observed in upper 30 cm layer which was 3.7 cm at the time of physiological maturity of maize and further reduced to 2.1 cm when moisture was conserved 30 days after the harvest of maize. Moisture in 180 cm profile during third year was 17.8 cm whereas 30.5 and 25.8 cm moisture storage was recorded during the first and second year, respectively. Wheat yield responded to moisture conservation at different stages after harvest of maize. The decline in wheat yield varied from 7 to 35 % due to delay in moisture conservation from 0 to 30 days. Higher storage of profile moisture in surface layer positively correlated with wheat grain yield than the whole profile storage of 180 cm. Increase in wheat yield was related to rainfall pattern during its growth season also.
Keywords: Rainfed, wheat yield, moisture conservation, maize.

INTRODUCTION

About 70 per cent of the total cultivated area in India is rainfed, contributing about 42 per cent of the total food grains production to feed the burgeoning population. The rainfed areas suffer due to frequent weather aberrations resulting in crop failure. Since the cultivation in rainfed areas involves high risk of crop failure, farmers in such a situation are reluctant to make high investment in their land for improving production (Anonymous, 1983). In Punjab, the sub-montaneous tract adjoining undulating piedmont plains in the south of *Shivalik* hills is popularly known as the *'Kandi'* zone. It comprises 0.5 Mha constituting about 10 % of geographical area of the state. This belt is dominated by maize- wheat cropping system (Dhaliwal *et al.,* 2008a). Topography of the area is undulating as well as sloppy and the

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average annual rainfall is more than 1100 mm, 80 per cent of which is received during *kharif* (Maskina *et al.,* 1996). Although this belt has a distinct advantage of higher rainfall than other parts of the state, but due to topographical and lithological constraints, a major part of the rainfall is not utilized by the crops (Verma *et al*., 2000). The irrigation facilities in this zone are very limited and most of crop production is dependent on rains (Prihar *et al.,* 1989). As a consequence, farmers of this area have to rely on the profile moisture for proper germination and growth of wheat crop (Dhaliwal *et al.,* 2008b).

Moisture conservation is an important component of rainfed farming after harvest of *kharif* crops, especially after maize. Wheat germination is ensured when moisture is conserved immediately after harvest of maize crop (Maskina and Dhaliwal, 1998). Farmers of this area are aware with the importance of soil moisture conservation and do so through a meticulously done 'g*il dabna'* practice since long. They harvest *kharif* crop and plough the field same evening and plank it early morning which leaves fine soil mulch at surface of the field due to softening of soil clods with moisture during the night. Soil mulch helps in conserving profile moisture by preventing evaporation losses. With the mechanization of agriculture, people are leaving this important practice because after harvesting *kharif* crop, they keep waiting for a number of days for a tractor on rent. This adversely effects the conservation of moisture in the profile.

Keeping these points in view, the conservation of moisture after harvest of maize is necessary for proper germination of wheat crop. This objective can be fulfilled only if farmers adopt moisture conservation measures in maize-wheat cropping sequence. The aim of this study was to evaluate the response of rainfed wheat (*Triticum aestivum* L.) to moisture conservation practice after harvest of preceding maize (Zea *mays* L.).

MATERIALS AND METHODS

A field experiment was carried out for four consecutive years at Zonal Research Station for *Kandi* area, *Ballowal Saunkhri* in *Shaheed Bhagat Singh Nagar* district of Punjab, under rainfed conditions in a randomized block design with three replications to quantify the effect of timing of moisture conservation after harvest of maize crop on wheat yield. This research station is situated 355 m above mean sea level at 31^0 06' 05'' latitude and 76^0 23' 26'' longitudes. The treatments consisted of moisture conservation through ploughing followed by planking at physiological maturity, 0, 10, 20 and 30 days after harvest of maize crop.

Table 1: Physico-Chemical characteristics of experimental soil

Soil parameters		Value
pH		8.7
EC (dSm^{-1})		0.15
Organic Carbon (%)		0.25
Available N (kg ha^{-1})		265
Available P (kg ha^{-1})		13.8
Available K (kg ha^{-1})		162
Moisture retentive capacity (1/3 bar) (%)		10.4
Moisture retentive capacity (15 bar) (%)		3.1
Texture	Sand (%)	72.2
	Silt (%)	17.9
	Clay (%)	9.9
Textural class		Sandy Loam

The physico-chemical characteristics of experimental soil are given in Table 1. It consisted of 72.2, 17.9 and 9.9 % sand, silt and clay respectively and is sandy loam (*Typic Ustochrept*) and non-saline. It is low in organic carbon (0.25%). The corresponding value of moisture retention at field capacity (0.3 bar pressure) was 10.4 % and at 15 bars 3.1 % on weight basis in 0-180 cm soil profile. The pH of experimental field was 8.7. The soil was low in available nitrogen (265 kg ha^{-1}), medium in available phosphorus (13.8 kg ha^{-1}) and sufficient in available potassium (162 kg ha^{-1}).

Table 2. Rainfall (mm) distribution at experimental site during different seasons

Month	Year				Normal (1984-2002)
	1st	2nd	3rd	4th	
Kharif					
May	16.0 (6)	0.0 (0)	26.1 (4)	70.9 (8)	38.2
June	85.2 (7)	10.0 (2)	184.6 (12)	95.1 (12)	95.7
July	517.0 (19)	220.0 (16)	264.7 (16)	270.7 (19)	342.0
August	549.9 (19)	410.0 (20)	347.5 (19)	392.3 (17)	335.1
September	114.0 (9)	320.0 (6)	225.2 (7)	93.6 (12)	170.8
Total	1282.1 (60)	960.0 (44)	1048.1 (58)	922.6 (68)	981.8
Rabi					
October	0.0 (0)	4.0 (1)	65.6 (2)	27.1 (8)	25.1
November	0.0 (0)	5.0 (2)	0.0 (0)	59.6 (7)	9.3
December	7.9 (4)	1.0 (2)	1.2 (1)	180.9 (6)	34.9
January	56.3 (9)	52.0 (5)	27.6 (4)	4.6 (2)	34.4
February	46.7 (11)	111.0 (8)	11.6 (4)	74.0 (9)	38.9
March	54.2 (5)	35.0 (9)	9.0 (6)	43.7 (6)	29.5
April	9.7 (6)	8.0 (2)	78.1 (10)	14.0 (5)	18.8
Total	174.8 (35)	216.0 (29)	193.1 (27)	404.0 (43)	190.9

*Figures in parenthesis are the number of rainy days.

Maize variety (JH 3459) was sown (20 kg ha^{-1}) during 3rd week of June to 1st week of July every year with recommended doses of N (80 kg ha^{-1}) and P_2O_5 (40 kg ha^{-1}). Half N and full P_2O_5 were applied at the time of sowing whereas the remaining N was applied one month after sowing. Maize was harvested at physiological maturity and repeated ploughing and planking were done to conserve moisture. Moisture was also conserved after 0, 10, 20 and 30 days of harvest of maize crop at physiological maturity through ploughing and planking. Soil moisture was determined thermo-gravimetrically at different depths upto 180 cm to determine the status of moisture conserved at different times after harvest of maize. Wheat variety PBW 175, recommended for sowing in Kandi area, was sown (100 kg ha^{-1}) at a depth of 15 cm in the first fortnight of November every year. Recommended doses of N (80 kg ha^{-1} through urea) and P_2O_5 (40 kg ha^{-1} through DAP), were applied. Half N, and full P_2O_5 were applied at the time of sowing, whereas the remaining N was applied with sufficient winter rains. Wheat crop was harvested in the month of April and grain yield data was recorded. Rainfall data (Table 2) for all the growing seasons was collected from observatory established near experimental site at the Research Station.

RESULTS AND DISCUSSION

Soil moisture

The data for profile moisture storage in 0-30 and 0-180 cm depth of soil revealed that with delay in moisture conservation through tillage for creating soil mulch after harvest of maize crop, there was significant and continuous decline in moisture content (Tables 3 and 4). Data in Table 3 indicated that moisture loss in top 30 cm soil through evaporation was maximum (18 mm) when tillage operation was delayed 30 days after harvest of crop whereas a loss of 15, 11 and 3 mm was observed in 20, 10 and 0 days after maize harvest, respectively over moisture conserved through tillage at physiological maturity. It is evident that with delay in tillage operation after crop harvest there was significant loss of soil moisture from the profile. However, moisture loss from physiological maturity to harvest was only marginal. The trend of moisture loss from whole profile (0-180 cm) was similar to that observed in case of top 30 cm. Average soil moisture loss recorded was 20, 44, 68 and 94 mm at physiological maturity and with delay in tillage by 0, 10, 20 and 30 days after harvest, respectively. Dhaliwal *et al*., 2008a) and Prihar *et al.*, (1989) reported similar observations on soil moisture conservation after harvest of maize crop.

Table 3: Profile moisture (cm/30 cm) at sowing of wheat as effected by time of creating soil mulch

Time of soil mulch creation	Year			Mean
	1st	2nd	3rd	
Physiological maturity	3.7	4.9	3.7	4.3
Harvesting of maize	3.6	4.5	3.4	3.8
10 DAH	2.8	3.5	2.8	3.0
20 DAH	2.4	3.0	2.5	2.7
30 DAH	2.2	2.5	2.1	2.4
CD (0.05)	0.7	0.7	0.6	-

Maize yield (q ha^{-1})

Maize yield was influenced by amount of rainfall and its distribution during crop growing seasons. The maize yield, at 14 % moisture content, obtained during the four years was 28.6, 20.8, 41.6 and 30.2 q ha^{-1} respectively. The yield during second year the lowest as very low rainfall was received during the months of May and June. As a result germination and crop stand were poor. Contrary to that, yield during the third year was highest as there was uniform distribution of rainfall during the crop growth period.

Table 4: Profile moisture (cm/180 cm) at sowing of wheat as effected by time of creating soil mulch

Time of soil mulch creation	1st	2nd	3rd	Mean
Physiological maturity	30.5	25.8	17.8	24.7
Harvesting of maize	28.3	23.9	16.0	23.0
10 DAH	26.7	19.7	14.5	20.6
20 DAH	22.6	17.5	13.5	18.3
30 DAH	20.3	14.0	11.5	15.5
CD (0.05)	1.6	2.2	1.4	-

Wheat yield as affected by residual profile moisture:

The time of moisture conservation through ploughing and planking significantly influenced the crop yield during all the growing seasons (Table 5). The data reveal that when moisture was conserved at physiological maturity of maize, it recorded the highest wheat yield during all the years. It is evident that delay in moisture conservation by 10, 20 and 30 days after harvest of maize, significantly decreased wheat grain yield except during 4th year where yields were recorded at par with each other. Wheat yields recorded with treatments of moisture conservation at physiological maturity and at harvest, were at par with each other during all the growing seasons. In general, decline in wheat yield due to delay of moisture conservation was from 2.7 to 17.2, 3.0 to 12.6, 2.5 to 6.1 and 0.1 to 5.7 q ha^{-1} during 2nd , 1st , 4th and 3rd year respectively, of growing seasons. It can be attributed to more water loss from soil through evaporation from profile during 2nd year than the 1st and 3rd years as well as less and erratic rainfall behavior during *Rabi* season (Table 4). The overall reduction in wheat yield due to delay in moisture conservation after maize harvest at physiological maturity was 7.1, 19.1, 30.3 and 34.9 per cent at 0, 10, 20 and 30 days respectively. Dhaliwal *et al.,* (2008a) reported similar observations for maize and wheat crops.

Table 5: Effect of creating soil mulch at different times after harvest of maize on grain yield (q ha^{-1}) of wheat.

Time of soil mulch creation	Year				Mean
	1st	2nd	3rd	4th	
Physiological maturity	26.0	33.0	18.3	41.2	29.6
Harvesting of maize (Normal)	23.0	30.3	18.2	38.7	27.5
10 DAH	19.4	25.0	14.2	37.4	24.0
20 DAH	14.2	18.3	13.7	36.5	20.6
30 DAH	13.4	15.8	12.6	35.1	19.2
CD (0.05)	3.4	3.4	2.8	3.8	-

DAH- Days after harvesting of normal crop

Yield recorded during 3rd year is relatively low as compared to other years which can be attributed to erratic behavior and irregular distribution of rainfall. As a consequence, low soil moisture storage was there in the profile. Also, there was poor rainfall during growing period (Table 2). Soil water storage of 17.8 cm was recorded in 180 cm profile during 3rd year where moisture was conserved at physiological maturity as compared to 1st and 2nd years while values are 30.5 and 25.8 cm, respectively. The lowest yield (18.3 q ha^{-1}) was recorded during 3rd year when wheat was sown after conserving moisture at physiological maturity while highest yield (41.2 q ha^{-1}) was registered during 4th year.

Levels of moisture in the profile at different stages of conservation

As the *Kandi* area is rainfed, yield of different crops depends upon rainfall, its distribution behaviour and moisture stored in the profile after the monsoon period is over. Erratic behaviour of rainfall and undulating topography jointly determine the storage of moisture in the profile, which affects the germination of crops. High rainfall with its erratic distribution adversely affects the yield of a crop and due to undulating topography; most of the surface water is lost as run off. The yield of wheat crop was reduced to a greater extent in the 3rd year due to less water stored in the profile. There was only 3.7 cm 30 cm^{-1} water at the time of physiological maturity of maize which further reduced to 2.1 cm 30 cm^{-1} when moisture was conserved 30 days after the harvest of maize. The same yield reduction was also evident from the data when only 17.8 cm water was recorded in 180 cm profile (Table 4) as compared to the 1st and 2nd years where 30.5 cm and 25.8 cm water was recorded in the same section respectively.

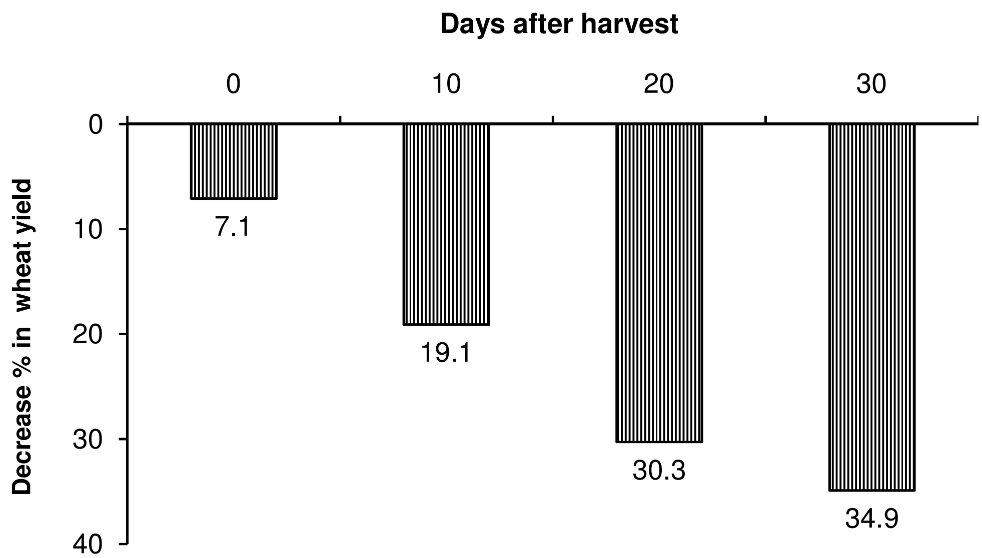

Fig. 1: Decrease in wheat yield due to delay in moisture conservation after *kharif* crop harvest at physiological maturity of maize

The soil moisture in the profile was highest when maize was harvested at physiological maturity and soil mulch was created at that time. With the increase in time of moisture conservation from 0 to 30 days after maize harvest, the profile moisture reduced progressively. The decrease in the yield of wheat during the 3rd year was directly proportional to surface run off, erratic behaviour and irregular distribution of rainfall (Table 2) due to which moisture was not properly stored in the profile. On the other hand, rainfall distribution was uniform during the 1st and 4th years which gave higher yield of wheat and more profile moisture in surface (30 cm) and profile (180 cm). Similar observations were reported by Greb *et al.,* (1970) and Sandal and Acharya, (1997).

Soil moisture and wheat yield relationship:

The regression analysis of soil moisture measurements under all treatments over three year period showed that wheat yield can be predicted from soil moisture storage at the time of seeding according to the following relation:

$Y = -3.4 + 7.28\ \theta$ $r^2 = 0.88^{**}$ (For 0-30 cm profile)

$Y = 4.88 + 0.73\ \theta$ $r^2 = 0.44^{**}$ (For 0-180 cm profile)

Wheat yield (Y, q ha^{-1}) showed a significant (**at 1% level of confidence) positive correlation with soil moisture storage (θ, cm) indicating that moisture storage in top 30 cm profile explained 88 % variation in wheat grain yield while 180 cm profile storage explained only 44 % variation. It indicates that top 30 cm surface soil moisture storage was best correlated to yield than the whole profile moisture storage. Similar results were reported by Verma *et al.,* (1999) under rainfed wheat.

Conclusions

Moisture conservation by creating soil mulch through repeated ploughing and planking immediately after the harvest of maize crop is very useful for ensured germination, plant growth and good yield of wheat crop. Moisture conservation at physiological maturity of maize registered the highest wheat yield. Only about 7-10 per cent reduction in wheat yield occurred when moisture was conserved at full maturity of maize. The reduction in yield of wheat was upto 35 per cent if moisture conservation was further delayed by 30 days. The increase in surface (0-30 cm) and profile moisture (0-180 cm) during the 2nd and 4th years showed a significant correlation with increase in wheat yield.

REFERENCES

[1] Anonymous,1983. Brief description of the soil – *A report from National Bureau of Soil Survey & Land Use Planning (RCD 91), ICAR*, Kanpur, India.

[2] Dhaliwal, S. S., C. B. Singh, A. S. Toor 2008a. Maize-wheat productivity as influenced by soil and fertilizer management practices in submontaneous tract of Punjab. Indian J. Ecol. 35(2): 126-129.

[3] Dhaliwal, S. S, C. B. Singh, A. S. Toor 2008b. Resource management for suitability and productivity of different soils in submontaneous tract of Punjab. Crop Res-An intern. J. 36 (1, 2 &3): 147-151.

[4] Greb, B.W., D. E. Smika and A. Black 1970. l. Water conservation with stubble mulch fallow. J. Soil and Water Cons. 25: 58-62.

[5] Maskina, M. S. and S. S.Dhaliwal 1998. Suitable cropping sequences for Kandi area of Punjab. Prog. Fmg. Vol.6: 7-8.

[6] Maskina, M.S., Sukhwinder Singh and S.S. Dhaliwal 1996. Soil and water management practices for Kandi for Kandi region of Punjab. Prog. Fmg. 6: 6, 27.

[7] Prihar, S.S., K. S. Sandhu, M. Singh, H. N. Verma and R. Singh 1989. Response of dryland wheat to small supplemental irrigation and fertilizer nitrogen in submontane Punjab. *Fert. Res*. 21:23-28.

[8] Sandal, S.K. and C. L. Acharya 1997. Effect of conservation tillage on moisture conservation, soil- conditions, seedling emergence and grain yield of rainfed maize(Zea and wheat (Triticum aestivum). *Indian Journal of Agricultural Sciences* 67 (6): 227-231.

[9] Verma, H.N., S. Singh and R. S. Narang 1999. Yield of rainfed wheat (*Triticum Aestivum*) in relation to seeding zone moisture and seed. *Indian J. of Agron*. 45(3): 548-553.