



Effect of moisture conservation and integrated nutrient management on summer maize (*Zea mays*) in Kandahar, Afghanistan

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Received: 15 September 2018; Accepted: 31 May 2019

Key words: Cob weight, Leaf area index, Maize, Production-efficiency, Water productivity

Maize (*Zea mays* L.) is one of the most important food cereals in Afghanistan grown throughout the country, but its average productivity in Afghanistan (2.48 t/ha), is much below the world's average yield of 5.5 t/ha (Anonymous 2015). The major limitations for low maize yield in Afghanistan include lack of improved varieties, poor availability of good quality seed, declining soil fertility lack of high quality fertilizers, inadequate production technologies and frequent droughts, lack of irrigation, diseases, insect pests and weeds (Ibrahimi *et al.* 2017). Maize is a heavy feeder of the nutrients and affected by the deficiency of essential plant nutrients to a greater extent than other cereals (Kumari *et al.* 2017, Ghosh *et al.* 2017). Thus, optimizing organic and inorganic manure (INM) for maize is important for higher productivity and resource-use efficiency. Moreover, adequate availability of moisture in the soil is essential for better growth and productivity of crops, especially under scarce irrigation-water availability vis-à-vis erratic rainfall behaviour. Moisture conservation practices like bed planting and use of crop residues as mulch have been found to improve productivity of maize (Jakhar *et al.* 2017a, 2017b). Hence, the current investigation was conducted to determine the effect of moisture conservation practices and INM on maize growth, productivity, profitability and resource-use efficiency.

The experiment was conducted at Tarnak farm of Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan (latitude

31°30' 26" N; longitude 65° 51'1" E; 986 m altitude; semi-arid climate). The average daily temperature ranges around 30–48°C during maize growing season (summer season). No rainfall occurred during the crop period. Soil of the experimental field was clay-loam having pH 7.8, 0.49% organic carbon, 10.6 mg/kg NH₄-N, 28.6 mg/kg NO₃-N, 19.9 mg/kg available-P, and 148 mg/kg available-K. The treatments included three soil moisture conservation practices [flatbed (FB), raised bed (RB) and raised bed + mulching (RBM)] in main-plots and four INM practices, viz. control-no fertilizer application (INM₁), 100% RDF (150:60:40 kg/ha NPK (INM₂), 50% RDF (75:30:20 kg/ha NPK)+ FYM (5t/ha) + 2% urea spray (INM₃), and 50% RDF (75:30:20 kg/ha NPK) +FYM (10t/ha) +2% urea spray (INM₄) assigned in sub-plots using a split-plot design, replicated thrice. The maize hybrid Shemal-08 was planted on May 1st, 2017 with spacing 60×20 cm using 20 kg/ha seed and harvested on 21st August 2017. The entire P and K and half N dose were applied at sowing time and remaining N was applied 25 DAS through triple super phosphate (TSP), muriate of potash (MOP) and urea, respectively. Foliar spray of urea (2%) was done at knee-high and tasseling stage each, for the respective treatments. The data on plant characters, yield components and yield were acquisitioned using the standard procedures (Rana *et al.* 2014). Crop was irrigated 10–12 times depending upon moisture conservation treatments. Water productivity (WP) was computed by using the formula suggested by Dass and Chandra (2013). Production-efficiency (PE) was computed as yield divided by crop duration and monetary-efficiency (ME) as net return divided by crop duration. All data were analyzed using analysis of variance technique for a split-plot design (Rana *et al.* 2014).

At knee-high (KH) and tasseling stages, RBM showed the highest leaf area index (LAI), number of cobs/plant, cob length, cob girth and cob weight. Better plant growth as depicted by a higher LAI resulted in significantly larger yield attributes in RBM plots compared to FB. Cob weight was 13.5% higher in RBM than FB. Thus, RBM plots produced the highest grain (5.22 t/ha) and straw (7.22 t/ha) yields that

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were 14.5% and 10.1%, respectively higher than FB and 7.9% and 5.6%, respectively higher than RB planting. Mulches insulate the soil surface from being heated up by direct sunlight and conserve soil moisture, thereby, protects the crop from heat stress in summer season (Prasad *et al.* 2016). Adequate supply of moisture positively influences growth and productivity of a crop directly as well as indirectly by increasing the availability and utilization of nutrients, and application of grass, straw and tree biomass mulch retained more than 10% higher moisture in surface soil compared to control (Dass *et al.* 2013, Dass and Bhattacharyya 2017, Rana *et al.* 2018, Jakhar *et al.* 2018a, 2018b). Thus, the LAI, yield attributes, and grain and straw yields in RBM plots were better over FB, in current study (Table 1, Fig 1).

The INM treatments, INM₂ and INM₄ depicted significantly higher LAI compared to INM₃ and INM₁ (Table 1). The use of INM₄ significantly improved number of cobs/plant over all other INM treatments. Cob length and cob girth were significantly lower in INM₁ than other INM treatments. Cob weight was significantly higher in INM₂ and INM₄, compared to INM₃ and INM₁. The increase in grain yield due to INM₄ and INM₂ over INM₁ (control) was 71.9 and 64.4% and over INM₃ 12.5 and 7.5 50%, respectively. Enhancement in straw yield due to INM₂, INM₃ and INM₄ was 34.5, 29.0 and 38.5% over INM₁ (5.48 t/ha), respectively. The supply of nutrients through organic and inorganic sources fulfills dual purpose of conserving soil moisture and meeting season-long nutrient demand of crop (Dass *et al.* 2013). Moreover, the INM treatment (INM₄) could have increased nutrient availability in sufficient amount consequent to their release into the soil slowly by gradual mineralization at a constant rate leading to an increased uptake of nutrient because of the better soil environment created owing to the addition of organic sources combined with inorganic source of nutrient (soil and foliar application); these positive impacts of INM enhanced the

plant growth and consequently enhanced the yield attributes and yield (Choudhary *et al.* 2006). Again, maize is a nutrient exhaustive crop and requires a heavy external application of nutrients (Kavita *et al.* 2017), particularly nitrogen; thus cutting down nutrient dose to 50% and applying only 5 t/ha FYM + urea spray (2%) twice (INM₃) might have not been able to meet out the nutrient requirement of maize resulting in significantly lower growth and yield.

On an average, RBM increased cost of cultivation by AFN 4530/ha over RB and AFN 5,780/ha over FB, however, net return was also highest with RBM. Higher grain and straw yields resulted in higher gross returns ultimately leading to higher net return from RBM compared to RB and FB. The highest net returns resulted in the highest ME in the RBM. WP was highest in RBM, which was 78.4% higher than FB and 26.1% higher than RB. The RB increased WP by 41.5% over FB (Table 2). In RBM, the number of irrigations was reduced by 2 due to mulch application that conserved soil moisture and prolonged irrigation interval, and quantity of water applied in each irrigation was also about 25% lower as water was applied only in furrows filled up to 2/3rd depth, compared to FB and RB without mulch. Thus, a lower water-use coupled with higher grain yield resulted higher WP in RBM compared to FB and RB, respectively. A higher PE in RBM is explained by the higher grain yield under this treatment.

Both INM₂ and INM₄ yielded higher net return over INM₃ and INM₁ due to higher grain and straw yields under the former two treatments. The B: C ratio was not affected significantly by INM options owing to higher FYM costs (Choudhary and Rahi 2018). The INM₄ and INM₂ recorded 65.3% and 61.1% higher WP over INM₁ and 8.2% and 11.1% higher over INM₃, respectively. PE under INM₄ and INM₂ was also higher than INM₁ and INM₃, respectively. INM₂, INM₃ and INM₄ exhibited significantly higher ME over INM₁ (Table 2), mainly due to higher grain and straw

Table 1 Effect of moisture conservation practices and integrated nutrient management options on leaf area index and yield parameters of maize

Treatment	Leaf area index		Cobs/ plant	Cob length (cm)	Cob girth (cm)	Cob weight (g)
	Knee high stage	Tasseling stage				
<i>Moisture conservation</i>						
FB	0.78	3.67	1.24	15.0	11.5	84.3
RB	0.85	3.79	1.37	16.3	11.8	88.2
RB + mulch (3 t/ha)	0.92	4.07	1.47	17.3	12.4	95.7
SEm±	0.019	0.049	0.03	0.22	0.15	1.95
CD (P=0.05)	0.077	0.189	0.13	0.83	0.64	7.66
<i>Integrated nutrient management</i>						
NM ₁	0.52	2.44	1.10	13.2	10.3	63.5
NM ₂	1.03	4.54	1.36	17.3	12.4	101.9
NM ₃	0.82	3.79	1.38	16.6	12.2	90.6
NM ₄	1.04	4.61	1.60	17.7	12.7	101.6
SEm±	0.013	0.057	0.06	0.39	0.20	3.12
CD (P=0.05)	0.022	0.169	0.20	1.17	0.60	9.29

Table 2 Effect of moisture conservation practices and integrated nutrient management options on economics and resource use efficiency of maize

Treatments	Cost of cultivation (AFN/ha)	Net returns (AFN/ha)	B:C ratio	Water productivity (kg/m ³)	Production efficiency (kg/ha/day)	Monetary efficiency (AFN/ha/day)
<i>Moisture conservation</i>						
FB	51,815	76,042	1.48	0.65	40.9	681.7
RB	53,065	82,204	1.56	0.92	43.4	737.3
RB + mulch (3 t/ha)	57,595	87,759	1.53	1.16	46.5	781.7
SEm±	-	2,138	.038	0.01	0.9	21.9
CD (P=0.05)	-	8,394	NS	0.05	3.6	86.0
<i>Integrated nutrient management</i>						
NM ₁	38,743	56,544	1.46	0.62	30.3	517.7
NM ₂	52,783	98,091	1.86	1.04	48.8	881.1
NM ₃	57,553	83,533	1.45	0.92	45.1	744.9
NM ₄	67,553	89,839	1.33	1.06	50.1	790.6
SEm±	-	2,999	0.06	0.02	1.2	27.3
CD (P=0.05)	-	8,911	NS	0.04	3.5	81.1

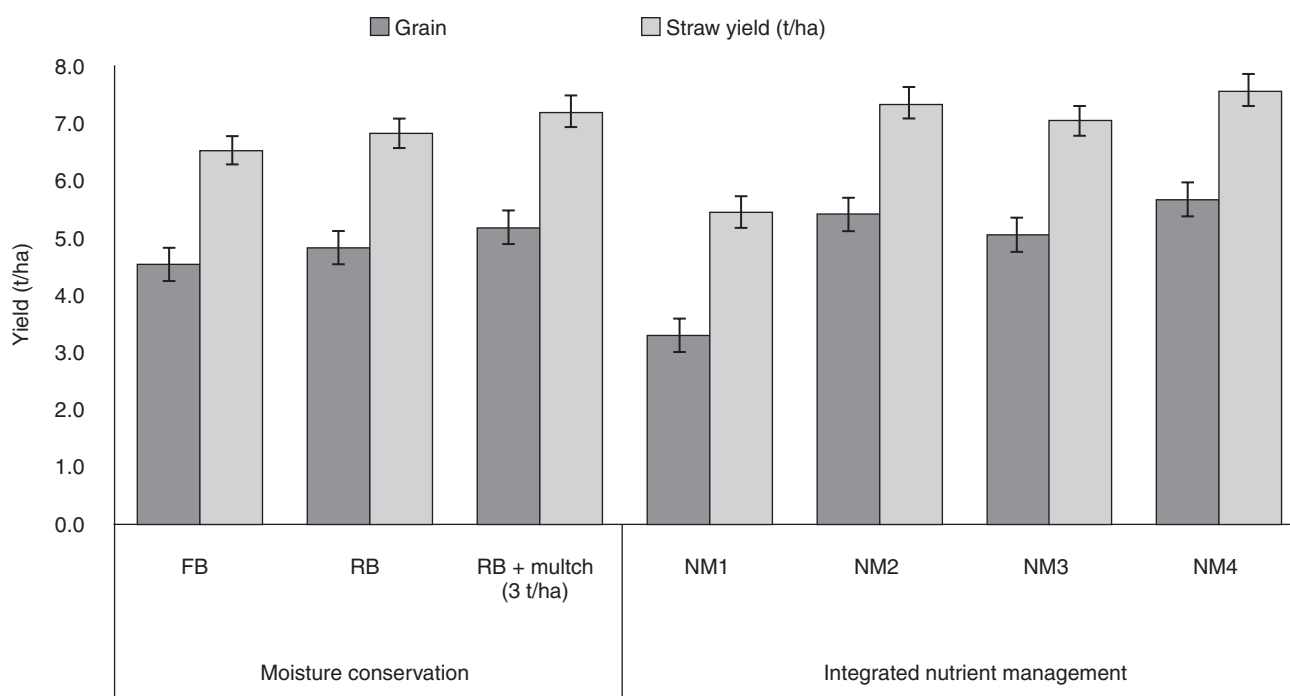


Fig 1 Grain yield, straw yield and harvest index of maize under various moisture conservation practices and integrated nutrient management.

yields that increased net returns finally leading to higher ME.

In Kandahar region of Afghanistan, planting maize on raised-beds along with wheat crop residues-mulch (3 t/ha) significantly improved the growth, yield, net returns, monetary-efficiency, production-efficiency and water-productivity over flat-bed planting. Applying 50% RDF + FYM (10 t/ha) and 2-foliar sprays of urea (2%) first at knee-high stage and second at tasseling stage, resulted in highest growth, yield, production efficiency and water productivity, which was in general at par with 100% RDF. These results

suggest that summer maize crop in Kandahar and other similar regions may be fertilized using INM approach to enhance productivity and resource-use efficiency.

SUMMARY

A field experiment was conducted at Tarnak Farm of Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan during summer season of 2017 to determine the effect of moisture conservation practices and INM on maize growth,

productivity, profitability and resource-use efficiency. Planting maize on raised-beds along with wheat crop residues-mulch (3 t/ha) significantly improved the growth, yield attributes, yield, net returns, monetary-efficiency, production-efficiency and water-productivity over flat-bed planting. Applying 50% RDF + FYM (10 t/ha) and 2-foliar sprays of urea (2%) first at knee-high stage and second at tasseling stage, resulted in the highest growth, yield, production efficiency and water productivity, which was in general at par with 100% RDF. These results suggest that summer maize crop in Kandahar and other similar regions may be planted on raised beds mulched with crop residue (3 t/ha) and fertilized using INM approach to enhance productivity, profitability and resource-use efficiency.

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