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Effect of plastic mulching on Biometric characteristics and yield of paddy (*Oryza sativa* L.) in Vidarbha region of Maharashtra state

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Abstract

The field experiment entitled with “effect of plastic mulching on Biometric characteristics and yield of paddy” carried out with the help of ATMA in 12 tahsils of Gadchiroli district in Maharashtra state from June to October in the 2017-2019. The average annual precipitation of Gadchiroli District is 900 - 1400 mm. The annual mean temperature is 30.1°C - 35.3°C, (The effective accumulated temperature of the annual mean temperature is 4386.2°C - 5247.1°C·d). Different thickness (20, 30, 40 µm) of high-density polyethylene (HDPE) film (6 m × 1.7 m) was paved on each plot before planting. The plot without HDPE film was CK. Each treatment was replicated thrice. All plots were arranged in a randomized blocks design, and the plot size was 10.2 m². Each plot was surrounded by a buffer zone of 0.2 m wide. In the growing season, water layer with 3 - 5 cm depth was maintained in the buffer zone. The paddy soil, belong to clay, contained 53.3 mg·kg⁻¹ available N, 10.05 mg·kg⁻¹ available P, 74.9 mg·kg⁻¹ available K, 21.4 g·kg⁻¹ organic matter, and its pH was 6.4. Seed of four paddy varieties were selected for experimentation. Seeds were placed on mulching bed with the planting density of 0.43 m × 0.35 m and 2-3 seed is per hole. The traditional method of puddling and transplanting in heavy rainfall region leads to soil losses. This loss can be stopped in plastic mulching with to increase in productivity by 27.74%. Growth of weeds and expenditure on weed control is very less as compared to traditional method hence it helps to increase productivity and suitability of paddy mulching technology. In traditional method expenditure of Rs. 2950/- is incurred on puddling, Nursery and transplanting, per acre saving in seed cost by Rs. 900/-. Due to silver colour in mulching of mulching reflection of sunlight is more which enhances growth of plants especially in rainy and cloudy days. In all the season green colour of paddy plants was noteworthy. Also, it leads to early maturity of the crop by 15 days. Reduction in the cost of cultivation motivates farmers to grow crops in the Rabi and summer season. Due to increase in productivity the expenditure of plastic mulching of Rs. 8000/- is earned by farmers in the first crop. The total expenditure in mulching was Rs. 17400/- and cost of total production was Rs. 37072/- which leads to net profit worth Rs. 19672/- where as in control plot net profit was only Rs. 10104/-. It is strongly recommended that Paddy growing farmers of Vidarbha region are advised to cultivate paddy on the plastic mulching.

Keywords: Biometric characteristics, plastic mulching, yield, weed control, economics

Introduction

Paddy (*Oryza sativa* L.) is one of the most important food crops in the world. Half of the world's population is dependent on paddy as a staple food. In Asia, approximately 92% of paddy in the world is produced and consumed (IRRI, 1997) ^[11]. In India paddy is grown in 43.86 million ha, the production level is 104.80 million tones and the productivity are about 2390 kg·ha⁻¹ (Anonymous, 2015) ^[1]. It is grown under diverse soil and climatic conditions the productivity level of paddy is low compared to the productivity levels of many countries in the world. Also, about 90% of the cultivated land belongs to Marginal, Small and Medium farmers which is another constrain in increasing the productivity of rice in the country. It is, therefore, there is ample scope to increase the productivity of rice in the country. The highest productivity is 6710 kg·ha⁻¹ of China followed by Vietnam (5573 kg·ha⁻¹), Indonesia (5152 kg·ha⁻¹), Bangladesh (4375 kg·ha⁻¹) etc. There are improved technologies and various interventions which

could be adapted to increase the productivity in the country. Cultivation of hybrid paddy has potential to increase the productivity and needs to be promoted. (Yang *et al.*, 2000)^[17]. Paddy production consumes large quantity of irrigation water. Estimated that rice consumed about 90% of total irrigation water for all crops (Gu *et al.*, 2012)^[16]. Additionally, paddy is the crop that offers has great potential to save irrigation water, because its physiological water requirement ($4500 \text{ m}^3 \cdot \text{water} \cdot \text{ha}^{-1}$) is much less than its actual water consumption, which is equivalent to that of some upland crops (Liu *et al.* 2012 and Peng *et al.*, 1999)^[15, 14].

Plastic film mulching, one of water saving management practices for rice production, is developed in 1980s and has been adopted as a new rice cultivation technique in many regions of China Bhuiyan, 1992 and Krish *et al.*, 2011)^[13, 12]. Under plastic film mulching management practice, the rice production is based on limited irrigation without constant flooded conditions on soil surface. It is substantially different from both traditional flooded rice cultivation and rain-fed. Plastic film mulching management the paddy production is based on limited irrigation. This can reduce irrigation frequency and amount of water. In recent years, plastic film mulching has been widely applied throughout the world. The total planting with plastic film mulching has reached 100,000 ha (Wakamastu *et al.*, 1997)^[10]. A lot of researches have revealed that plastic film mulching has many advantages, such as moderating soil temperature by insulating the soil surface, conserving soil moisture, preventing leaching of fertilizers, controlling weed growth under mulch film, making maturity earlier and increasing yield (Gao *et al.*, 1992, Gao *et al.*, 2000, Wu *et al.*, 1999, Cao *et al.*, 2012)^[9, 8, 7, 5]. High-density poly- ethylene (HDPE) film is preferred as mulching material for crop production (FAO, 2001)^[4]. In plastic mulching, the thickness of mulch film should be in accordance with type and age of crops. Economics suggest that the film thickness should be the minimum possible commensurate with desired life and strength (Sarolia and Bhardwaj, 2012)^[3]. At the present, there is lack of information about the thickness of plastic-film mulching with non-flooding conditions. Under HDPE film mulching cropping system, the objective of this study is to select the optimal thickness of HDPE film for rice production (Xia *et al.*, 2008)^[2]. Herein, we investigated the effect of various thickness of HDPE film on physiological index of rice, soil parameter and weed control, etc.

Materials and Methods

The field experiment entitled with “effect of plastic mulching on Biometric characteristics and yield of paddy” carried out with the help of ATMA in 12 tahsils of Gadchiroli district in Maharashtra state from June to October in the 2017-2019. The average annual precipitation of Gadchiroli District is 900 - 1400 mm. The annual mean temperature is 30.1°C - 35.3°C , (The effective accumulated temperature of the annual mean temperature is 4386.2°C - 5247.1°C d). Different thickness (20, 30, 40 μm) of high-density polyethylene (HDPE) film ($6 \text{ m} \times 1.7 \text{ m}$) was paved on each plot before planting. The plot without HDPE film was CK. Each treatment was replicated thrice. All plots were arranged in a randomized blocks design, and the plot size was 10.2 m^2 . Each plot was surrounded by a buffer zone of 0.2 m wide. In the growing season, water layer with 3 - 5 cm depth was maintained in the buffer zone. The paddy soil, belong to clay, contained $53.3 \text{ mg} \cdot \text{kg}^{-1}$ available N, $10.05 \text{ mg} \cdot \text{kg}^{-1}$ available P, $74.9 \text{ mg} \cdot \text{kg}^{-1}$ available K, $21.4 \text{ g} \cdot \text{kg}^{-1}$ organic matter, and its pH was 6.4. Seed of four paddy varieties were selected for experimentation. Seeds were placed on

mulching bed with the planting density of $0.43 \text{ m} \times 0.35 \text{ m}$ and 2-3 seed is per hole. All the technical observation has been taken by ATM and BTM of ATMA in consultation with KVK, Gadchiroli. Weed number and weed mass were used to evaluate the effects of HDPE film on weed control. One month after planting, weed number in each plot was surveyed, with the interval of 20 days, totally 3 times. Once the last survey finished, all weeds were collected to measure fresh mass, and then dried at 70°C for 2 days to measure dry mass. The formula of weed control effect is as follow:

Weed control effect = (weed number of CK – weed number of HDPE film mulching)/ weed number of CK $\times$ 100.

The soil temperature was determined at 2, 5 and 10 cm below ground at various time points. For this, all the beneficiary farmers have been trained in regard to the methods of cultivation techniques. In the process of selection of farmers, early adopters were selected. In the year 2016 - 2 no., 2017- 45 no., 2018-75 no. 2019-15 no. of successful demonstrations were conducted. In Kharif 2016 - 2019, 20, 30, 40 gsm Plastic Mulching Paper was used. However, after the harvest 20, 30 gsm paper did not last longer, so that 40 gsm Plastic Mulching Paper was recommended. It is observed that it will complete three crops due to its good condition. Effective measures were made for registering the observations of crop in growth periods. The observations were recorded by ATM and BTM of ATMA. The control area for the production of the variety was an ethical polynomial, which was made mandatory for productivity comparisons. Field should be prepared by deep ploughing and add 20-30 cartloads (10 tons) of FYM per hectare. By using vermicompost, the land remains porous and frosty. Prepare 1meter wide bed, length of the field with height 15 cm. Keep distance between two beds of 30 - 45 cm this is done with the help of tractor drawn ridger, then beds will be done at a reasonable cost. No stone, stubble free field should be there. The beds should be done probably in the last week of May or in the first week of June. Silver color Mulching – 20/30/40 Micron Place FYM or vermicompost on the beds in sufficient quantity as it will not be replaced it for next season. Mulching paper can be placed properly and, on both sides, should be pressed as it should not be lifted by air and carried away by water. Perforation on mulching paper A 6 – 8 cm diameter steel bowl was welded with a rod. Heated a bowl of this vessel as per pre-made (25 x 25 cm) hole on the mulching paper. Local technicians have developed techniques by using a new method for locating holes likewise to reduce the required manpower and timely mulching paper was punched in advance at low cost & in time. After adequate rainfall of more than 100 mm, 3-4 grains paddy were placed in the hole area. In the punched hole weeds were removed if any as there will be no weeds due to the mulching paper after weeds. Used 70-kilogram urea briquettes per acre. Placed the briquettes at 4 to 5 cm depth with urea briquette applicator at center of 4 plants. Water management In the Kharif season there was no need for irrigation due to rains, but if stress condition arrives lifesaving irrigation was done as per requirement. Water stress should not be occurred in grain filling stage. In this condition water was released in the gap of the beds. Caring for a Mulching Paper: When the mulching paper was placed on the beds, press both the sides firmly. Due care was taken to ensure that there should not be any pointed material below and animals should not disturb the mulching paper. Wherever possible fencing to the surroundings as required for protection against stray animals. Harvesting of

crops: After maturity of 90% of the grains harvesting was undertaken with the help of “PKV-Serrated sickle” and after drying threshing was done. Crops were getting matured and harvested earlier at least 15 days than regular transplanting or control plots. After crop harvesting, the next crop planning after harvesting of paddy sprayed Glyphosate 76 WC on paddy stalks due to which harvested paddy crops will not grow again. The rabi crop was sown with the urea briquettes applicator to place the gram / popat /maize crop with the dibbling method. The next paddy cultivation can be done on this paper in the summer season.

Results

From the results it is observed that Gadchiroli district receives on an average of 1440 mm rain fall. Paddy mono cropping is done in the district. Puddling was done by tractors. Soil / Mud is softened for transplanting, Heavy rains carry the productive components by erosion and drain. Hence a large proportion of natural resources were wasted and productivity also decreases. In plastics mulching during the summer season, soil preparations are done and mulching is spread on the ground. Therefore, all types of erosions are controlled out (like raindrop, splash, rill, gully erosion). Beds percolate enough water in the soil. Paddy seed is sown directly through seed. Hence loss of soil is controlled and by avoiding tillage operation viz., plowing and puddling that leads to soil erosion has been avoided. Also, the use of minimum tillage techniques is being used. This has reduced the expenditure on manpower and time consumed. Due to plastic mulching, weed infestation was decreased and since the competition of weeds for nutrient with paddy has ended. Hence the growth of paddy crop occurred very fast. Soil moisture retention time is increased. Therefore, the growth of the crop has remained constant during the rainy season. Hence the number of tillers and the weight of the grains also increased. In total productivity has increased.

Table 1 showed that in the kharif 2018 season, rice yields received are 5296 kg ha⁻¹. The average of 3 years is 4741 kg ha⁻¹. The dry spell in the district and the incidence of BPH in the region has reduced the average productivity but, in these plots, the loss occurred by BPH was recovered below ETL. In the traditional paddy cultivation method, the cost of puddling, nursery raising, planting of seedlings, seed requirement is more as compared to mulching. So, the cost of production is increased by Rs. 2960. Also, the shortage of manpower is avoided by

direct sowing. The seed used is three kilograms per acre. Therefore, minimum saving of Rs. 900/acre. Due to climatic conditions in the traditional paddy crop in standing water system in the crop, soil microbes and earthworms does not stay alive but due to the availability of limited water under the mulching, and due to excess water drainage, the temperature of the soil is maintained so that the microorganisms process in the soil increases and the food grains available in the soil are easily available to the plants. Due to the balance of soil moisture, air and water, there was clearly visible increase in earthworms. The actual number of earthworms found in the soil showed that the number of soil conservation factors has increased. The use of DAP urea briquettes in the field reduces the quantity of the chemical elements of the soil and its full use results into high productivity at low cost. The availability of sunlight during the rainy season is less pronounced for photosynthesis, but due to the reflection of light rays in the silver colored mulching paper, due to the availability of additional light (high intensity), the early crop growth has been observed. The maturity period of the entire crop is decreased by about 15 days so that silver and silver coloring paper was used in the second and third year, and continuity of this observation was found in all the plots. There is early maturity of the crop for at least 15 days, it may also be the result of decreasing the time required for the seedlings after the transplanting of the seedlings. Overall, the duration of the crop decreases in this method. In Gadchiroli farmers follow paddy mono crops system. In the rabi season, there is limited irrigation facilities and hence the crops are not able to sow due to less time for land preparation and due to hardening of the soil by puddling. Generally, lathyrus is used for the relay cultivation (before paddy harvest) in some places, but after harvesting paddy on plastic mulching, the plantation of gram, pea and beans and maize can be done by using available soil moisture. The good production of rabi crop was taken in limited irrigation facilities. This yields good results for farmers by saving 1050 kg ha⁻¹ of (wal and Popat) Pea and beans as legumes. The maize crop earns around Rs. 30,000/- per acre. In the Rabi season, due to less effort and cost of cultivation in the field, the trend of rabi cultivation has increased in the field of farmers using mulching paper. Due to the use of 30gsm plastic mulching paper it could not last until the summer. In the demonstration on the 40 gsm mulching paper, it sustained for 4 crops hence recommended to prefer it.

Table 1: Demonstration of Paddy on Mulching paper in Kharif – 2018 (Kg ha⁻¹)

Sr. No.	Taluka	No. of Demonstration	Avg. yield in Mulching plot (Kg ha ⁻¹)	Average yield in controlled plot (Kg ha ⁻¹)	Production increased in %
1.	Gadchiroli	5	4725	3715	27.18
2.	Dhanora	5	4115	3620	13.67
3.	Chamorshi	6	5525	4220	30.92
4.	Mulchera	7	5325	3843	38.51
5.	Armori	8	6333	4423	43.18
6.	Kurkheda	6	5804	3710	56.14
7.	Korchi	9	5420	3700	46.48
8.	Wadsa	7	5655	3838	47.34
9.	Aheri	5	5205	3570	45.79
10.	Etapalli	6	4930	4009	23.15
11.	Bhamragad	6	4712	4077	15.57
12.	Sironcha	5	5809	4505	28.94
Total		75	5296	3935	34.58

Table 2: Average Production of Paddy in Kharif – 2016-19 (Kgha⁻¹)

Sr. No.	Season Particulars	No. of Demonstration	Average in yield demonstration plot	Average yield in controlled plot	Production increased in percentage
1	Kharif – 2016	1	4155	3011	27.53
2	Kharif – 2017	45	3830	2682	29.97
3	Kharif - 2018	75	5296	3935	25.7
4	Kharif - 2019	15	4950	3680	25.66
	Average	136	4557.8	3327	27.74

Table 3: Economics of plastic mulching demonstration and controlled plots (Area 0.40 ha)

Sr. No.	Particulars	Demonstration plots Rs.	Controlled plots Rs.	Comparison (+/-)
1.	a) Cost of primary tillage operation	3000	3600	-600
2.	Cost of Plastic mulching	8000	0	+8000
3.	a) Seed rate (Kg.)	3	15	-12
	b) Cost of seed (Rs.)	120	600	-480
	c) Cost of Raising of seedlings (Rs.)	0	800	-800
	d) Cost of cultivation (Rs.) / cost of transplanting (Rs.)	1100	2650	-1550
4.	a) Inter cultivation (Labour) (Rs.)	450	1200	-750
	b) Herbicide + Labour	100	1100	-1000
5.	a) Fertilizers + Labour	1400	1800	-400
6.	a) Disease and insect control expenditure (Rs.)	350	700	-350
	b) Labour	300	600	-300
	c) Intensity of infestation (%)	--	--	--
	i) Stem borer (%)	0	4	-4
	ii) Thrips (%)	1	9	-8
7.	Cost of harvesting (Rs.)	2000	2400	-400
	Total Expenditure (Rs.)	16820	15450	+1370
8.	No. of Irrigations given during dry spell	1	3	-2
	Biometric Observations			
9.	a) No. of tillers	55-65	25-30	+30.35
	b) Maturity of crop	115	135	-20
	c) Grain / Straw ratio	0.61	0.45	+0.16
10.	Crop productivity (Kg/ha.)	5296	3935	+1361
11.	a) Yield according to market price (Rs./ha.)	92680	68862	+23818
	b) Yield according to market (Rs./Acre)	37072	27544	+9528

Table 4: Use of Mulching Paper for other crops

Sr. No.	Year	No. of Demonstration	Paddy crop	Gram, Maize in Rabi season	Green gram and Paddy on Summer
1.	2016-2017	1	1	-	-
2.	2017-2018	45	45	13	2
3.	2018-2019	75	75	29	5
4.	2019-2020	15	15	15	-

Table 5: Performance of Paddy varieties for quantitative parameter cultivated in control plot

Cultivars	Plant height at harvest (cm)	Days to 50% flowering	Panicle Length (cm)	Productive Tillers Plant	1000 grain weight (gm)	Filled grains -1 panicle	Chaffy grains -1 panicle	Grain Yield -1 plant (gm)
PKV-HMT	108	109	18.16	8	14	103	37	13
PKV-KISAN	118	107	22.11	9	16.8	119	39	17.9
PKV-Khamang	119	103	22.92	8	17.7	148	27	21.2
Shriram	130	108	20.9	9	12.7	126	28	15.4

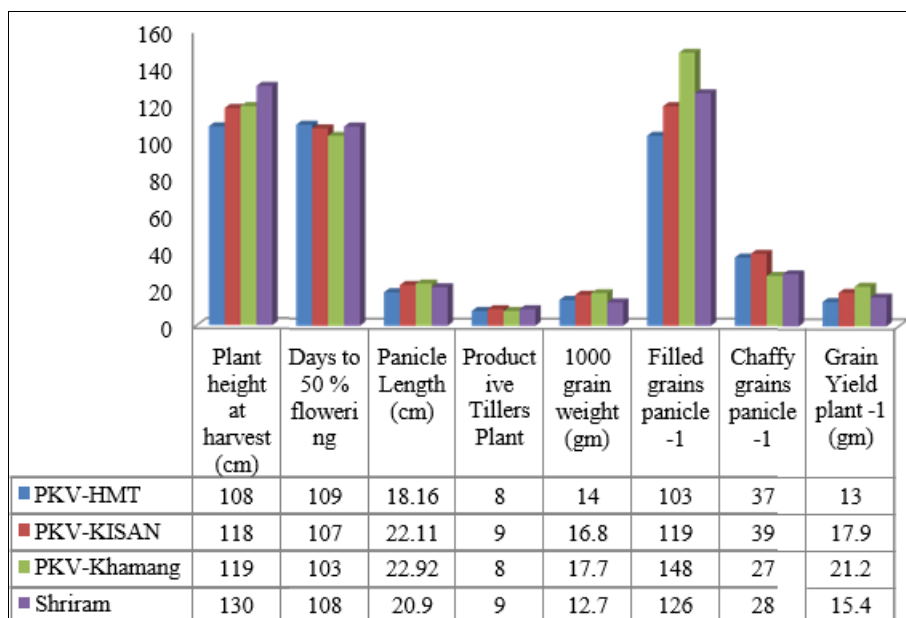


Fig 1: Performance of Paddy varieties for quantitative parameter cultivated on control plot

Table 6: Performance of Paddy varieties for quantitative parameter cultivated on mulching

Cultivars	Plant height at harvest (cm)	Days to 50% flowering	Panicle Length (cm)	Productive Tillers Plant	1000 grain weight (gm)	Filled grains -1 panicle	Chaffy grains -1 panicle	Grain Yield -1 plant (gm)
PKV-HMT	110	115	18.65	15	15	108	38	16.5
PKV-KISAN	120	109	23.03	14	17.2	123	39	21.50
PKV-Khamang	120	103	23.32	16	18.6	159	27	23.6
Shriram	130	112	21.25	15	12.9	135	30	16.70

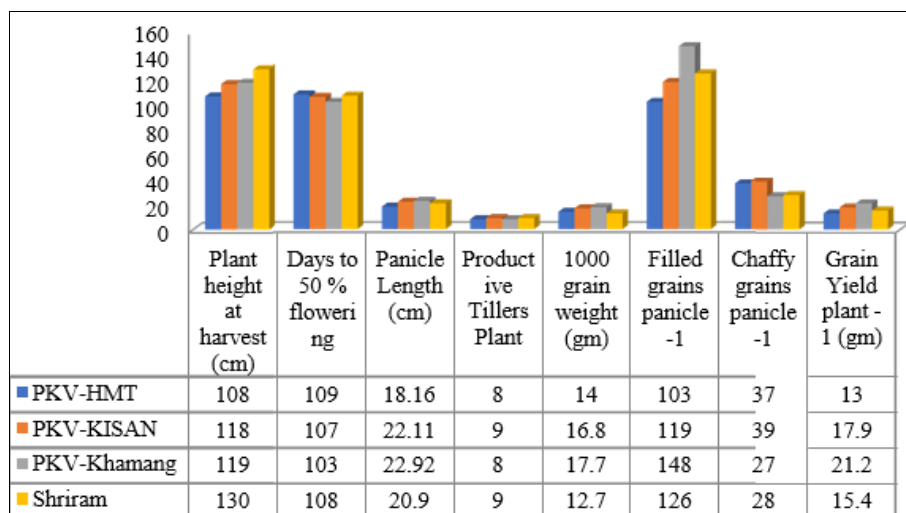


Fig 2: Performance of Paddy varieties for quantitative parameter cultivated on mulching

Conclusion

The traditional method of puddling and transplanting in heavy rainfall region leads to soil losses. This loss can be stopped in plastic mulching with to increase in productivity by 27.74%. Growth of weeds and expenditure on weed control is very less as compared to traditional method hence it helps to increase productivity and suitability of paddy mulching technology. In traditional method expenditure of Rs. 2950/- is incurred on puddling, Nursery and transplanting. Per acre saving in seed cost by Rs. 900/-. Due to silver colour in mulching of mulching reflection of sunlight is more which enhances growth of plants especially in rainy and cloudy days. In all the season green colour of paddy plants was noteworthy. Also, it leads to early maturity of the crop by 15 days. Reduction in the cost of

cultivation motivates farmers to grow crops in the Rabi and summer season. Due to increase in productivity the expenditure of plastic mulching of Rs. 8000/- is earned by farmers in the first crop. The total expenditure in mulching was Rs. 17400/- and cost of total production was Rs. 37072/- which leads to net profit worth Rs. 19672/- where as in control plot net profit was only Rs. 10104/-. It is strongly recommended that Paddy growing farmers of Vidarbha region are advised to cultivate paddy on the plastic mulching.

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References

1. Anonymous. Agricultural Statistics at Glance-2015; c2015. p. 22-29.
2. Xia B, Yang SY, Liu QB. Summary of Ecological Factors on Rice Leaf Photosynthesis Function. *Crop Res*; c2008. p. 140-142.
3. Sarolia DK, Bhardwaj RL. Effect of Mulching on Crop Production under Rainfed Condition: A Review. *Int. J Environ Res*. 2012;2:8-9.
4. Food and Agriculture Organization (FAO) of the United Nations. Statistical Databases; c2001.
5. Cao HX, Liu Y, Liu YX, Jin SH, Yue YB, Zhu DW, *et al*. Biomass-Based Rice (*Oryza sativa* L.) above Ground Architectural Parameter Models. *J Integr Agric*. 2012;11(10):1621-1632. DOI: 10.1016/S2095-3119(12)60165-8.
6. Shen R, Wang XC, Liu J, Luo XS. Test and Demonstration on Wet Cultivation with Film Mulching.
7. Wu H, Zhu ZR, Liang YC, Shi WY, Zhang LM. A High-Yielding, Water-Saving and Fertilizer-Saving Cultivation Technique for Rice Mulched by Plastic Film under Dry Land Condition. *J Zhejiang Univ. Sci*. 1999;25:41-42.
8. Gao LZ, Jin ZQ, Zhang GS, Shi CL, Ge DK. A Numerical Model to Simulate the Incident Radiation and Photosynthate for Rice Canopies with Optimum Plant Type. *Jiangsu J Agric. Sci*. 2000;16:1-9.
9. Gao Z, Jin ZQ, Huang Y, Chen H, Li BB. Rice Cultivational Simulation, Optimization and Decision-Making System (RCSODS). Beijing: Chinese Agricultural Science and Technology Press; c1992.
10. Wakamatsu. Development of Direct Sowing Techniques for Costly Rice Cultivars. Influence of Polyethylene Film Mulching on Growth and Heading Date. *Tohoku J Crop Sci*. 1997;40:57-58.
11. Rice Almanac. 2nd ed. Los Banos: International Rice Research Institute (IRRI); c1997. p. 181.
12. Krish SI, Ashok G, Alok M, Krishna KK, Mohit D. Practical Manual on Plastic Mulching. National Committee on Plastics Application in Horticulture (NCPAH); c2011.
13. Bhuiyan SL. Water Management in Relation to Crop Production: Case Study on Rice. *Outlook Agric*. 1992;21(4):293-299.
14. Peng S, Shen K, Wang X, Liu J, Luo X, Wu L, *et al*. A New Rice Cultivation Technology: Plastic Film Mulching. *Int. Rice Res. Notes*. 1999;24:9-10.
15. Liu XC, Qiao L, Liu CZ, Lu ZC, Zhao HY, Li JH, *et al*. The Effect about Physiological Index of 'Liangyou6326' with Different N Application Rate Under the Condition of Film Mulching. *Chin Agric. Sci. Bull*. 2012;28:33-37.
16. Gu Y, Liang ZW, Huang LH, Ma HY, Wang MM, Yang HY, *et al*. Effects of Plastic Film Mulching and Plant Density on Rice Growth and Yield in Saline-Sodic Soil of Northeast China. *J Food Agric. Environ*. 2012;10:560-564.
17. Yang M, Liu XJ, Sun HY, Li WQ. A Preliminary Study on Ecological Effect of Plastic-Film Mulching on Upland Rice in Summer. *Res Arid Areas*. 2000;18:50-53.