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Research Article

Evaluation & Development of Cultivation Techniques of Rainfed Maize + Sweet Potato Inter-Cropping under Indian North-Western Himalaya

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Abstract: Maize (*Zea maize* L.) is grown for human food, animal fodder, and chicken feed in India's Northwestern Himalayan Region (NWHR), which covers over 0.33 million hectares of cultivated land. In the NWHR of India, substantial soil erosion is a major challenge in maize production, resulting in low rainfed maize productivity. During the peak rainy season in NWHR, a single maize crop can only cover up to 30% of the land, leaving more bare soil vulnerable to soil erosion. Furthermore, sole maize growing only generates roughly Rs. 30,000-40,000 in net income per hectare field, making maize farming less profitable for farmers. Using a randomized block design with four replications, a field experiment was conducted with five treatments: maize-wheat (control), maize + sweet potato-wheat, maize + colocasia-wheat, maize + ginger, and maize + turmeric to conserve soil and water, increase crop productivity, and farmers profit by introducing soil conserving and high-value crops with rainfed maize cultivation. The authors discussed the developed scientific rainfed maize + sweet potato (*Ipomoea batatas* [L.] Lam) intercropping technique in NWHR, which had not before been devised for this region. From 8.7 t ha^{-1} soil loss of sole maize, maize + sweet potato intercropping can minimize it to 1.5 t ha^{-1} and increase maize grain yield to 3.5 t ha^{-1} from 3.1 t ha^{-1}. In addition to higher maize production, the system also produced 5.0-7.0 t ha^{-1} of fresh sweet potato tubers. Thus, intercropping of maize + sweet potato under NWHR can reduce soil erosion while also enhancing maize yield and farmers' profit in rainfed conditions.

Keywords: soil and water conservation, maize + sweet potato intercropping, North-Western Himalaya, net income, crop productivity

1. Introduction

In India, rainfed agriculture covers 67% of the net sown land, provides 44% of food grains, and employs 40% of the population [1]. Agriculture is highly difficult and risky under a rainfed environment, and crop yields are very

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variable and unstable due to low input use efficiency, as well as the vagaries of monsoon caused by climate change [2]. Food production is under constant pressure to feed an ever-increasing population of rainfed ecosystems. As a result, we are compelled to grow and improve the productivity of rainfed areas while also conserving vital natural resources [3-4]. The soil resource along with good rainfall of India's North-Western-Himalayan Region (NWHR) is fertile, allowing for the cultivation of a wide range of crops under rainfed conditions. Rainfed maize is the most prevalent crop in NWHR, covering a 0.33 m ha area. However, farmers are losing money from rainfed maize farming due to severe soil erosion, which results in significant soil and water loss and poor crop yield (Figure 1). If farmers continue to sole maize cultivation without any soil conservation strategies, soil loss due to erosion on a 4% slope can reach up to 30.0 t ha^{-1} due to more open soil and direct contact of high-intensity raindrops with soil [5]. A significant amount of soil nutrients, including 25-30 kg nitrogen (N), 1.0-1.5 kg phosphorous (P), 20 kg potassium (K), and 300-350 kg carbon (C) per hectare, have been lost due to soil erosion [5]. Corn's morphological structure exposes a wider area of soil, making it more susceptible to erosion. Because the sole maize crop only covers 20-30% of the soil surface up to 30 days after sowing, most soils are prone to erosion. The aforementioned challenges with maize production have forced farmers to abandon or shift away from maize growing.

Figure 1. A sole maize crop of NWHR damaged by high-intensity raindrops

Intercropping of rainfed maize + sweet potato can help commercialize agriculture in the North-Western Himalayan region while also reduce farmers' reliance on outside inputs including fertilizers, pesticides, and labour. In comparison to sole maize, which only covers 30% of the soil at this time, maize + sweet potato intercrop can cover up to 60% of the soil 30 days after planting. Sweet potatoes' dense foliage traps raindrops on their leaves, reducing their velocity thus protecting the bare soil. At a 2% soil slope, cultivating sweet potato with maize reduces soil loss to 1.5-2.0 t ha^{-1}, according to the present research. Sweet potato roots can reach a depth of one meter in the soil, boosting water absorption and minimizing runoff. Aside from the highest quality tubers, this crop produces 5-7 tonnes of dry biomass (including dry stem, leaves, and fine roots) from a hectare field. Its biomass contains 40.0-42.0% C, 1.5-2.02% N, 0.15-0.27% P, and 1.05-1.78% K. A hectare of biomass can recycle around 3.0-3.5 tonnes of C, 100-120 kg of N, 13.5-16.2 kg of P, and 89-106 kg of K [6]. In the soil, sweet potato biomass degrades quickly and becomes a good compost. Adding sweet potato leftovers to the soil will result in a large increase in carbon and soil nutrient content.

1.1 *Research gaps & need for further research*

Farmers in the NWHR region generally cultivate sol maize, which results in soil loss of 8-10 t ha^{-1}, creating constant deterioration of our most significant soil resources. Aside from massive soil erosion, there is massive runoff flow from the sole maize field, which carries significant amounts of soil nutrients also. The runoff with soil sediments from the steep land into the water reservoirs reduces the carrying capacity of the reservoirs. Farmers are likewise less

profitable under mono maize cropping. Although there are various maize-based intercropping systems such as maize + beans, maize + millets, and so on, they are only confined to above-ground soil advantages, and some are less viable for farmers. As a result of the multiple production obstacles and reduced profits from solitary maize agriculture, many farmers have abandoned maize cultivation. As a result, farmers in the NWHR need a maize-based intercropping system that may be highly profitable and sustainable. They also want an intercrop that can improve soil qualities, reduce runoff flow, and generate farm inputs (nutrient source) in maize cultivation. Sweet potato is an important tuber crop in India, which is growing for various benefits. Even though the sweet potato crop has numerous benefits in terms of conserving and enhancing production resources as well as increasing agricultural income, farmers in the NWHR appear to be unaware of sweet potato growing practices, particularly as an intercrop with maize, and their benefits to the agricultural system. There is no accepted scientific technique for cultivating rainfed maize + sweet potato intercropping in the NWHR at this time. This necessitates the introduction of sweet potato as an intercrop crop with the maize, and the development of cultural practices of maize + sweet potato intercropping to the region's farmers. We also need to show farmers the advantages of maize + sweet potato intercropping over solitary maize, which is why we compared the advantages of maize + sweet potato intercropping with sole maize in this publication. The creation of rainfed maize + sweet potato intercropping growing technology could lead to soil and water resource conservation, enhanced maize and sweet potato production, and higher agricultural profit.

2. Materials & methods

A field experiment entitled 'evaluation of the maize-based inter-cropping system to conserve soil & water and improve farm income in rainfed areas of North-Western Himalaya' was conducted at ICAR-Indian Institute of Soil and Water Conservation (IISWC), Dehradun. Maize-wheat (control), maize + sweet potato-wheat, maize + colocasia-wheat, maize + ginger, and maize + turmeric were the five cropping system treatments in the trial (Figure 2(a) & 2(b)). As part of the treatments, the total biomass produced by intercrops was measured and recycled to the field. With four replications, the experiment was done using a randomized block design. A total of 20 plots were designed in the experiment where each plot has the size of 9×8 m^2 size. The runoff with sediments was collected and measured using multi-slot devices installed with plots and soil and water loss from the field was calculated. The soil moisture samples were collected after harvest and soil moisture was measured through the gravimetric method using the following formula:

$$\text{Soil moisture (\%)} = \frac{\text{Wet weight (g)} - \text{dry weight (g)}}{\text{Dry weight (g)}} \times 100$$

The canopy cover of the crop was measured 30 days after planting with a 100-box iron gauge, and the canopy cover was expressed as a percentage. The infiltration rate from the soil was measured after the harvest of crops using a double-ring infiltrometer with inner and outer rings of 22.5 cm and 45.0 cm in diameter, respectively, and each ring measuring 27 cm in height. The methodology is discussed in detail in the next section.

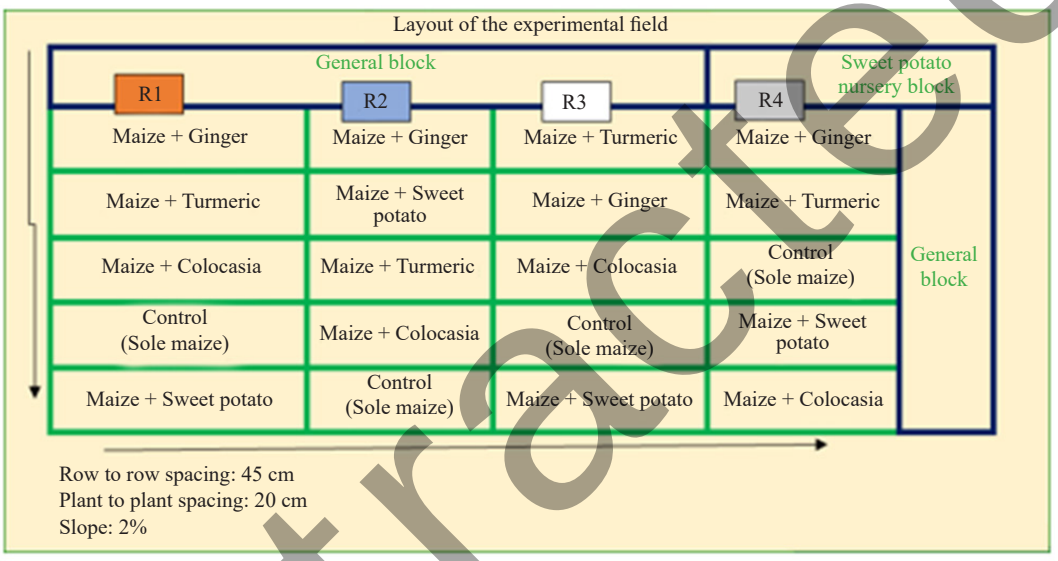
2.1 *Statistical analysis*

In the experimental field, a Randomized Block Design (RBD) was used, with five treatments and each treatment replicated four times. RBD statistical analysis was performed. Least Significant Difference (LSD) values at $P = 0.05$ were used to establish the significance of the difference between treatment means.

2.2 *Distribution & climate*

Maize is recognized as the "Queen of Cereals" around the world because it has the highest genetic production potential of all cereals. It is grown on about 150 m ha area in about 160 countries, with a larger range of soil, climate, biodiversity, and management approaches, and contributes 36% (782 million tonnes) of global grain production. India

is the fourth in terms of area and the seventh in terms of production among maize-growing countries, accounting for about 4% of the global maize area and 2% of total production. In India, the maize acreage was about 9.2 m ha in 2018-19 [7]. The maize is growing about 27,895 thousand hectares in Uttarakhand. Rainfed maize is the most prevalent crop in NWHR, with a productivity of 1.5 t ha^{-1} and an area of 0.33 m ha [8]. After wheat, rice, maize, potato, barley, and cassava, sweet potato was the seventh most important food crop in the world [9-10]. Sweet potato is grown in 117 countries on an 8.62 m ha area, yielding 105.19 million tonnes with a yield of 12.20 t ha^{-1} [11]. In India, sweet potato farming covers a 0.13 m ha area, yielding 1.47 million tonnes [11-12]. Sweet potatoes are hardy crops that supply poor farmers in many developing countries with an excellent amount of carbohydrates, vitamins, and minerals. In addition, they can produce more edible energy per acre per day than wheat, rice, or cassava [9-10]. Although sweet potato farming is limited in Uttarakhand, the crop has a great chance of success due to favourable soil, climate, condition, and high market demand. However, under the rainfed conditions of NWHR, no intercropping of maize and sweet potato has been observed. Thus, implementing rainfed maize + sweet potato intercropping in NWHR could result in a successful increase in yields of both crops while also preserving and enhancing production resources.



(a)

(b)

Figure 2. The layout of the field (a) and establishment of maize + sweet potato crop (b)

Maize and sweet potato can withstand temperatures ranging from 25 to 35 degrees Celsius and humidity levels of 60 to 80%. For appropriate growth and productivity, the crop required plenty of sunshine hours. During the Kharif

season, the region receives a lot of rain (1,200-1,500 mm), which is enough to meet the crops' water needs. Table 1 summarizes the meteorological data collected during the growing season of maize + sweet potato in India's NWHR.

Table 1. Meteorological data collected during the growing season of maize + sweet potato in 2020-21

Month	Mean temperature (°C)		Relative humidity (%)		Mean wind velocity (km hr^{-1})	Av. daily bright sunshine (hr)	Av. daily evaporation (mm)	Rainfall (mm)
	Maxi.	Mini.	7:19 AM	14:19 PM				
Jan-20	18.3	4.8	95.1	56.3	1.0	3.2	1.0	122.5
Feb-20	23.3	6.0	94.1	45.0	1.4	5.7	1.5	35.1
Mar-20	25.7	10.3	92.7	51.9	1.7	3.4	2.1	133.6
Apr-20	31.8	13.6	83.8	37.5	1.9	3.1	3.1	13.4
May-20	35.1	16.1	74.4	37.4	2.2	5.2	5.2	36.0
Jun-20	34.1	22.6	87.5	55.9	1.5	1.7	4.0	139.6
Jul-20	32.6	23.8	94.5	73.2	1.2	2.2	3.4	346.3
Aug-20	32.4	24.6	95.7	80.4	1.0	2.9	3.0	374.0
Sep-20	33.5	23.4	94.2	64.6	0.9	4.4	3.0	114.8
Oct-20	32.6	14.3	93.2	40.1	0.8	7.0	2.4	0.0
Nov-20	25.7	7.8	93.2	45.3	1.0	4.5	1.4	0.0
Dec-20	21.1	4.1	94.6	43.1	0.9	4.0	0.9	17.8

2.3 *Nursery raising technique of sweet potato*

To grow a healthy sweet potato nursery, the field should have a high-water holding capacity. Before planting the tubers, the soil should be fed with properly decomposed Farmyard Manure (FYM) @ 15 t ha^{-1} as well as 50 kg:40 kg:40 kg N, P, K ha^{-1}. To prevent the development of termite or another soil-borne pest, spray the soil with chlorpyriphos @ 1.5-2.0 ml L^{-1} water before planting the tubers. Crop leftovers applied to the soil surface as mulch for establishing the nursery can help to conserve rain moisture from the preceding monsoon and winter seasons. Healthy sweet potato vines can be grown in a nursery by planting healthy tubers. To prevent tuber fungal damage, sweet potato tubers can be treated with carbendazim 50% WP @ 1 g L^{-1} water before planting. To generate cuttings for a hectare of land, 80-100 kg of fresh sweet potato tubers with 3-4 buds are required. A tiny nursery area of 50-70 m^2 is enough to raise vines for a one-hectare plot of land. Sweet potato tubers can be sown in the nursery during March to cultivate a rainfed sweet potato crop in Himalayan conditions. The harvested rainwater from any rainwater harvesting structure can be used to provide 2-3 light irrigation. Sweet potato nursery needs only a little space to produce cuttings for the planting in NWHR's mountainous terraces, therefore water management in the nursery can be simply handled utilizing any water source. Fresh and healthy tubers can also be planted immediately to grow the main crop of sweet potato if no water supply is available. The cuttings will be ready by the end of May (Figure 3). After receiving the first monsoon rain, the crop of rainfed sweet potato as an intercrop in maize should be sown in the first week of June.

2.4 *Soil*

Rainfed maize and sweet potato intercropping systems necessitate a well-drained, fertile, humus-rich soil with adequate moisture retention capability. The sandy loam soils are good for intercropping maize and sweet potato.

Because of its high organic matter content, the soil in the northwestern Himalayan region is ideal for these crops. Both crops thrive well in a pH range of 6.5-7.5.

Figure 3. A sweet potato nursery at IISWC, Dehradun, India

2.5 *Field preparation and sowing*

For successful growing of rainfed maize + sweet potato inter-crop, one ploughing with a disc plough can be done to break the hardpan of soil. After that, ploughing with a cultivator and planking should be done to ensure optimum soil pulverization. Both crops should be sown/planted as soon as possible to take advantage of the stored soil moisture. Termite and other soil-borne insect damage can be avoided by treating the soil with chlorpyriphos at 1.5-2.0 L ha^{-1} during field preparation. The Bunds with a height of 7-10 cm and a width of 5-10 cm can be made with a bund maker or by hand for seeding the maize crop. Maize should be planted in the first week of June at a spacing of 90 × 20 cm, with a seed rate of 20-25 kg ha^{-1}. Healthy cuttings of 15-20 cm in length with 3-4 leaves can be planted at 90 × 20 cm spacing to produce a sweet potato crop. For a hectare of land, 80-100 kg freshly sprouted tubers with 3-4 buds are required, while 55,555 cuttings are required for a hectare of land if the sweet potato is planted using vines. In the interrow intervals of maize, one row of sweet potatoes should be planted. Sweet potato crops, like maize, should be grown on bunds of the same size to reduce water stagnation and to allow proper drainage of surplus water. Planting both crops on bunds also improves optimal crop growth, reducing crop lodging in maize and promoting sweet potato tuber development.

2.6 *Varieties*

2.6.1 *Maize*

Maize varieties such as Kanchan-26, Kanchan-85, Vivek Sankul Makka 35, VLQPMH 59, and others can perform better under rainfed conditions in India's northwestern Himalaya.

2.6.2 *Sweet potato*

Pusa Lal, Pusa sunehari, Pusa safed, varsha, etc. can be grown effectively in the rain-fed conditions of India's northwestern Himalaya.

2.7 *Nutrient management*

Apply 10-15 tonnes of properly decomposed FYM to the soil 15-20 days before planting sweet potato +

maize intercrops. For healthy tuber development, sweet potatoes required a good quantity of P & K fertilizers. The recommended fertilizer dose for rainfed maize + sweet potato intercrops is 150 kg:90 kg:40 kg N, P, K ha^{-1}. The full dose of P & K and half dose of N fertilizers should be applied at the time of sowing/planting of crops. The remaining half dose of N can be delivered in three foliar sprays at 30, 45, and 60 days following sowing/planting in equal doses for maize & sweet potato. Although the combined nutrient demand may be higher than the fertilizers dose mentioned here, the nutrient recycled through sweet potato residue and FYM application can meet out the crop demand.

2.8 *Weed management*

The high vegetative cover produced by the sweet potato crop discourages the growth of weed flora and maintains the field clean (Figure 4). Once the maize crop had grown to about 1 meter in height, it was no longer susceptible to weed damage. In the rainfed maize + sweet potato intercrops, only a few annuals & perennial weeds including *Commelina benghalensis* (Benghal dayflower), *Cyperus rotundus* (purple nutsedge), *Cynodon dactylon* (Bermuda grass), and *Solanum nigrum* (black nightshade) were seen. Weed management measures are only required during the first growing stages of both crops. A spray of pendimethalin 30 EC @ 1.0-1.5 kg ha^{-1} a.i. can be applied at the time of first ploughing and before sowing of crops for proper weed control. Aside from that, efficient weed management requires one hand weeding is required at 25-30 days after sowing/planting both crops.

Figure 4. A weed-free maize + sweet potato intercrop system at IISWC, Dehradun, India

2.9 *Insect pest management*

2.9.1 *Fall armyworm of maize crop*

This insect has the potential to wreak havoc on maize crops (Figure 5). The fall army work attack begins when the crop is nearly 25-30 days old and progresses through the stages of cob development and grain filling. The insect prefers to eat leaves, but it will also eat delicate stems. This insect has recently become a severe problem in maize crops in India's northwestern Himalayas. Female moths lay their eggs on the leaf's top or lower surface. Each egg mass has 50-150 eggs in it. Smooth-skinned larvae with three creamy yellow dorsal and lateral lines, ranging in color from light tan to green, can cause considerable crop damage.

Control measures

For easier management of fall armyworm, the maize crop should be sown at the same time in a bigger field rather than at different times. The insect damage can be reduced by adding 200 kg $acre^{-1}$ of neem cake to the fields. To encourage natural enemies of the fall armyworm, keep field bunds clean and also plant flowering plants like marigold,

sesame, niger, sunflower, coriander, fennel, and others on bunds. If the infestation is greater than 10%, apply *Bacillus thuringiensis* v. Kurstaki formulations (400 g acre^{-1}) at 2g L^{-1} in a whorl application. If the infestation is greater than 20%, a whorl application of any of the pesticides listed below is more effective.

1. Chlorantraniliprole 18.5 SC (200 ml ha^{-1}) @ 0.4 ml L^{-1}
2. Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC (120 ml ha^{-1}) @ 0.25 ml L^{-1}
3. Spinetoram 11.7% SC (250 ml ha^{-1}) @ 0.5 ml L^{-1}
4. Emamectin benzoate 5% SG (200g ha^{-1}) @ 0.4g L^{-1}
5. Dichlorvos 76 EC (250 ml ha^{-1}) @ 0.5 ml L^{-1}.

Figure 5. Fall armyworm attack in maize crop under maize + sweet potato intercropping in NWHR of India

2.9.2 *Sweet potato weevil*

The only highly harmful insect found in the sweet potato crop under NWHR is the sweet potato weevil; the damage caused by other insects is minor. In its adult form, the sweet potato weevil is a shiny black antlike bug with a huge snout and a red neck. It feeds on a sweet potato leaf, limiting the plant's leaf growth in a maize + sweet potato intercrop system (Figure 6). The eggs, on the other hand, are put in the cavities of the sweet potato root or on the vine's soil surface, causing damage. Sweet potato weevils can have up to eight generations in a single year. Wild morning glory (*Calystegia sepium*) and black nightshade (*Solanum nigrum*) are two weeds that the sweet potato weevil may thrive on. Thus, the field should be free of weed plants.

Management

For the proper management of sweet potato weevils first, remove the wild host of the insect such as black nightshade and wild morning glory weeds. When purchasing sweet potato tubers, make sure they are certified weevil-free. Rotate crops to avoid planting sweet potatoes in the same bed more than once every three years. Mound soil around the base of the plant to help protect the stems from egg-laying adults. Mulch the soil to help keep it moist and prevent cracking which restricts adults access to sweet potato roots. If the serious attack of sweet potato weevil is seen, apply dichlorvos @0.5 ml L^{-1} water.

2.10 *Harvesting and yield*

When maize and sweet potato are intercropped, both crops provide good crop yields without giving any adverse effect on the performance of each other. To measure the crop yields of both maize & sweet potato, the crop sample is

taken from a 2 × 2 m^2 area. The maize crop from maize + sweet potato intercropping can be harvested first during the last week of September (Figure 7). Maize plants can be left in the field for 3-4 days to allow for thorough drying before being shelled and threshed. Under rainfed conditions, a maize crop intercropped with a sweet potato can yield up to 3.0-3.5 t ha^{-1} of grain and 4.0-4.6 t ha^{-1} of straw.

Figure 6. Leaf & tuber damage caused by sweet potato weevil

(a) (b)

(c) (d)

Figure 7. The harvesting view of maize and sweet potato crop under NWHR of India

The sweet potato crop may be harvested in the second fortnight of December, following the maize harvest. As an intercrop with maize, rainfed sweet potatoes can produce up to 5-7 t ha^{-1} fresh tubers and 5-7 t ha^{-1} of dry biomass.

3. Result and discussion

Maize + sweet potato intercropping performs better in rainfed NWHR than sole maize crop (Table 2). In terms of conserving multiple production resources, the intercropping technique worked well. In contrast to farmers' methods of growing a single maize crop on flat ground, in developed cropping techniques of maize + sweet potato intercrops, crops are planted on the bed across the slope, reducing runoff flow and soil and water loss. The sweet potato crop intercropped with maize reduces weed population and diversity by not allowing any space for weed growth and suppresses weed growth through strong growth of crops (Figure 8), therefore reducing herbicide application doses for weed control.

Table 2. The advantages of rainfed maize + sweet potato crop cultivation methods over solitary maize cultivation

S. No.	Cultivation practices	Maize + sweet potato	Sole maize
1.	Sowing/planting of the crop	Planting on beds across the slope	Flat planting
2.	Weed diversity	A very less population of *Cyperus rotundus* *Commelina benghalensis* and *Solanum nigrum* are seen	Serious incidence of more diverse weeds like *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Amaranthus viridis*, *Ageratum houstonianum*, *Commelina benghalensis*. *Gnaphalium uliginosum*, *Lepidium*, *Cyperus rotundus*, and *Cynodon dactylon* are observed, all of which lowered crop yield significantly
3.	Weed management	Only one spray of pendimethalin before sowing @ 1.0-1.5 L ha^{-1} is needed. Growing sweet potato itself suppresses the growth of weeds	To control the weeds, more herbicide spraying is required
4.	Residue generation & utilization	Sweet potato crops produce a lot of residues, which are used for moisture conservation and nutrient cycling	Farmers use maize straw as fodder, thus there is no residue recycling under the sole maize crop
5.	Adding nutrients to the soil through recycling crop residue	100-120 kg N, 13.5-16.2 kg P & 89-106 K ha^{-1} can be added to the soil through recycling of sweet potato residue	Farmers in the area do not recycle maize residue, thus there is no nutrient input through crop residue
6.	Insect-pest	Less incidence of fall armyworm of maize	High crop damage from fall armyworm of maize
7.	Soil moisture conservation for succeeding crop	After harvesting the crop, the soil moisture was retained at a high level, which is ideal for growing the following rainfed wheat crop	Due to excessive soil moisture loss during the maize growing season, there is less moisture after the harvest of sole corn

Soil moisture was retained and soil loss was reduced by providing adequate soil cover, limiting runoff, and increasing soil infiltration and porosity. The intercropping of maize + sweet potato provides roughly 60% coverage for the first 30 days after planting, allowing maximum rainfall to be intercepted on leaves and reducing direct contact of high-intensity rain droplets with bare soil. As a result, soil loss can be drastically reduced (Table 3). Sweet potato crops also produce about 5-7 tonnes of dry biomass, which is recycled to the fields and acts as soil mulch, reducing soil moisture loss and adding a considerable quantity of plant nutrients. In comparison to solitary rainfed maize, which generates a net income of around Rs. 30,000-40,000 per hectare, the rainfed maize + sweet potato system under NWHR can generate a net return of up to Rs. 160,000-170,000 per hectare of land. The cultivation cost of the one-hectare

rainfed maize + sweet potato system is Rs. 45,000-50,000, which is a little higher than the cultivation cost of sole maize (Rs. 28,000-30,000). As a result, the rainfed maize + sweet potato system is extremely beneficial for NWHR producers.

(a)

(b)

Figure 8. Comparison of weed growth in maize + sweet potato (a) and under sole maize crop (b) in NWHR of India.

Table 3. Improvement in soil properties through adopting maize + sweet potato intercropping over sole maize in rainfed conditions of NWHR

S. No.	Production parameters	Maize + sweet potato	Sole maize
1.	Crop canopy coverage at 30 days after sowing/planting (%)	59-60	27-30
2.	Soil moisture after harvest (%) at 0-15 cm	21.0	13.9
3.	Soil loss due to erosion (t ha^{-1})	1.5	8.7
	Soil bulk density (Mg m^{-3}) at 0-15 cm	1.38	1.44
4.	Soil infiltration (cm hr^{-1}) at 0-15 cm	0.74	0.51
4.	Grain/tubers yield (t ha^{-1})	3.5 (maize) 5-7 (sweet potato)	3.1
5.	Straw/dry mass yield (t ha^{-1})	4.6 (maize) 5.0-7.0 (sweet potato)	4.1
6.	Net return (Rs. ha^{-1})	160,000-170,000	30,000-40,000

4. Conclusion

To summarize, implementing improved cultivation practices for rainfed maize + sweet potato systems can save NWHR soil and water resources, and increase the profit from maize farming. The system has several advantages of reducing weed population & diversity, nutrient addition to the soil through huge crop biomass, improving soil properties, reducing soil & water loss, and also minimizing fall armyworm insect over sole maize crop. The sweet potato crop is very much compatible with maize for growing and also can be easily adopted by the farmers because it doesn't add more cost over maize cultivation. Thus, it can be concluded that the rainfed maize + sweet potato intercropping system can sustain the maize production in the NWHR with a higher net profit to the farmers.

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Conflict of interest

The authors declare that they have no conflict of interest.

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